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QUINTANA ROO, MEXICO

NOVEMBER 2002

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Parque Maravilla Natural de Xel-Há, Mexico

FORT PIERCE, FLORIDA 2004

Gulf and Caribbean Fisheries Institute, Inc.

(A South Carolina Non-Profit Corporation)

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And to the tireless efforts of the staff of CINVESTAV - IPN *Unidad Mérida* that served as our host.

Opening Remarks

55th Gulf and Caribbean Fisheries Institute
November 11 -15, 2002
Xel-Há - Quintana Roo, Mexico

Alejandro Acosta — Chairman, Gulf and Caribbean Fisheries Institute

Ladies and Gentlemen, In behalf of the members of the board of directors for GCFI, it pleases me to welcome you all to the 55th annual meeting of the Gulf and Caribbean Fisheries Institute. We are very excited about this meeting particularly because we are back in Mexico. This is the third time in the last ten years that we are having a meeting in this beautiful country. We at the GCFI feel fortunate to be hosting this meeting here in Xel-Há and to be able to bring to our members the opportunity to interact and to exchange ideas with a large number of Mexican scientists working in all the areas of interest that we be will discussing during this meeting. A very important and relevant aspect of this meeting is the locality in which the meeting is taking place, the Mayan Riviera. This is an area highly sensitive to ecological impacts, in which the coastal resources are under a lot pressure for development. Having an entire infrastructure developed for tourism does not only affect the marine and coastal resources but also impacts the socioeconomic of the local people. I hope that by interacting with local scientists and managers working in this area and by trying to keep a balance between development and conservation, we can all bring some of our expertise and knowledge gained here in the management and sustainability of coastal resources to our homes in the Caribbean. During this meeting we will have the opportunity to visit one of the natural wonders of the area, the Xel-Há Park. GCFI is extremely thankful for the generous support from the park, whose fundamental task is to respect and conserve the natural ecosystem of this area. We will also have the opportunity to learn more about the park and how their management is getting involved in the community by encouraging the care of adjacent areas to the park, by developing educational programs and by implementing biological, environmental and social programs.

There has been an obvious increase in the last few years in the number of papers submitted regarding the role of marine reserves and community-based management of marine reserves, as well as in the biology and economic value of spawning aggregations. This clearly indicates that scientist are now more than ever taking the responsibility of providing information and doing research toward the goal of managing marine resources in a sustainable manner. The agenda of the following days covers diverse scientific and institutional aspects of interest in many areas of the Gulf of Mexico and the Caribbean. We are having three special sessions during this meeting.

The first special workshop is about Marine Protected Areas hosted and sponsored by the Marine Resources Assessment Group in association with the Caribbean Conservation Association, the University of West Indies and the Caribbean Natural Research Institute (CANARI). I want to point out that this workshop is by invitation only. The participants of this workshop are actively involved in the development and implementation of MPA in the region. The

workshop is intended to focus mainly on the lessons learned from the in-depth Caribbean studies lead by MARAG. This workshop follows as a complement to the GCFI symposium last year of Caribbean Marine Protected Areas. The results from last year's symposium will be available next year as a supplemental issue of Gulf and Caribbean Research.

Next on the agenda is the Spawning Aggregation Symposium. This is a very relevant and important topic throughout the region. Dr. Bill Hayman from the Nature Conservancy and Dr. Brian Luckhurst from Bermuda Division of Fisheries are organizing this symposium. Both of them have been able to put together a very comprehensive agenda and, more importantly, this symposium has the representation of members of the Ministry of Fisheries and Director of Fisheries from Belize, Government officials from the Bahamas and Honduras as well as fishermen from Bahamas, Belize, Mexico, Guatemala, Honduras, and the United States that have been active in promoting the protection of this important resource.

Finally, on Friday, we are having a special symposium on Queen conch. This symposium is organized by Dr. Dalila Aldana from CINVESTAV and co-sponsored by CYTED-CONACYT. Over 20 distinguished-invited scientist from the Gulf and Caribbean region as well as a large number of students from Mexico will be participating in this event. This is the first time since the 1991 workshop on Queen Conch in Caracas, Venezuela, that so many experts in this area are getting together.

As you all can see we have a very busy agenda for the next five days. We are providing a unique opportunity for scientists, government representatives, NGO representatives and students to interact and to learn from each other.

I would like to highlight some of the major accomplishments of GCFI since last year. The continued use of the listserver as well as the web page have facilitated the communication and the dissemination of information among members and we hope to continue using electronic media for all our communications. I would like to thank Mr. David Anderson and Dr. Bob Ditton from Texas A & M University and Bob Glazer from Florida Fish & Wildlife Conservation Commission for their continuous support in maintenance of the list server and the web page respectively. A service that we are providing in our web page and that is not been used to its full potential is the GCFI bulletin board. This can be a very valuable tool to exchange information and to interact with other scientists in the region. Please take advantage of it. I would like to thank la empresa del Parque Xel-Há (Señores Francisco Cordova, Eduardo Briones and Manuel Sanchez and his team), al program de cooperación Internacional CYTED-CONACYTA and CINVESTAV Unidad Merida especially, Dr. Dalila Aldana and her team for their leadership, support and vision in bring this meeting to Xel-Há.

Finally, I would like to remind all of you that the Gulf and Caribbean Fisheries Institute is a non-profit organization based on the work of volunteer members which serve on the board of directors and work throughout the year in order to put together this annual meeting. In order for us to provide a better service to all of you, we need your input, support and cooperation. Please get involved and participate throughout the year to promote your organization.

Thank you all for coming and have a fruitful meeting.

Palabras de Opertura

Damas y caballeros; En nombre de los miembros de la junta directiva y de la menbresia del Instituto de Pesquerías del Golfo y el Caribe, Gulf of the Caribbean Fisheries Institute, me satisface darles la bienvenida a todos a la 55 reunión anual Nosotros estamos muy entusiasmados sobre esta reunión, principalmente debido al hecho que estamos de regreso en México. Éste es la tercera vez en los ultimos diez años que tenemos nuestra una reunión en este hermoso y hospitalario país. Nosotros en el instituto nos sentimos afortunados de poder dar a nuestros miembros la oportunidad de intercambiar y aprender sobre los avances y trabajos que están haciendo los científicos mejicanos que trabajan en todos los campos de interés que estaremos discutiendo durante esta reunión. Un aspecto muy importante y relevante de esta reunión es el lugar en el cual la reunión está desarrollando, La Rivera Maya. Esta es un área altamente sensible a los impactos ecológicos, en la cual los recursos costeros y pesqueros están bajo la presión del desarrollo. Tener una infraestructura enteramente desarrollada para el turismo no solamente afecta a los recursos marinos y costeros pero también afecta los aspectos socio económico de la gente local. Estoy seguro que de la iteración con los científicos locales que trabajan en esta área y que están trabajando para mantener un equilibrio entre el desarrollo y la conservación, todos podremos llevar a nuestros hogares la experiencia y el conocimiento adquiridos aquí en el manejo y aprovechamiento sustentable de recursos costeros y pesqueros Durante esta reunión tendremos la oportunidad de visitar una de las maravillas naturales del área que es precisamente el lugar donde nos encontramos esta mañana el parque de Xel-Há.

El instituto de pesquerías del golfo y el Caribe esta sumamente agradecido por el aporte prestado por los administradores del parque quienes tienen como tarea fundamental el de respetar y conserva el ecosistema natural de esta área. Estas visitas al parque Xel-Há nos darán la oportunidad de aprender más sobre el mismo y cómo su gerencia se involucran con las comunidades cercanas, auspiciando el cuidado de las áreas adyacentes al parque, a si como desarrollando programas educativos, biológicos, ambientales y culturales.

En los últimos anos en nuestra organización ha visto como ha aumentado el número de los artículos y presentaciones relacionados con el tema de las reservas marinas, y su manejo con un enfoque comunitario así como temas vinculados a la protección de agregaciones reproductivas de especies demersales. Esto indica claramente que los científicos ahora más que nunca, están tomando la responsabilidad de generar la información necesaria que nos permita manejar los recursos marinos y pesqueros de una manera sostenible. La agenda a desarrollar durante los próximos días cubre aspectos científicos e institucionales del más diverso interés para nuestros países en el golfo de México y del Caribe. Sin embargo queremos hacer especial énfasis en tres sesiones o talleres

El primer taller especial está sobre las áreas marinas protegidas auspiciado por el Marine Resources Assessment Group (MRAG), en asociación con la asociación de Conservación del Caribe, la Universidad de West Indies y el Instituto de Investigaciones Naturales del Caribe (CANARI). Este taller es un complemento al

simposio de Áreas marinas protegidas que se llevo acabo en la pasada reunión del Instituto.

El segundo taller esta dedicado a las agregaciones reproductivas de peces. Este aspecto es muy relevante en toda la región. El Dr. Bill Hayman del Nature Conservacy y el Dr. Brian Luckhurst de la División de Pesquerías de Bermudas serán los anfitriones de este simposio. Ambos han desarrollado una agenda muy completa e importante y cuentan con la presencia y representación de los miembros del Ministerio de Pesca y el Director de Pesquerías de Belice; los oficiales del gobierno de las Bahamas y Honduras así como pescadores Bahamas, Belice, México, Guatemala, Honduras, y los Estados Unidos quienes han sido actores muy activos en la protección de estos importante eventos reproductivos.

Finalmente, el viernes tenemos un taller especial sobre el caracol (*Strombus gigas*). Este simposio esta organizado por el Dr. Dalila Aldana y es auspiciado por CINVESTAV Unidad Mérida y el programa CYTED-CONACYT. Alrededor de 20 distinguidos científicos del Caribe y del Golfo de Méjico han sido invitados a participar en este simposio, quienes tendrán la oportunidad de interactuar con una importante representación de estudiantes de Mejicanos quienes también atenderán este simposio. Este taller representa la muy esperada continuidad del taller sobre este recurso que tuvo lugar en Caracas Venezuela en 1991

Como ustedes pueden ver tenemos una agenda muy atareada durante los próximos los cinco días. Nuestro foro representa una oportunidad única para que los científicos, los representantes del gobierno, y ONGs, así como los estudiantes de intercambien ideas y aprendan unos de los otros.

Quisiera terminar destacando algunos de los principales logros alcanzados por el instituto durante el pasado año. El uso continuo del listserver y del portal de Internet ha facilitado la comunicación entre los miembros y nosotros esperamos continuar usando los medios electrónicos para todas nuestras comunicaciones. Quisiera agradecer a Sr. David Anderson el Dr. Bob Dittion de Texas A and M University y al Señor Bob Glazer del Florida Fish and Wildlife Conservation Commission por su continuo apoyo en estos dos renglones. Un servicio que estamos proporcionando en nuestra pagina web es nuestro boletín de anuncios el cual puede ser una herramienta muy valiosa para el intercambio de información y comunicación con otros científicos en la región. Por favor aprovechen este servicio.

Me gustaría agradecer a los gerentes del Parque Xel-Há (Señores Francisco Córdova, Eduardo Briones y Manuel Sánchez y el equipo que les acompañan). Al programa de Cooperación internacional CYTED-CONACYT y al CINVESTAV UNIDAD Mérida, y muy especialmente a la Dra. Dalila Aldana y su equipo por su visión, soporte y liderazgo en traer este encuentro a XEL-Há

Finalmente quisiera recordarles que GCFI es una organización sin fines de lucro y esta basada en el trabajo voluntario de los miembros de su junta de Directores quienes desarrollan tareas durante todo el año par poder ofrecerles una mejor reunión cada año. Para que podamos darle un mejor servicio necesitamos tener sus opiniones, ayuda y cooperación. Por favor contamos con su participación.

Gracias a todos por venir y espero que disfruten esta reunión.

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Fishery: The Fear Factor in Management

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I was visiting a shrimp dealer in Port Aransas this summer when I noticed a long picture on his wall. It was one of those 2-foot panoramic scroll pictures like they take of your high school graduating class. But this was a scene of nearly 100 big steel hulled gulf shrimp boats tied together side by side totally blocking Aransas pass to all boat traffic. It was 1989, and it was just one of numerous port blockades across the gulf. This was to be the largest single protest of marine fisheries regulations in US history, and it was all about the new turtle excluder devices (TED) required in shrimp trawls.

Now the TED had been in development for over 10 years. A huge investment in time and money had been expended to scientifically develop the best possible device. The industry had participated fully in hundreds of test runs on commercial vessels. The endangered status of turtles made for a clear resource need. The Endangered Species Act provided an unequivocal legal mandate. Other options like closed seasons and areas were much harsher on the shrimping industry. So why the massive protest that brought the wrath of the coast guard and national marine fisheries service down on their heads?

Anthropologists have studied this issue intently. There have been dozens of scientific article,s and even whole books written, to try and explain this reaction. Socio-psychological paradigms have been applied, dependency theory versus modernization theory, urban versus rural power shifts, sum-zero game between recreational elites and traditional harvesters, and so on..

But in the end I think one word describes what drove the behavior of so many on all sides: FEAR!

And it was that fear, manifested differently for each group, and each person, that dictated the outcome of the TED wars, just as it has dictated the course of events in the Florida net ban war, the Texas and Louisiana gill net war, the New England ground fish war, the west coast salmon wa, the Canadian lobster trap wars, and on and on.

Fear is the poorly managed component in fishery management today, which has so often created unnecessary wars or prevented successful resolution of conflicts. That is my principal thesis for you today.

Now let me be honest about my credentials for speaking to this human attribute. I had one freshman class on introduction to psychology in college.... But, I've also watched these fishery battles from the inside and the outside for 25 years... on the job training you might say.

My second thesis for you today is that, by and large, the profession of marine fishery management has been a failure. Certainly, these managers have had a lot of help in creating those failures, but after decades of trying they still have so few examples of having achieved optimum yield from our public marine resources.

My credentials for this assertion are more formal: several fisheries degrees, dozens of journal and technical scientific articles, years of field sampling, hundreds of fishery conferences, director of the largest state marine sampling program in the U.S., chairman of the Gulf of Mexico Fishery Management Council. I am one of those fishery managers.

You want evidence that fishery managers are failures? Of the 300 known fishery stocks harvested in the U.S., 33 % are clearly overfished with many more approaching that status. Of the world's top 200 fisheries, 60 % are fully exploited or overexploited. In the Gulf of Mexico alone, red snapper, Nassau grouper, jewfish, red grouper, sharks, billfish, king mackerel, and red drum are all considered overfished.

What if 33% of the highway bridges in this country fell down each year? Would we think bridge engineers were doing the best they could, but it's just a real difficult job to keep a bridge in good condition, so we'll just let them keep on trying?

If you want evidence that some people don't think marine fishery management is currently working well, you might look at the number of lawsuits challenging specific management actions. Ten years ago there were just a handful of lawsuits, today there's 112 and growing daily against the national marine fisheries service alone.

Someone once told me that NOAA stands for national organization for the advancement of attorneys. But bringing in more attorneys is a natural reaction to being sued, and do you think being sued strikes fear in the heart of a fishery manager? Fear of the extra workload, fear of being proven wrong and losing credibility, fear of personal liability! Do you the think the fear of being sued is capable of stifling much needed management initiatives? Why risk the hassle and heartache when you can legitimately claim you need more data or more stakeholder input before making a decision?

But now the national marine fisheries service has adopted a precautionary approach to fisheries management. We're supposed to err on the side of conservation. How can a lawsuit risk-averse strategy coexist with a resource risk-averse strategy?

One way is for the managers to make the decision matrix a clean, clear, simple, yes or no process. Enter the mathematical model. Doing fishery management by plugging values in a formula. If we use the best available data, then the answer that gets spit out must be the best as well, right? So what if we are trying to model a hugely complex ocean ecosystem that changes constantly.

I want to tell you that I am greatly impressed with the achievements of fishery modelers and statisticians throughout our profession. It's amazing to see Mother Nature turned into a computer program that actually attempts to predict fish population levels. The question about models, though, is whether they drive the management train or just provide guidance on which way the train should go.

Like the highway bridge engineer, we fishery managers want predictability in what we build. We want to be fish engineers. We want to take the guesswork our of this messy management business. Nothing to be afraid of if you have a

statistically defensible position. Crank out a number and end the debate over how many fish can be caught. But let's remember what the acclaimed statistician Dr. George Box wrote:

"All models are wrong, some may be useful."

Let's consider the modeling efforts on red snapper, which is one of the most thoroughly studied fish in the gulf. Snapper are overfished, and the recovery timeline says we need full recovery by 2031. Now, in the process of calculating what full recovery is and how to get there by 2031, we have to know first how many fish are currently being caught, what age they are, and how fast they grow. We also have to know the number of eggs produced by all the mature female snapper in the Gulf of Mexico. Then we have to know the number of those eggs that will survive the gauntlet of natural and fishing mortality to become adult, spawning fish. Having made this simple calculation we now have to do the same thing for each of the new year classes over the next 31 years. Having now calculated what the snapper population will be in 2031, we're now ready to decide how many we can catch today to make sure we reach our 2031 target, assuming of course, that nothing changes in the Gulf currents or habitats, the predator-prey relationships stay the same, immigration, emigration, by-catch, fishing technology, and illegal harvest all stay the same.

Why are we surprised when managers and stakeholders alike look with unrestrained horror and fear on placing their careers and their livelihoods in the hands of this number crunching machine? Why do we see people who spent their whole life on a fishing boat suddenly carrying around laptop computers and trying to describe how the spawning potential ratio and the maximum fishing mortality threshold have been miscalculated?

But the show must go on. The national standard guidelines developed by NMFS demand it. And after the number crunching machine had finished digesting its meal, it revealed to the world that the biomass of red snapper in the Gulf of Mexico in 2031, when maximum sustainable yield was achieved, would be as high as four billion pounds. For comparison, the biomass at MSY for all the cod and haddock in the Gulf of Maine and Georges Bank combined is one-tenth that amount.

"All models are wrong, some may be useful."

And it is the scientists themselves that know that the best. We are trained to know that every experiment has a bias, that the observer may be influencing the object being observed, and that you cannot ever fully prove the null hypothesis.

The good news is that people, decision makers in particular, still desperately want science to provide definitive answers to problems of the human condition. As abused and misused as science has been throughout our history, what is the universal cry we hear when a debate occurs? Do a scientific study, convene a scientific panel!

When fishery management decisions are challenged, what is the principal reason? It's because the science is bad. Let's get better science; let's collect more objective data. Everybody always agrees we need more scientific data. With this backdrop, the scientist should be in the driver's seat, but will scientists step up to the challenge or retreat to the safe, warm confines of some ivory tower? No hard allocation decisions, no political controversies, no public scientific opposition.

I know a professor of terrestrial ecology, one of the best scientists in this field at any university; he told me a story once about how he agreed to serve as a consultant on a controversial land preservation proposal. He did his study and he presented his scientific conclusions. But then he was put on the witness stand during a hearing — and there were the lawyers from the opposing side challenging his credentials, his methods, his conclusions, and his very objectivity. They raked him over the coals with technicalities, even though his results were perfectly valid. He told me he couldn't wait to get back to the safety of his office and vowed never to get involved in public policy issues again. He was afraid.

But if the best minds in our profession won't step into the ring and be willing to defend their science, who will? How will we make the best decisions for the resource and users if the people with some of the most valuable knowledge are sitting on the sidelines? And when should our scientists get involved in actively sharing their results? When the definitive study is finally done — when the last chapter of the book on the subject has been written? No. Whenever the decision-making process needs guidance, that's when our professionals need to be there. The fear of applying incomplete science has been one reason for our failures.

Let's return to our shrimper protest of TEDs. What were they afraid of and what did they really want? Dr. Anthony Margavio in his in-depth study of the TED wars found over 95 % of the shrimpers feared they would be put out of business. They feared a huge loss of shrimp from their nets. They feared the additional cost and injury potential of TEDs. They feared that accepting this new rule would just lead to even more restrictive rules.

It's interesting when Dr. Margavio was conducting interviews; he found that everyone wanted to talk to him so the "truth" could be heard. We hear that frequently at council debates. "I'm just looking for the truth." I think that's a sign that science is still a welcome participant and, in fact, may be able to supply a common ground, an agreed upon truth, on which stakeholders can build.

But we have our work cut out for us. For every legitimate fishery management tool, there is a legitimate stakeholder fear that must be dealt with. Size limits will reduce the supply of preferred fillet sizes and we'll lose our markets to foreign suppliers. Trip limits will reduce large vessel efficiency and we'll lose out to the small vessel fleet. Closed seasons will disrupt the steady supply demanded by the market. Closed areas will reduce valuable fishing grounds and lead to a takeover by environmentalists. Vessel monitoring systems will be an invasion of privacy. Vessel permits will allow for suspensions for minor fishing violations. Limited entry will prevent my kids from being fishermen. It will lead to a corporate takeover of the small businessman.

So what's a poor fishery manager to do? Even the good manager, trying to regulate for the long term, has to be afraid of all the future unknowns and the ever-present law of unintended consequences?

Science has not been forsaken in fisheries management, but it has been subjugated by fear and misunderstanding. To fix this we need to start by recognizing and managing our fears. Humanness is real. Fear becoming an irrational and intransient force is real.

And when we find people who have found ways to manage their fears - both in the scientific and fishing communities - we need to empower them. Facilitate them; bring them forth as leaders. Let their courage infect their peers. Create an atmosphere where reason and logic are at least on an equal footing with fear.

I remember the Texas Parks and Wildlife's first workshop on implementing a limited entry program for commercial finfish fishermen. It was a large crowd of mostly big, rough, burly men who lived their lives on the water. Their livelihoods were declining because of our old nemesis - the tragedy of the commons – too many fishermen chasing after too few fish. But still they wanted nothing to do with being regulated by bureaucrats in Austin. And as their voices rose in opposition, the crowd grew surly, shouting insults and taunts at the managers. Someone yelled, "I bet there's not one real fishermen in this room that wants limited entry." suddenly a voice spoke from the corner, "Yes there is. I do." it was a well-known, hard fishing old-timer. The crowd quieted down. The discussion moved to the details of a limited entry program, and a year later the Texas governor signed the finfish limited entry act into law. And that old timer who had the courage to manage his fears is now the chairman of my finfish advisory committee.

I thank you very much for allowing me to speak to you today.

The CFRAMP Project: A Decade of Contribution to Sustainable Development and Management of Fisheries in the Caribbean

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ABSTRACT

In 1991 twelve Caribbean countries launched the CFRAMP Project, with financial and technical support from CIDA and ICOD of Canada. The overall goal of CFRAMP was to promote management of the fisheries resources to permit sustainable use of these resources by the people of the region. The specific purpose of the program was to enhance the institutional capacity and information available for fisheries management planning and policy formulation. The main activities of CFRAMP were: training of fisheries personnel in areas related to fisheries assessment and management; establishment of fisheries data and information management systems; resource assessment studies; preparation of fisheries management plans; establishment of national advisory/decision making mechanisms; community awareness building and the strengthening of fishers groups and organizations to increase their capacity to participate in co-management arrangements in partnership with the governments; and establishment of a permanent regional fisheries body which will continue to provide policy and technical support and coordination for sustainable fisheries development and management at the CARICOM level after CFRAMP ends. The CFRAMP Project has come to an end after ten years of operation and over $20 million in expenditure. This paper provides a brief review of the major contribution of the Program to the sustainable development and management of Caribbean fisheries.

KEY WORDS: Fisheries management, CFRAMP, Caribbean fisheries

El Proyecto CFRAMP: Una década de Contribución al Desarrollo Sostenible y Manejo de las Pesquerías en el Caribe

En 1991, doce países del Caribe se embarcaron en el Proyecto CFRAMP, con apoyo técnico y financiero de CIDA y ICOD de Canada. La meta principal de CFRAMP fue el promover el manejo de las recursos pesqueros para permitir el uso sostenible de esos recursos por parte de la gente de la región. El propósito específico del programa fue mejorar la capacidad institucional y la disponibilidad de información pesquera para la planificación del manejo pesquero y la formulación de políticas. Las actividades principales del programa CFRAMP fueron: entrenamiento del personal pesquero en las áreas relacionadas con evaluación y manejo de las pesquerías; establecimiento de sistemas de manejo de datos e información pesquera; estudios de evaluación de los recursos; preparacion de planes de manejo pesquero; establecimiento de mecanismos nacionales asesores y de toma de decisiones;

capacitación de la comunidad y fortalecimiento de grupos y organizaciones de pescadores para incrementar su capacidad en los arreglos de co-manejo en colaboracion con los gobiernos; y el establecimiento de un cuerpo permanente rector de las pesquerías regionales el cual continuará proveyendo apoyo técnico y político y coordinación para el desarrollo y manejo sostenible y manejo de las pesquerías a nivel del CARICOM después de finalizado el proyecto CFRAMP. El proyecto CFRAMP finaliza después de diez años de operación y sobre $20 millones de gastos en apoyo al sector. Este documento provee una breve revisión de la mayor contribución del Programa al desarrollo sostenible y al manejo de las pesquerías caribeñas.

PALABRAS CLAVES: Manejo Pesquero, CFRAMP, Pesquerías del Caribe

INTRODUCTION

With the advent of the Third United Nations Convention on the Law of the Seas (UNCLOS III) in 1982, and the practice of coastal states to extend their maritime jurisdiction to include 200 miles exclusive economic zones (EEZ), Coastal Sates in the Caribbean acquired sovereignty and jurisdictional rights over extensive living marine resources within their maritime waters. States not only gained legal rights to these living resources, but they also assumed legal obligations and responsibilities with respect to conservation, protection and optimum sustainable utilization of these living marine resource.

In 1982, shortly after the signing of UNCLOS III in Montego Bay, Jamaica, CARICOM convened the Second Technical Regional Meeting of CARICOM Fisheries Officers in Kingston, Jamaica to discuss the situation of fisheries among the Member countries of CARICOM. The meeting recognized the severe constraints faced by the countries which rendered them unable to exercise their rights, discharge their obligations, and take full advantage of the new opportunities arising from UNCLOS III, owing to their small developing economies, limited capacity, lack of technology, and limited information regarding the fishery resources. Against this background, the countries identified the need for a regional project to:

i) Provide an up-to-date scientific assessment of the fish stocks within their EEZs,
ii) Strengthen the capability of the national fisheries administrations for fisheries development and management, and
iii) Create a regional fisheries organization to facilitate closer cooperation and coordinate support to the countries (CARICOM 1982).

Following this Meeting, in the mid 1980s, the CARICOM Countries requested assistance of the Government of Canada to enable them to address the deficiencies identified. And after extensive studies and discussions among the Canadian International Development Agency (CIDA), the International Centre for Ocean Development (ICOD) and the CARICOM Countries, the CARICOM Fisheries Resource Assessment and Management Programme (CFRAMP) was conceptualized

and developed as a cooperative effort involving Canadian and Caribbean fisheries experts.

In 1991, after more than six years of discussions and negotiations, CARICOM and the Government of Canada, represented by ICOD, signed a Memorandum of Understanding (MOU) officially launching CFRAMP as a development project to promote sustainable use and conservation of the fishery resources of the region (CFRAMP 1991). The goal of the project as documented by the MOU was,

> *"to promote the management and conservation of fishery resources of CARICOM countries to permit their exploitation on the basis of sustainable yield."* The purpose was, *"to enhance the basic information and institutional capacity necessary to manage and develop fishery resources in the CARICOM region."*

And the expected outputs were:

i) Strengthened capabilities to manage fisheries resources on a sustainable basis
ii) Trained personnel at both national and regional levels
iii) Improved and expanded fisheries management information
iv) Regional fisheries management mechanism installed at the CARICOM level.

The project was envisaged initially to last for eight (8) years from 1991-1998, and financed by a budget of Canadian $20.8 million, with $17.6 million contributed by the Government of Canada and the remaining $3.2 million by the CARICOM Countries. However, owing to delays experienced at the commencement of the project, the Government of Canada (CIDA) agreed to an extension of just over 2 years, to March 31, 2001.

The beneficiary countries were Antigua and Barbuda, Barbados, Belize, Dominica, Grenada, Guyana, Jamaica, Montserrat, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, and Trinidad and Tobago.

Organizational Structure

CFRAMP's administrative structure (CFRAMP, 1995) involved the Government of Canada (CIDA), which was supported by a Canadian private sector company as Canadian Executing Agency on the one hand, and CARICOM Secretariat and CARICOM Member States (represented by their Ministries of Agriculture and Fisheries Departments) on the other hand. The Standing Committee of Ministers of Agriculture (SCMA) of CARICOM, which has now been replaced by the Council for Trade and Economic Development (COTED), had overall responsibility for CFRAMP, on the CARICOM side. The SCMA was supported by a Programme Review Committee (PRC) comprising Permanent Secretaries responsible for fisheries of each member state, plus representatives from CIDA and the CARICOM Secretariat. The PRC met at least once each year to provide policy guidance and approve the annual work plans. The PRC was supported by a

Technical Committee made up of independent fisheries experts.

The project activities were planned, implemented and coordinated by the CARICOM Fisheries Unit (CFU), an arm of the CARICOM Secretariat, which was established for the purpose of implementing the project. The CFU was headquartered in Belize City and conducted its work through the Belize Office and two other Resource Assessment Units located in St. Vincent and the Grenadines and Trinidad and Tobago.

The CFRAMP project activities were designed and organized on the basis of the Logical Framework Matrix with work breakdown structure (WBS), which for the technical program consisted of the following:

WBS 300 Fisheries Management Data Systems
- WBS 310 Catch and Effort Data System
- WBS 320 Licensing and Registration System

WBS 400 Fisheries Resource Assessment
- WBS 410 Reef and Pelagic Fishes Assessment
- WBS 420 Shrimp and Groundfish Assessment
- WBS 430 Lobster and Conch Assessment

WBS 500 Fisheries Resource Management
- WBS 510 National Fisheries Management
- WBS 520 Regional Fisheries Management
- WBS 530 Community Involvement and Education
- WBS 540 Long-term Training

The technical activities of CRFAMP commenced with a series of baseline studies, sub-project initiation missions and participatory planning workshops (sub-project specification workshops), during which reviews of the situation existing in the countries at the time were conducted and the interventions to be made by CFRAMP were discussed and developed through a consultative process involving CRFAMP staff, the participating countries, external experts and representatives of regional and international organizations connected to the fisheries sector. The strengthening of collaboration and cooperation with other regional and international organizations involved in fisheries in the Caribbean was recognized as indispensable in achieving the objectives of CFRAMP. In this connection careful attention was given to building and maintaining good working relationships with organizations such as FAO, the Caribbean Fisheries Management Council, the University of the West Indies, ICLARM, and ICCAT among others.

RESULTS

Fisheries Management Data Systems

The Catch and Effort and Licensing and Registration Subprojects were implemented in parallel throughout the Project. The activities to be carried out under these two subprojects were determined through a Subproject Initiation Mission (Fanning 1992) to the twelve countries in 1991, and further developed

during the Subproject Specification Workshop (Manwaring and Fanning, 1993) in June 1992. The main objectives of WBS 310 (Catch and Effort Data Collection System) were to establish national systems to collect, manage, and report on quantities of catch by species and the effort made to obtain this catch. The main objectives of WBS 320 (Licensing and Registration System) were to establish national systems to monitor and manage the fisheries by tracking change in numbers of fishermen, fishing boats, and fishing gear.

Frame surveys were conducted in the countries. These surveys were necessary as a basis for establishing computerized registration and licensing systems that could provide up-to-date listings of landing sites, fishermen, vessels and gear types as well as socio-economic information on the fishers. This information was also needed to obtain estimates of total effort used in estimating total landings from the sample data in the data collection systems.

All twelve participating countries now have basic data collection systems in place. However, the extent to which the sampling systems and the data have been collected varies considerably among countries. The systems include field sampling plans, computer hardware, and specialized software to support the management and analysis of data collected, and trained staff to manage the systems and analyze and interpret the data. CFRAMP provided funding to the countries to employed data collection/management staff for between two to five years in each country, with the understanding that at the end of the funding the countries would take responsibility for the new staff. The countries were also provided with customized version of the Trip Interview Program (TIP), which is used to store, manage and report on their fisheries catch, effort and biological data, and a computerized Licensing and Registration System (LRS) program which was developed by CFRAMP. TIP is owned by the National Marine Fisheries Service of the United States, however, CFRAMP made extensive modifications to the original program to create a program that met the needs of the CARICOM countries. Fisheries staff with responsibility for data management and analysis have been trained in basic data analysis and statistical procedures. In addition, three regional personnel have been trained to provide maintenance support for the databases in the countries. National fisheries statistical reports and atlases are being produced by the countries (CFRAMP 1996, 1997, 2001).

A new fisheries database software program that combines both TIP and LRS into a windows based program called CARIFIS has been developed to replace the existing programs and will be distributed to the countries at the end of 2003.

In order to improve access to information worldwide as well as to improve communication among the countries CRFAMP assisted the countries to connect to the Worldwide Web. CFRAMP also assisted countries to create their own wed sites and established a web site, www.caricom-fisheries.com to serve the countries.

Resource Assessment

The purpose of the WBS 400 Resource Assessment Subprojects was to provide information regarding the status of commercially important species such as reef

fishes, large and coastal pelagics, flyingfish, spiny lobster, queen conch, shrimp and groundfish to improve their management and sustainable utilization. This was the largest and one of the most important components of the CFRAMP project, since the provision of scientific information on the state of the exploited stocks is an indispensable requirement for management and sustainable development.

The assessment subprojects commenced with subproject initiation missions to the countries, and the preparation of draft research plans, followed by subproject specification workshops during which the regional research plans were refined and elaborated, and national implementation plans prepared. Research plans were prepared for reef and pelagic fishes (CFRAMP 1993, CFRAMP,1994), shrimp and groundfish (S&G RAU 1995, 1996, 1997) and lobster and conch (Luckhurst and Marshalleck 1995, CFRAMP 1997a). The research plans involved collection of biological data, the conduct of specialized studies and reviews and analysis of the data collected to provide information on the state of the stocks. Close cooperation was maintained with organizations such as FAO, CFMC, and ICCAT during both planning and implementation of the project activities.

A biological data collection (BDC) system network was established in the countries to provide data on the size, age, and state of maturity of selected commercially important species. National fisheries departments were provided with supplementary staff to assist with data collection where necessary, material and field equipment for sampling, training in biological data collection, and training in stock assessment in collaboration with FAO (CFRAMP 1994, Luckhurst and Marshalleck 1995, S&G RAU 1996, Riise 1996). The data collected were used as input to stock assessments, along with the data generated by the catch and effort data collection system. Regional assessments workshops were held for reef and pelagic fishes in 2000 and 2002 (CFRAMP 2001a); for the spiny lobster (*Panulirus argus*) in 1997 and 1998 in collaboration with FAO (FAO 2001); for queen conch (*Strombus gigas*) in March 1999, in collaboration with the Caribbean Fisheries Management Council (Anon. 1999) and for shrimp and groundfish in 1997 and 1998, in collaboration with FAO (FAO, 1999).

The International Commission for the Conservation of Atlantic Tunas (ICCAT) has responsibility for management of large pelagic fishes in the Atlantic Ocean. For this reason CFRAMP attended ICCAT meetings and activities each year of the Program to ensure integration of the work of CFRAMP with ICCAT's (Mahon and Murray 1992, Singh-Renton and Mahon 1993). This provided the CARICOM countries with an essential link to ICCAT, and enabled CFRAMP to acquire and interpret data and information on large pelagics, contribute data and other information to the ICCAT process, and also participate in joint activities with ICCAT (Mahon et al. 1994, Singh-Renton and Mahon 1996).

In a similar manner, a significant part of the assessment work related to shrimp, groundfish and spiny lobster was conducted in collaboration with FAO/WECAFC, whereas the work on *Strombus gigas* was coordinated with the CFMC, and ensured integration of the CFRAMP activities with initiatives of other states in the Wider Caribbean that share the resource in question.

Basic data and information systems have been established at the national level. Both quality and quantity of statistical and biological data on commercially exploited species have been improved. In addition, several specialized resource assessment studies and reviews have been conducted including but not limited to the following:

i) Habitat mapping and estimation of potential fish yield in the leeward islands, on the basis of available habitat;
ii) Underwater surveys of queen conch densities on the fishing grounds in Belize, Jamaica and Antigua and Barbuda;
iii) Study of fish export from a marine reserve in St. Lucia;
iv) Economic study of the industrial conch fishery in Jamaica;
v) Biomass survey of Alice Shoal (an offshore bank which is jointly managed by the Governments of Jamaica and Columbia;
vi) Study of trading boat activities in the Grenadines Islands;
vii) The role of drifting objects in pelagic fisheries in the Southeastern Caribbean;
viii) Study of reproductive seasonality of lobsters in St. Lucia;
ix) Analysis and interpretation of catch and effort data for offshore pelagic fisheries in and adjacent to the EEZ of several CARICOM States, based on over 30 years of data obtained from the ICCAT database in Spain;
x) Pilot project to monitor larval settlement of spiny lobsters in the region;
xi) In collaboration with FAO and the countries along the northeastern coast of South America, conducted assessment of several species of shrimp and groundfish

National Fisheries Management Planning

The expected outputs strengthened fisheries management plans in place for each country as well as procedures and protocols are established for stakeholder input the fisheries management decision making. This subproject was initiated with a mission to the countries in 1991(Faulkner et al. 1992), followed by a Subproject specification workshop in Jamaica in December 1992 (Haughton 1992). CFRAMP provided technical assistance to the countries in preparing plans for National Fisheries Advisory Committees (FAC) and National Fisheries Management Plans (FMP) for their major fisheries. The fisheries management plans define the national goals and objectives for each fishery, identifying the status and problems for resolution, the best means of achieving the objectives, and procedures for monitoring and adjusting the fisheries management measures implemented. By the end of 1997 all the participating countries had FMPs. These were based on the available information regarding the status of the fisheries and need to be reviewed and updated periodically as more and better information regarding the fisheries is generated from the resource assessment and information systems subprojects.

Underlying the management approaches is the fact that the resource is limited and can support, in a sustainable manner, only a limited number of fishers and fishing boats. These management measures are therefore designed to regulate and control fishing mortality.

Fisheries Advisory/Decision Making Mechanisms are legally required in most CFRAMP member countries including Belize, Barbados, and all OECS States with the exception of Montserrat. In some countries the Fisheries legislation set out the terms of reference, mandate, authority, structure, and composition of the FAC, but is generally silent on the mode of operation of the FAC. Plans for FACs were prepared for each country.

CFRAMP organized a series of national consultations on the fisheries sector to:

i) improve awareness of the status, plans and potential of the fisheries sector in the country;
ii) clarify the role of CFRAMP, and national fisheries administrations; and
iii) generate greater clarity, commitment and coordination among the organizations and groups working in fisheries in the country to enhance achievement of the developmental and conservation objectives.

These consultations brought together stakeholders from different background to share their views on fisheries management and are believed to have contributed to the creation of a more positive environment for fisheries management across the region (CFRAMP 1997, 1998, 2001).

Training and Human Resource Development

Human resource development is one of the cornerstones of the CARICOM countries' long-term strategy for sustainable development. At this time the region does not have the critical mass of fisheries scientists, managers, and technicians that is needed for sustainable fisheries development.

The training project started with a needs assessment survey in 1992 (O'Rielly and Clarke 1993). This was followed by a regional workshop of Chief Fisheries Officers during which regional and national training plans were elaborated. Between 1992 and 2001, twenty one (21) long-term scholarships were awarded to fisheries personnel from the region to undertake studies leading to Ph.D, M.Sc, B.Sc degrees and diplomas in fisheries related disciplines including fisheries and marine resources development and management, resource assessment, statistics, economics, computer sciences and aquaculture. In addition training material were prepared and more than 30 short regional and sub-regional training courses were convened, targeting different categories of fisheries department staff and fishers from the participating countries, covering subjects such as data collection, fisheries statistics, fish stock assessment, fisheries management, extension methodology, communication techniques, fishing boat inspection and registration, basic computing and general management for fisheries personnel. Most persons who have received CFRAMP scholarship support have returned to their countries and have taken up leadership positions in their national fisheries administrations. Scholarship recipients use their expertise not only in their country of origin but share their skills with other CARICOM countries in need through technical cooperation network facilitated by CRFAMP. Of the 21 long-term scholarship recipients only three persons have either moved away from fisheries or have not returned after completing their training (CFRAMP 1996, 1997, 1998, 2001).

Establishment of the CRFM

The creation of a Regional Fisheries Management/Advisory Mechanism (RFM) was identified as one of the three purposes of CFRAMP. The CRFAMP MOU defines the rationale for a regional fisheries body in the following terms:

> *"The Regional Mechanism Sub-Project shall address the need for sustainable fishery management at the regional level. The management of shared resources, the sharing of experience and expertise, and interaction with non-Community neighbours shall all be important considerations for most Community Member States, which will be addressed in this Sub-Project....This Sub-Project shall assist the region in specifying, and establishing an appropriate infrastructural mechanism for the provision of these services and assist on-going regional management."*(CFRAMP, 1991)

The initiative to define and establish the RFM commenced in 1996 with the preparation of a concept paper (Mahon et al. 1996). This was followed by several others studies and numerous regional workshops and working group meetings to develop and agree on the detailed arrangements for the mechanism, including preparation of the legal agreement, contribution formula, and strategic plan (Rainford and Mitchell 1998, CFRAMP 2000, 2001)

The Legal Agreement for the Caribbean Regional Fisheries Mechanism (CRFM) was signed by the CARICOM Heads of Government in February 2002 and the body was officially inaugurated in March 2003 replacing the CARICOM Fisheries Unit, which was established to deliver the CFRAMP project (CRFM, 2002). According to Article 4 of the Agreement establishing the CRFM, the objectives of the mechanism are:

i) The efficient management and sustainable development of marine and other aquatic resources within the jurisdictions of Member States;

ii) The promotion and establishment of co-operative arrangements among interested States for the efficient management of shared, straddling or highly migratory marine and other aquatic resources;

iii) The provision of technical advisory and consultative services to fisheries divisions of Member States in the development, management and conservation of their marine and other aquatic resources.

The CRFM is now fully operational and has taken over the projects and responsibilities previously held by the CARICOM Fisheries Unit.

Community Involvement and Education

The Community Involvement and Education sub-project emerged from the recognition that, for the sustainable management of the fisheries resources of the region to succeed, the active support and involvement of the resource users would be critical. This would entail the mobilization of, and provision of, technical support

for the organization of fishers and other stakeholders; the strengthening of their organizations, and the building of their capacities to effectively participate in national resource management decision making and in community-based co-management regimes. The Subproject began with a baseline survey of fishing communities in participating countries, which was followed by a six-week strategy formulation mission and preparation of a strategic plan (Espeut 1994, Brown 1995).

Initial efforts in this sub-project were directed at upgrading the national fisheries extension capability through:

i) Staff training,
ii) Provision of field equipment, and logistical support for public awareness and education campaign,
iii) Supporting and developing approaches to co-management through pilot projects,
iv) Stimulating community awareness in fisheries issues by informing fishers and their communities of the benefits of involvement and of the pros and cons of fisheries management, and
v) Training of fishers and the leaders of fishers organizations in the region.

The focus of activities then shifted towards working more directly with fishers, to strengthen and empower their organizations, improve knowledge of conservation and fisheries management among the resource users and strengthening their capacity to participate in co-management arrangements with governments. The subproject also conducted public awareness and education programs to build support for fisheries management at the community level (CFRAMP 1996, 1997, 1998, 2001).

CONCLUSION

CFRAMP was the first major fisheries project of its type, focused as it was on sustainable development and management of the region's fisheries. A mid-term review had this to say,

> *"CFRAMP stands as an outstanding example of a project not only carefully thought through, but planned with the full involvement of all the participating partners"* (Gardner et al. 1996)

While it is it still early to determine the full impact of the project, it is clear that major strides have been made by the countries as a result of it. The capability of national fisheries departments and staff have improved substantially; data and information regarding the abundance, distribution and status of commercially important fish stocks have also improved significantly; FMPs and FACs have been prepared, fishers have been mobilized, empowered, and are more involved in management planning in partnership with governments; a regional fisheries body has been established and is operational, there is much more networking and cooperation among the CARICOM countries and between the countries and other organizations and third countries. According to Caddy (2001) who conducted the final review of

the project, "*the overall conclusion is that CFRAMP has been an excellent program for the region, and a progressive and pervasively positive influence in all sectors of work of fisheries departments.*"

In concluding, through the generous contribution of the Government of Canada, CRFAMP brought us together to a new level of cooperation and networking, allowed us to better understand the fisheries situation in the region, and highlighted how much more we need to do to ensure sustainable utilization and conservation of these important resources. CFRAMP has laid a solid foundation for sustainable fisheries in the Caribbean region.

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A Preliminary Investigation of the Relationships Between the Legislative Status and Ecological Impacts of Marine Protected Areas on the Socio-economic Status of Stakeholders in Jamaica and the Turks and Caicos Islands

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ABSTRACT

This paper examines the effects of legislative status, institutional arrangements for management, and ecological conditions of Marine Protected Areas (MPAs) on the socio-economic status of stakeholders. The study sites selected for investigation were the Negril Marine Park in Jamaica, and the Princess Alexandra Land and Sea National Park in Providenciales, Turks and Caicos Islands.

The socio-economic data were collected primarily through the use of a formal questionnaire instrument administered to the principal user groups. The questionnaire was used to collect information on demographics, capital assets and individuals' perceptions of the marine parks. The ecological evaluation involved comparative analyses of the coral reef benthic structure, urchin and fish censuses as well as a stakeholder interview survey to assess changes inside and outside the boundaries of the marine parks. The evaluation of the managerial regime of the MPAs involved a review of the legislative policies and institutional mechanisms incorporated in the management plans of the study sites.

Results indicated that variation in the institutional arrangements for management and different management plans has resulted in different effects on the social and economic characteristics of user groups. For the most part, the unofficially managed Negril Marine Park achieves its management objectives yet exhibits minimal economic and social impacts on stakeholders, concurrent with minimal ecological improvements. The Princess Alexandra Land and Sea National Park being designated a non-consumptive use area with little community participation, produces relatively more social than economic and ecological impacts on stakeholders.

In general, there have been minimal ecological changes associated with the implementation of the MPAs and minimal economic impacts on stakeholders. Despite this, there appears to be wide support for the MPAs among stakeholders and a desire for improved management and community participation.

KEY WORDS: Caribbean, Marine Protected Areas, Socio-economic Impacts

Investigación Preliminar de las Relaciones entre el Estado Legislativo y los Impactos Ecológicos de Áreas Protegidas Marinas en el Estado Socioeconómico y los representantes en Jamaica y las Islas Turk y Caicos

Este trabajo examina el efecto de prácticas directivas y de impactos ecológicos de áreas protegidas marinas en el estado socioeconómico de tenedores de apuestas. Los sitios del estudio seleccionados para la investigación eran el parque marina de Negril en Jamaica, y la princesa Alexandra Land y parque nacional del mar en Providenciales, turcos y las islas de Caicos. Los datos socioeconómicos fueron recogidos sobre todo con el uso de un instrumento formal del cuestionario administrado a los grupos de usuario principales. El cuestionario fue utilizado para recoger la información sobre demographics, activos fijos y opiniones de los individuos de los parques marinas. La evaluación ecológica implicó análisis comparativos de los censos bénticos de la estructura, del pilluelo y de los pescados del filón coralino así como comparaciones en los tamaños de las especies comercialmente significativas de los pescados dentro y fuera de los límites de los parques marinas. La evaluación del régimen directivo del MPAs implicó la revisión de las políticas legislativas y de los mecanismos institucionales incorporados en los planes de la gerencia de los sitios del estudio. Los resultados indicaron que mientras que había generalmente un impacto ecológico mínimo, los varios planes de la gerencia de MPA produjeron varios efectos sobre las características sociales y económicas de los grupos de usuario. Para la mayor parte, el parque marina unofficially manejado de Negril alcanza sus objetivos de la gerencia con todo económicos de los objetos expuestos y sociales los impactos mínimos en los tenedores de apuestas concurrentes con las ventajas ecológicas mínimas. La princesa Alexandra Land y el parque nacional del mar que era señalado un área no_ti'sica del uso produjeron impactos relativamente más sociales comparados a los impactos económicos y ecológicos en tenedores de apuestas. Fue concluido que aunque el éxito de un parque marina se puede medir por variables económicas, sociales, ecológicas y directivas, la medida verdadera de éxito miente en encontrar un equilibrio de todas las variables para proporcionar ventajas equitativas a todos los tenedores de apuestas.

PALABRAS CLAVES: Áreas protegidas marinas, impactos ecológicos, prácticas directivas

INTRODUCTION

Within the Caribbean region, Marine Protected Areas (MPAs) have been widely implemented in support of fisheries management, conservation, sustainable resource use, and tourism. However, in a number of cases, implementation has not translated into active management (Geoghegan et al. 2001, Appeldoorn and Lindeman in

press). Furthermore, the typical approach to MPA implementation has revolved around the management and regulation of natural resource consumption with little attention given to the effects of the MPA on the social, cultural and economic concerns of stakeholders (Geoghegan et al. 2001). There are other cases where resource managers have incorporated a panacean approach to MPA implementation, only to fall short in achieving management objectives through weak institutional arrangements (UNEP 1996).

The primary stakeholders of the region's MPAs are typically individuals from coastal communities with small incomes who subsist on local resources. As such, they are likely to be significantly impacted by implementation of MPAs, and their support will be crucial to the long-term success of any MPA. Stakeholder resentment towards MPAs can intensify in cases where stakeholders are unable to perceive or achieve the benefits proclaimed by MPA managers. Consideration of the impacts on low income stakeholders and improvement of MPA design and management to benefit these individuals is therefore considered important to the success of the region's MPAs, yet there is a dearth of information on this subject.

The specific objectives of the studies reported here were to evaluate the impacts of the institutional arrangements and ecological changes within two MPAs (Negril Marine Park in Jamaica, and the Princess Alexandra Land and Sea National Park in the Turks & Caicos Islands) on the socio-economic status of stakeholders. These studies (see Best 2002, Richards 2002, O'Sullivan 2002, and Francis 2002) are summarised and synthesised in this paper and form part of a larger project (DFID #R7976) examining the impact of MPAs on the livelihoods of local communities in the Caribbean.

METHODOLOGY

Data on the institutional arrangements for the MPAs were collected through a review of policies and management plans, a management questionnaire, a user questionnaire administered to persons at each study site, and interviews with persons, other than managers, who may have direct or indirect influence on legislation, policy, or management of the particular MPA. Direct researcher observation at each MPA was also used to reach certain conclusions. Further details are given by Best (2002) and Richards (2002).

Impacts of MPA implementation on the local coral reef ecology were assessed primarily through underwater surveys and comparative analysis of benthic cover data, and urchin and fish abundance inside and outside the boundaries of the MPA. This was supplemented by a stakeholder interview survey to determine their perception of changes to the ecology of the area since implementation of the MPA (see O'Sullivan 2002 for full details).

Data on the current socio-economic status of MPA stakeholders and changes in status as a result of the MPA were collected primarily through the use of a formal questionnaire instrument administered to the principal MPA user groups, as

identified by the MPA managers. The socio-economic assessment was supplemented by data collected through informal discussions with park users, focus group meetings with user groups of the park and researcher observation of activities within the environs of the MPA (see Francis 2002 for more details).

RESULTS

Negril Marine Park

Managerial Status — The Negril Marine Park (NMP), the marine component of the Negril Environmental Protected Area, was formally declared on March 4, 1998 pursuant to section 5 of the Natural Resources Conservation Authority (NRCA) Act of 1991 (enacted April 29, 1991). As stipulated under section 5 of the NRCA Act, the designation of the NMP was on the recommendation of the Authority, after consultation with the Jamaica National Heritage Trust. Pursuant to Section 38 of the NRCA Act, the Natural Resources Conservation (Marine Parks) Regulation was passed in 1992 to provide guidelines to prohibited activities such as disturbance of corals and other marine organisms and artifacts within designated marine parks, including the NMP. The NMP has eight zone designations aimed at controlling fishing, recreational and boating activities. Fishing is not permitted in the narrow Swimming Zone, the coastal strips designated for Non-motorised and for Motorised Craft, the two relatively large Diving Zones, the four Replenishment Zones, the Anchorage Zone and the No-Fly (parasailing) Zone. However, fishing is allowed in the majority of the park area, designated as a Fishing Zone, while recreational activities are not allowed.

The National Environment and Planning Agency serves as the lead agency ultimately responsible for all protected areas but it has the power to delegate functions to any agent. The Negril Coral Reef Preservation Society (NCRPS), an NGO, has been undertaking the day to day management activities of the NMP since its implementation in 1998, although the official instrument of delegation from the Government was only received on October 9, 2002.

The management plan for the NMP supports a number of objectives including *inter alia*: the conservation of resources, information sharing with stakeholders, community participation, and most importantly, enabling the use of the NMP for multiple purposes with minimal damage to the natural resources.

Ecological Status — The survey sites chosen for the benthic analyses at the NMP study site were Top Sandy Cay (inside the park) and Cousin's Cove (outside the park).

Both survey sites were dominated by macroalgae cover, which was found to be higher (36 %) at Top Sandy Cay than at Cousin's Cove (29 %). By contrast, turf algae cover and hard coral cover were significantly lower at Top Sandy Cay than at Cousin's Cove (Table 1).

A large number and high species diversity of fish were found at both survey sites. Furthermore there was no difference in the overall density of fish between the sites (Table 1), and the top four families (Pomacentridae, Labridae, Scaridae, Acanthuridae) were the same for each site.

Urchins were abundant at both sites with mean densities of 179 per 80 m^2 at Top Sandy Cay and 143 per 80 m^2 at Cousin's Cove. Of the dominant species (*Echinometra viridis*, *Diadema antillarum* and *Tripneustes ventricosus*) only the latter varied significantly in abundance between the two sites with highest values at Top Sandy Cay (Table 1).

Results of the interview survey of 40 users on their perceptions of changes in the area since implementation of the MPA revealed consensus with regard to decreased fish abundance and size both within and outside the park, decreased coral cover, increased macroalgae cover and increased urchin abundance.

Socio-economic Status — The principal user groups identified for the socio-economic assessment were watersport operators and fishers. Sample sizes and selected characteristics of these user groups are given in Table 2. Most users had been in their current occupation for a long time (average: 25 years for fishers, 14 years for watersport operators and did not appear to have been displaced from the park area, since their average time in the park was 24 years for fishers and 14 years for watersport operators (Table 2). Furthermore most fishers (77 %) and 25 % of watersport operators identified themselves as traditional users of the park area. Both fishers and watersport operators are highly dependent on the park area for their livelihoods, with most fishers (67 %) and all watersport operators deriving between 75 % and 100 % of their income from their activities in the park (Table 2).

Interestingly the majority of users (83 % of fishers; 75 % of watersport operators) did not see a change of salary with the establishment of the park (Table 3). Just three fishers (10 %) reported a decline in salary, whilst one fisher and 25 % of the watersport operators reported an increase (Table 3). The majority of fishers (63 %) were uncertain of the effect of the park on customer demand, although 33 % of the watersport operators did indicate an increase in customers after the creation of the park.

Qualitative investigations revealed that the fishers considered themselves as being displaced or excluded by the "foreign" hoteliers and watersport operators. Added enmity between watersport operators and fishers is fuelled by the fact that some fishers regard watersport operators as threatening their livelihood by damaging fish traps, while watersport operators blame the fishers for over fishing the marine life. A total of 67 % of fishers and 42 % of watersport operators have experienced intra- and inter-user conflict in the park (Table 3). Of these, the MPA does not assist in resolving conflict according to the majority (90 %) of fishers. This was contrary to the majority (60 %) opinion of watersport operators (Table 3). It was therefore not surprising that only 16 % of all fishers and 42 % of all watersport

operators saw the MPA as an avenue for conflict reduction among user groups (Table 3).

Ultimately, the majority of users supported the need for an MPA in the area (Table 3). Most fishers (60 %) felt that the Negril Marine Park was a successful MPA, in contrast to watersport operators, 75 % of whom felt that it was not. This is interesting, given that the majority of both user groups felt that conservation of resources was the key indicator of MPA success (Table 3). A substantial number of stakeholders were of the opinion that the community was a beneficiary of the Negril Marine Park and most of these believed that there was equal distribution of the benefit throughout the community. Of the few fishers who identified unequal benefit distribution, some identified sectors in the tourist industry as being the chief beneficiaries, with fishers and the general public as lesser beneficiaries. Likewise, watersport operators who saw the park as being unequally beneficial, all felt that the fishers were the lesser beneficiaries while 67 % identified themselves as being the main beneficiaries.

The majority of individuals in both principal user groups were dissatisfied with the current level of management of the park with virtually everyone (93 % of fishers and 100 % of watersport operators) stating that the MPA could serve a more beneficial role to themselves and their community (Table 3). Fishers identified community participation, improved regulations and improved information transfer as target areas. The majority of watersport operators on the other hand saw improved regulations as the greatest need, with improved management and community participation being secondary.

Princess Alexandra Land and Sea National Park

Managerial Status — The Princess Alexandra Land and Sea National Park (PALSNP) in Providenciales was created in 1992 under the National Parks Ordinance CAP 89 of 1975, through the National Parks Order which designated thirty-three protected areas at once. The National Parks Regulations (1992) detail the activities that are banned within the park. These include *inter alia*, the taking of artefacts, the destruction of, or injury to any animal or plant, the removal of sand, rock, coral, coral-rag or any calcareous substance, and anchor damage to coral reef structures whether living or dead. As such the entire MPA is a no-take reserve.

PALSNP is one of three protected areas managed by the Coastal Resources Management Project (CRMP), which started in January of 1999. Up until this time, there had been very little active management. It has a management plan (Homer, 2000) that is neither legally binding nor a part of the Physical Development Plan for Providenciales. According to PALSNP's management plan, the management objectives revolve around the protection of natural and scenic areas stressing the significance of fishery stock management, recreation and "touristic purposes". User activities within the park have been regulated through the designation of specific use zones (Aquatic Sports, Swimming and Training Zones in four locations; Access Zones for boats; a Swimming Zone for swimming and snorkelling only; and a Water-ski Zone for water-skiing, paragliding and similar activities using motorised vehicles)

as permitted under the National Parks Regulations. Under the CRMP, several Park Wardens have been employed, but none of them is legally empowered to enforce the park's regulations.

Ecological Status — The survey sites chosen for the benthic analyses at the PALSNP study site were Sellar's Cut (inside the park) and Fort George Cut (outside the park).

Hard coral cover was relatively high at both sites (Table 1). Significant differences between the survey sites were found for turf algae cover, encrusting coralline algae cover, sand, rock, rugosity index and fish density (which were all lower inside the park), and macroalgae cover (which was higher inside the park), indicating a less healthy reef inside the park (Table 1). Despite a difference in fish density between the two sites, the three top ranking families were the same (Acanthuridae, Haemulidae and Labridae). Urchin densities were low and there were no differences between sites (Table 1).

Results of the interview survey of 22 users on their perceptions of changes in the area since implementation of the MPA revealed consensus with regard to no change in fish abundance, species composition or mean size of fish inside the park, although there has been a decrease in abundance outside. The majority of respondents also felt that coral cover has decreased and macroalgae cover has increased within the park. They were less sure as to the patterns outside the park.

Socio-economic Status — The principal user groups identified for the socio-economic assessment were watersport operators, beach vendors and hoteliers. Sample sizes and selected characteristics of these user groups are given in Table 2. The average length of time in their current occupation for the watersport operators, hoteliers and beach vendors was 14, 16 and 4 years respectively (Table 2). The differences among the user groups are reflected in the observation that no hotelier identified with being a traditional user of the park as compared to 9 % of beach vendors and 26 % of watersport operators. Most users (85 % of watersport operators, 100 % of hoteliers and 91 % of beach vendors) are exclusively dependent on park related activities for income (Table 2).

Interestingly, most users did not identify a change of salary with the establishment of the park (Table 3). Only 30 % of watersport operators and 13 % of hoteliers acknowledged a salary increase since the MPA was established and a small percentage of watersport operators (5 %) reported reduced income. In terms of business expansion, 70 % of water sports operators, 63 % of hoteliers and 80 % of beach vendors recorded no business expansion associated with establishment of the park (Table 3).

Table 1. Summary of key ecological characteristics of coral reef communities at study sites within and outside the Negril Marine Park in Jamaica, and the Princess Alexandra Land and Sea National Park in Providenciales. Significant differences as indicated by Mann-Whitney tests comparing the 10 transect mean values at each site are shown.

MPA	Negril Marine Park				Princess Alexandra Land & Sea National Park			
Mean Community Characteristic	Top Sandy Cay (inside park)	Cousin's Cove (outside park)	Different	Site of greater mean value	Sellar's Cut (inside park)	Ft. George Cut (outside park)	Different	Site of greater mean value
Hard coral cover (%)	8.4	17.6	Yes	Outside park	22.0	20.5	No	
Hard coral diversity index	4.4	3.7	No		2.92	3.64	No	
Macroalgae cover (%)	35.7	28.8	Yes	Inside park	44.1	7.6	Yes	Inside
Turf algae cover (%)	7.7	27.7	Yes	Outside park	17.9	36.5	Yes	Outside
Coralline algae cover (%)	4.9	5.9	No		6.84	21.6	Yes	Outside
Sand cover (%)	26.4	12.6	Yes	Inside park	1.12	5.5	Yes	Outside
Rock cover (%)	6.8	2.67	Yes	Inside park	0	0.6	Yes	Outside
Rugosity index	1.1	1.2	Yes	Inside park	1.07	1.17	Yes	Outside
All fish density (80 m^{-2})	71.1	91.8	No		86.2	127.2	Yes	Outside
Urchin density (80 m^{-2})								
Echinometra viridis	118.5	69.4	No		0.6	0.6	No	
Diadema antillarum	47.4	67.1	No		0.7	1.6	No	
Tripneustes ventricosus	10.1	5.0	Yes	Inside park	0	0.1	No	

Table 2. Summary of selected demographic and economic characteristics of primary user groups of the Negril Marine Park in Jamaica and the Princess Alexandra Land and Sea National Park in Providenciales. N represents the estimated total number of users, n is the interviewed sample size.

MPA	Negril Marine Park		Princess Alexandra Land & Sea National Park		
Characteristic	Fishers [% responses] N ~180, n = 30	Watersport Operators [% responses] N ~14, n = 12	Watersport Operators [% responses] N ~24, n = 20	Hoteliers [% responses] N ~12, n = 8	Beach vendors [% responses] N ~11, n = 11
Mean years in occupation	24.83	13.83	13.5	15.9	4.4
Mean years in park	24.10	13.89	7.8	3.6	5.4
Reason for working in park					
Income	5 [16.7]	2 [16.7]	5 [26.3]	5 [83.3]	5 [45.5]
Tradition	23 [76.7]	3 [25.0]	5 [26.3]	0	1 [9.1]
Interest in conservation	0	3 [25.0]	1 [5.3]	0	0
Other	2 [6.7]	4 [33.3]	8 [42.1]	1 [16.7]	5 [45.5]
Age of respondent					
<30	7 [23.3]	2 [16.7]	5 [25.0]	1 [20.0]	3 [27.3]
30 to 40	7 [23.3]	4 [33.3]	8 [40.0]	1 [20.0]	3 [27.3]
41 to 50	6 [20.0]	4 [33.3]	5 [25.0]	1 [20.0]	2 [18.2]
51 to 60	6 [20.0]	1 [8.3]	2 [10.0]	2 [40.0]	3 [27.3]
>60	4 [13.3]	0	0	0	0
No Answer	0	1 [8.3]	0	0	0
Percent salary from park					
100 %	11 [36.7]	5 [41.7]	17 [85.0]	8 [100.0]	10 [90.9]
75-100 %	9 [30.0]	7 [58.3]	2 [10.0]	0	0
50-75 %	7 [23.3]	0	0	0	0
25-50 %	3 [10]	0	1 [5.0]	0	0
< 25 %	0	0	0	0	1 [9.1]
Level of education					
None	5 [16.7]	0	1 [5.9]	0	3 [42.9]
Primary	12 [40.0]	0	1 [5.9]	0	1 [14.3]
Secondary	13 [43.3]	5 [41.7]	3 [17.6]	1 [50]	1 [14.3]
Tertiary	0	7 [58.3]	12 [70.6]	1 [50]	2 [28.6]

Table 3. Summary of responses to selected questions regarding the impact of the MPA on the livelihood of primary user groups of the Negril Marine Park in Jamaica and the Princess Alexandra Land and Sea National Park in Providenciales.

MPA		Negril Marine Park		Princess Alexandra Land & Sea National Park		
Question	Answer	Fishers [% responses]	Watersport Operators [% responses]	Watersport Operators [% responses]	Hoteliers [% responses]	Beach Vendors [% responses]
Change of salary	Increase	1 [3.3]	3 [25.0]	6 [30.0]	1 [12.5]	0
	Decrease	3 [10.0]	0	1 [5.0]	0	0
	Unchanged	25 [83.3]	9 [75.0]	13 [65.0]	7 [87.5]	9 [90.0]
	Unsure	1 [3.3]	0	0	0	1 [10.0]
Business Expansion	Yes	2 [6.7]	3 [25.0]	6 [30.0]	3 [37.5]	1[10.0]
	No	27 [90.0]	8 [66.7]	14 [70.0]	5 [62.5]	8 [80.0]
	Unsure	1 [3.3]	1 [8.3]	0	0	1[10.0]
Was MPA a good idea	Yes	23 [76.7]	12 [100.0]	20 [100]	8 [100]	6 [60.0]
	No	1 [3.3]	0	0	0	3 [30.0]
	Unsure	6 [20.0]	0	0	0	1 [10.0]
Increased customer demand	Yes	1 [3.3]	4 [33.3]	8 [40.0]	3 [37.5]	4 [36.4]
	No	10 [33.3]	3 [25.0]	11 [55.0]	4 [50.0]	3 [27.3]
	Unsure	19 [63.3]	5 [41.7]	1 [5.0]	1 [12.5]	4 [36.4]
Indicators of MPA success	Conservation	18 [58.1]	10 [62.5]	9 [27.3]	4 [30.8]	3 [25.0]
	More tourists	2 [6.5]	1 [6.3]	0	0	3 [25.0]
	More economic benefits	2 [6.5]	0	2 [6.1]	0	0
	Enforcement	2 [6.5]	2 [12.5]	12 [36.4]	4 [30.8]	1 [8.3]
	Community Participation	0	1 [6.3]	3 [9.1]	1 [7.7]	0
	Research	0	1 [6.3]	1 [3.0]	0	0
	Other	1 [3.2]	1 [6.3]	6 [18.2]	4 [30.8]	5 [41.7]
	Unsure	6 [19.4]	0	0	0	0

Table 3 (continued).

Question	Answer	Fishers [% responses]	Watersport Operators [% responses]	Watersport Operators [% responses]	Hoteliers [% responses]	Beach Vendors [% responses]
MPA is successful	Yes	18 [60]	3 [25]	7 [35.0]	3 [37.5]	5 [45.5]
	No	6 [20.0]	9 [75]	13 [65.0]	5 [62.5]	3 [27.3]
	Unsure	6 [20.0]	0	0	0	3 [27.3]
MPA benefits community	Yes	20 [66.7]	7 [58.3]	19 [95.0]	8 [100.0]	6 [54.5]
	No	10 [33.3]	5 [41.7]	1 [5.0]	0	3 [27.3]
	Unsure	0	0	0	0	2 [18.2]
Community benefit distribution	Equally	17 [81.0]	4 [50.0]	10 [52.6]	7 [87.5]	6 [100.0]
	Unequally	4 [19.0]	3 [37.5]	9 [47.4]	1 [12.5]	0
	Unsure	0	1 [8.3]	0	0	0
Incidence of conflict	Yes	20 [66.7]	5 [41.7]	6 [30.0]	4 [50.0]	4 [36.4]
	No	10 [33.3]	7 [58.3]	14 [70.0]	4 [50.0]	7 [63.6]
Conflicting group	Fishers	10 [50.0]	5 [100.0]	4 [66.7]	0	0
	Divers	8 [40.0]	0	0	1 [20.0]	0
	Recreational users	1 [5.0]	0	1 [16.7]	0	0
	Other	1 [5.0]	0	1 [16.7]	4 [80.0]	4 [100.0]
MPA assists in conflict resolution	Yes	2 [10.0]	3 [60.0]	1 [20.0]	2 [50.0]	1 [25.0]
	No	18 [90.0]	2 [40.0]	4 [80.0]	2 [50.0]	3 [75.0]
MPA effect on conflict	Reduce	5 [16.7]	5 [41.7]	2 [10.0]	1 [12.5]	1 [9.1]
	Increase	0	0	4 [20.0]	1[12.5]	0
	No difference	24 [80.0]	7 [58.3]	14 [70.0]	5 [62.5]	7 [63.6]
	Unsure	1 [3.3]	0	0	1[12.5]	3 [27.3]
Satisfaction with MPA management	Yes	13 [43.3]	4 [33.3]	7 [35.0]	2 [25.0]	4 [36.4]
	No	16 [53.3]	8 [66.7]	13 [65.0]	6 [75.0]	6 [54.5]
	Unsure	1 [3.3]	0	0	0	1 [9.1]

Conflict within the park was experienced by 30 % of water sports operators, 50 % of hoteliers and 36 % of beach vendors. The major conflicting group for the watersport operators was the illegal fishers who accounted for the conflict experienced by 67 % of watersport operators. Hoteliers (40 %) reported conflict with beach vendors and watersport operators and 20 % of hoteliers had conflict with divers. For beach vendors, all cases of conflict involved other vendors. Conflict resolution was attained by 20 % of water sports operators, 50 % of hoteliers and 25 % of beach vendors. The consensus among respondents (70 % of watersport operators, 63 % of hoteliers and 64 % of beach vendors) was that the MPA had minimal effect on the level of conflict (Table 3). Conversely, 10 % of watersport operators, 13 % of hoteliers and 9 % of beach vendors saw the MPA as an avenue for conflict reduction among user groups.

Interestingly every watersport operator, every hotelier and 60 % of beach vendors supported the need for an MPA in the vicinity. However most watersport operators (65 %) and hoteliers (63 %) reported that the PALSNP was not a successful MPA, in contrast with the majority of beach vendors (45 %) who thought that it was a success (Table 3). This may be because the former groups judged success primarily on enforcement, whereas the vendors had other criteria (Table 3).

Interestingly, a large number of stakeholders (95 % of watersport operators, 100 % of hoteliers and 55 % of beach vendors) see the community as a beneficiary of the MPA. Of the respondents who associated the MPA with a benefit to the community, 53 % of watersport operators, 86 % of hoteliers and 100 % of beach vendors see the benefit distribution as being equal. Of the watersport operators who saw unequal benefit distribution, the tourism related industries (e.g. watersport operators and hotels) were identified as the main beneficiaries, whilst 89 % of watersport operators identified fishers and locals as the lesser beneficiaries. Locals were also identified by 100 % of the hoteliers as the least benefiting from the park, whereas 100 % of hoteliers responded that hotels were the main beneficiaries of the MPA.

The majority of individuals (65 % of water sports operators, 75 % of hoteliers and 55 % of beach vendors) were dissatisfied with the management of the Park. To facilitate improved park management, watersport operators identified improved regulations (46 %), improved management (32 %) and improved community participation (14 %) as being crucial. The hoteliers identified improved community participation (40 %), improved regulations (30 %), and improved information transfer (20 %) as essential elements of park improvement. The beach vendors identified improved facilities (27 %), improved information transfer (18 %), improved regulations (18 %), and improved community participation (18 %) as vital target areas for the Park authority. Virtually everyone (100 % of watersport operators, 100 % of hoteliers and 82 % of beach vendors) was of the opinion that the MPA could serve a more beneficial role to themselves and their community.

DISCUSSION

The Negril Marine Park

The majority of primary users are dependent on the MPA for their income. As such there is great potential for the MPA to have significant positive or negative effects on the stakeholders' economic standing.

Importantly, the majority of stakeholders support the need for an MPA, and most fishers and some watersport operators feel that the NMP is a successful MPA. A substantial number of stakeholders are also of the opinion that the community has benefited from the implementation of the NMP. Interestingly more detailed questioning revealed only a slight economic impact on the primary user groups. Fishers report minimal change in terms of business expansion, income or customer demand. It is no wonder then that the majority of them perceive negligible economic benefits ensuing from NMP's establishment. Watersport operators experienced some increases in these same areas, but the overall economic impact of the park is still relatively low.

The lack of positive economic impacts of the MPA on stakeholders emanating from changes in the ecology of the area is not surprising given lack of evidence of improvement within the park. In fact the reef site inside the park appears to be less healthy than the site outside the park (less hard coral, more macroalgae) and may have deteriorated because of tourism infrastructure development and heavier use associated with the park. Furthermore, fish densities appear to be no different within and outside the park, again not surprisingly since fishing (albeit under stricter management than outside) is allowed within a large area of the park.

The fact that very few stakeholders have suffered negative economic impacts is significant, and no doubt helps to explain their general support for the MPA, and their desire for improved management, particularly improvements to the implementation of regulations.

The current legislative status and institutional arrangement for management is constraining the effectiveness of the NMP as a conservation tool. For example, although the NMP was established in response to declining ecological conditions, the development plans advocated by the Urban Development Corporation can sometimes be entirely contrary to the principles of the NMP's management plan. Since the NCRPS is forced to accede to the UDC, this can lead to deleterious effects on the potentially positive ecological impacts of the NMP.

Another area for concern is stakeholder conflict. The social distinctiveness of each user group (as indicated by average level of education, length of time in occupation *inter alia*) plays a great role in their perceptions. There are also at least some stakeholders who believe that there is social inequity in the distribution of benefits emanating from the NMP and there are fishers who feel disenfranchised and displaced by 'foreign' hoteliers and watersport operators. These factors could evolve into greater hostility among user groups as well as towards the MPA, as the existence of the MPA potentially represents a change in the traditional system of

fishing practices and by extension the culture of the area. Therefore the MPA has a potentially important role to play in facilitating conflict resolution. Although stakeholders report little change in the level of conflict as a result of the NMP, they also report that the NMP has played a minimal role in conflict resolution to date.

The Princess Alexandra Land and Sea National Park

Most of the primary users are exclusively dependent on MPA related activities for their income, making them socially and economically vulnerable to changes within the MPA. The PALSNP appears to have had a degree of impact on the economic status of the primary users, with some watersport operators and hoteliers reporting improvements. However, the majority of stakeholders report no change. Of special interest is the significant number of reports on increased customer demand and business expansion, tempered by minimal reports of increased income. The disparity may be attributed to strategic bias affecting the individuals' responses. It is possible that the critical attitude of stakeholders towards the PALSNP translated into responses aimed at detracting from any direct economic benefits of the park. However, the lack of any real economic gains may also be a reflection of the all-inclusive tourism that could prevent access to benefits by the primary user groups.

The ecological evaluation suggests that the unprotected survey site is healthier than the protected one. Several factors may have contributed to this outcome including *inter alia*, ongoing tourism infrastructure development and the inability of the park wardens to enforce conservation efforts. However, the consensus opinion that fish populations have not changed in the park, whilst they have continued to decline outside the park, indicates that the PALSNP is perhaps having a positive effect, which could be attributed to its no-take status. Dramatic improvements are not expected given that active management has only been in place since 1999.

PALSNP has not significantly affected the level of conflict among the park's user groups, though a few respondents suggested a post MPA increase. For the most part, individuals did not see the MPA as a means of reducing the level of conflict within the park, a factor of particular importance because one stated objective of the PALSNP management plan is conflict control and reduction.

Importantly, the need for a MPA has wide support among stakeholders, and most stakeholders see some community benefits accruing from the MPA. This perception was shared more so by the watersport operators than by vendors. A small number of users perceived unequal benefit distribution amongst the community, opining that the tourism industry was benefiting at the expense of the fishers, locals and non-tourist-based businesses. The fishers and locals appear to be the most disadvantaged because all consumptive use is prohibited in the park, setting the tone for future conflict between the different classes of stakeholders.

Few users regard the MPA as successful, and this can be directly correlated to the high numbers of users who were dissatisfied with how the park was managed. Indeed, the dissident watersport operators and hoteliers attributed the management shortcomings to an ineffectual regulatory framework. On the other hand the dissatisfied vendors were vociferous in denouncing the existing system of

discrimination whereby "tourists can break the rules with impunity", a system that perpetuates the belief that the MPA exists primarily for tourists. Thus, in terms of social, economic, ecological, and management variables, PALSNP still has a long road ahead before it reaches a state where it is seen to be benefiting stakeholders equitably.

Commonalities

From the outset it would appear that the NMP and the PALSNP are dissimilar: the NMP is managed by an NGO, with stakeholder participation, whereas the PALSNP, which is government run, was established without stakeholder input and for the most part continues to operate in this way. Yet a close evaluation shows that the two MPAs are not so different.

With both MPAs the primary users are highly dependent on the parks for their income with the majority of users deriving their income solely from their park activities. Both MPAs are therefore in a position to dramatically alter the socio-economic well being of their stakeholders. However, only a minority of users in both cases report any positive or negative economic impacts from the MPA, and the majority report no difference.

Both MPAs have been established at least in part to conserve the marine ecology of the area, and yet in neither case has there been any marked improvement. In fact there has possibly been deterioration, particularly of coral reefs within the park boundaries. This highlights the fact that MPA management in the absence of integrated coastal zone management will not be able to control sources of pollution outside the park boundaries with deterioration of water quality and habitat more than likely. Neither the CRMP nor the NCRPS has a say in development planning. Therefore development could occur to the detriment of both the PALSNP and the NMP, putting them in a position where they are unable to achieve stated conservation objectives.

Both MPAs have some level of user conflict, with an inherent juxtaposition of the disenfranchised fishers and vendors on the one hand, and the watersport operators and the tourism industry on the other. Although the NMP is managed by an NGO, many of its users would argue that all stakeholders do not benefit equally nor have the same voice in how the park is managed. This is similar to the PALSNP. In both cases the traditional uses of the park seem threatened, indicating the potential for cultural dissipation. Both parks are likely to experience increasing levels of user conflict, particularly when it seems as if those at the lower echelons of society will continue to be disadvantaged in favour of the perceived upper class and tourists.

What is abundantly clear is that although the success of an MPA can be measured by economic, social, ecological, and management variables, the true measure of success lies in finding a balance of all variables, to provide equitable benefits among all stakeholders which will ensure sustainability of the MPA.

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La Pesca en Quintana Roo, México

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RESUMEN

México ocupa el décimo séptimo lugar entre los 30 principales países productores de productos pesqueros con un registro de captura promedio de 1.3 millones de toneladas anuales, lo cual ha sido privilegiado con el esfuerzo de pescadores, industriales y diversos agentes que inciden en la actividad.

Parte de este esfuerzo se genera en Quintana Roo, en dónde la pesca tradicionalmente se ha orientado a la captura de especies de alto valor comercial como son la langosta, camarón y caracol, sin embargo, debido a la creciente demanda en la producción de alimentos, en especial los destinados a satisfacer las necesidades de las mayorías, la producción de especies de escama ha tomado paulatinamente especial relevancia aunque los volúmenes de captura no han cubierto la importancia que debiera tener en función del potencial pesquero y de la gran diversidad de especies que existen en el litoral Quintanarroense.

No obstante lo anterior en los últimos años como consecuencia de un reflejo natural del crecimiento explosivo de la población estatal generada por el auge del turismo, la pesca se ha intensificado incrementándose el número de organizaciones sociales y pescadores independientes con lo cual destaca como una de las actividades productivas con mayores perspectivas de desarrollo en la entidad. Dentro del contexto nacional, en materia de producción, Quintana Roo se encuentra ubicado en el lugar número 20 aportando el 0.37% del total de la producción generada en el país. Si bien, dentro de los estados con litoral, en este renglón, su representatividad no es tan importante, si lo es en su aportación en el valor global de la producción dado que en nuestras aguas se explotan pesquerías comerciales de gran importancia económica como son la langosta, camarón y caracol y especies finas de escama en las cuales se sustenta la economía pesquera del estado.

PALABRAS CLAVES: Pesca tradicionalmente, Quintana Roo, México

Status of the Fishing Industry in Quintana Roo, Mexico

Mexico occupies the seventeenth place between the 30 main seafood producing countries with a capture average of 1,3 million tons annually, due to the effort of fishermen, industrialists, and diverse agents who affect the activity. Part of this effort is generated in Quintana Roo, where the fishing traditionally has been oriented to the capture of species of high commercial value such as lobster, shrimp and conch. Nevertheless, due to the increasing demand in food production, landings of less valued species have not kept pace with demand along the coast of Quintana Roo, Mexico. In recent years increasing population and an explosion in tourism has

resulted in intensified fishing effort and an increase in the number of independent social and fishing organizations. Within the national context, in the matter of production, Quintana Roo is located in the place number 20 contributing the 0,37% of the total of the production generated in the country. Although, within the states with the coast, in this line, its representativeness is not so important, if it is it in his contribution in the global value of the production since in our commercial waters they operate fisheries of great economic importance.

KEY WORDS: Traditional fisheries, Quintana Roo, Mexico

INTRODUCCIÓN

Los primeros pobladores que habitaron el Territorio Mexicano desarrollaron labores de pesca, principalmente aquellos cuya residencia fue en los litorales, sin embargo las comunidades indígenas del interior, cuya vida transcurría cercana a los lagos y ríos también emprendieron la pesca como una práctica cotidiana.

En el México del 2002 los mares aún mantienen su importancia no solo por su extensión, sino por la diversa gama de recursos que ofrecen sus aguas, entre los que destacan los pesqueros. Desde el punto de vista alimentario las especies marinas son de las más importantes fuentes de proteína para la población, además su aprovechamiento incide en gran medida en la promoción del desarrollo regional y genera gran impacto en amplios sectores de la economía nacional, es menester considerar que la pesca como tal, es finita por tanto el ordenamiento y regulación de la actividad es uno de los puntos medulares para su fortalecimiento

En Quintana Roo, México , la pesca tradicionalmente se ha orientado a la captura de especies de alto valor comercial como son la Langosta, el Camarón y el Caracol, sin embargo, debido a la creciente demanda en la producción de alimentos, en especial los destinados a satisfacer las necesidades de las mayorías, la producción de especies de escama ha ido tomando especial relevancia aunque los volúmenes de captura no cubren la demanda debido a los requerimientos del sector turismo en el norte del estado.

En los últimos años como consecuencia de un reflejo natural del crecimiento explosivo de la población estatal generado por el auge del turismo, la pesca se ha intensificado incrementándose el número de organizaciones sociales y pescadores privados con lo cual destaca como una de las actividades productivas de importancia para la entidad.

Como es del conocimiento público la regulación para el aprovechamiento de los recursos pesqueros corresponde al Gobierno Federal, por conducto de la Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación que a su vez cuenta con la Comisión Nacional de Acuacultura y Pesca (CONAPESCA) para ejecutar la política en materia de pesca y acuacultura y verificar su cumplimiento.

MARCO DE REFERENCIA

El estado de Quintana Roo ocupa la porción Oriental de la Península de Yucatán, contando con una superficie territorial de 50,843 kilómetros cuadrados. Limita al norte con el Golfo de México; al este con el Mar Caribe; al sur con el País de Belice, la Republica de Guatemala y el estado de Campeche; al oeste con esta última entidad federativa y el estado de Yucatán, teniendo una ubicación especialmente importante como puerta nacional de acceso a la cuenca del Caribe, estando constituido políticamente por ocho municipios, de los cuales 7 son costeros.

Desde el punto de vista pesquero el Estado de Quintana Roo cuenta con 40 kilómetros de litoral en el Golfo de México y 860 en el Mar Caribe; posee 21,000 kilómetros cuadrados de plataforma continental, 87,300 hectáreas de Bahías, Esteros y Lagunas y 84,000 hectáreas de cuerpos de agua en la parte continental, contando además con cuatro Islas, Los Bancos de Arrow Smith y Chinchorro en el Mar Territorial y la formación arrecifal que corre a todo lo largo del litoral del Mar Caribe.

La actividad pesquera del Estado se sustenta en cuatro áreas geográficas importantes:

i) *Litoral del Golfo de México* — Abarca la zona costera que va de los límites con el Estado de Yucatán a Cabo Catoche; quedando dentro de esta área la Isla de Holbox y la laguna estuarina de Yalahau.
ii) *Litoral Caribe Norte* — Comprende entre la Isla de Contoy y el límite Sur del municipio de Benito Juárez abarcando Isla Mujeres y la Laguna Estuarina de Chacmuchuch.
iii) *Litoral Caribe Centro* — Corresponde a los municipios de Cozumel, Solidaridad y Felipe Carrillo Puerto, ubicándose dentro de estos las Bahías de la Ascensión y del Espíritu Santo y el conjunto lagunar de Chunyaxché; destacándose éste por encontrarse dentro de la Reserva de la Biosfera de Sian Ka'an.
iv) *Litoral Caribe Sur* — Delimitada al Norte por el municipio de Felipe Carrillo Puerto del cual se incluye una porción y al Sur por la frontera con Belice, incluyéndose en esta última a la Bahía de Chetumal y desembocadura del Río Hondo.

En este marco geográfico se ubican asentamientos pesqueros de tipo urbano en: Puerto Juárez, Isla Mujeres, Playa del Carmen Tulúm y Cozumel; suburbanos como es el caso de Puerto Morelos, así como diversas comunidades rurales ubicadas a lo largo de la costa, tales como: Holbox, Chiquilá, Vigía Chico, Punta Herrero, Mahahual e Xcalak.

Cada una de estas áreas costeras guardan particularidades ecológicas que las diferencian entre si y es en este marco donde las actividades de captura se llevan a cabo en nuestro Estado.

POBLACIÓN PESQUERA

El máximo de sociedades cooperativas y permisionarios privados se localiza en el Litoral del Golfo de México, Caribe Norte y Caribe Centro del Estado en el cual se encuentran 21 de las 26 organizaciones registradas, lo que representa el 80% de este total. Las otras 5 restantes se asientan en el litoral sur, en los municipios de Felipe Carrillo Puerto y Othón Pompeyo Blanco. Esta polarización del sector se da en virtud de que en la región antes señalada las aguas son de mayor productividad y por otra parte, se dispone de la infraestructura básica para la actividad; menor porcentaje existe en la zona sur del Estado.

FLOTA

La flota pesquera en la Entidad está representada por 46 embarcaciones mayores de las cuales 20 son camaroneras y 28 escameras de mediana altura, 17 unidades de mediano porte utilizadas para transporte de producto y avituallamiento, así como 791 embarcaciones menores, estas últimas efectúan la pesca de ribera que en su mayoría son de 25 píes de eslora cuya actividad genera el 75% de la producción en el Estado.

En los últimos 7 años, la flota pesquera no ha tenido un incremento significativo toda vez que únicamente se ha dado un proceso de reposición de las unidades deterioradas.

De 1994 a la fecha se ha restringido la incorporación de más embarcaciones al esfuerzo pesquero del Estado.

ARTES Y EQUIPOS DE PESCA

Tradicionalmente la captura de caracol y langosta se ha realizado por buceo, ya sea a pulmón, tanques de aire comprimido o con compresoras, técnica muy arraigada en todo el estado, algunas cooperativas han incorporado las trampas, sombras o casitas cubanas y redes agalleras para la captura del crustáceo. No obstante lo anterior, la gran mayoría de los pescadores jóvenes continúan con el buceo.

Existe un especial control en las redes especializadas para la captura de camarón, a fin de no afectar otras especies durante las labores como es el caso de la tortuga marina para lo cual es de carácter obligatorio la instalación de excluidores en dichas redes especialmente diseñados para la protección del quelonio.

Para el caso de la escama, tiburón, pulpo y otras especies, generalmente se utilizan redes agalleras, palangres, jimbas, trampas de atajo, cobra líneas, líneas de mano, atarrayas, etc.

El registro total actual es de 35,551 artes y equipos de pesca en todo el Estado

INDUSTRIA PESQUERA

Actualmente la Entidad cuenta con 10 establecimientos entre los más importantes cuya actividad está enfocada al manejo de productos pesqueros. Del

total de empresas existentes 6 son consideradas como plantas industriales y 10 están clasificadas como comercializadoras.

En la etapa de transformación industrial se estima la participación de 350 personas ocupadas en el proceso productivo y en puestos administrativos.

La industria pesquera existente en el Estado se ha contraído, su capacidad instalada es mayor en algunos casos a su capacidad aprovechada y sus equipos han sido modernizados parcialmente, debido a los altos costos de sus fuentes de financiamiento y en la transformación de la materia prima aún emplean procesos productivos tradicionales.

PRODUCCIÓN

Quintana Roo, se encuentra ubicado en el lugar número 20 (aportando el 0.37%) del total de la producción generada en el País, con un promedio de 4,500 toneladas (Tabla 1). Si bien, dentro de los Estados con Litoral, en este renglón, su participación es menor, su aportación al valor global de la producción es importante dado que en nuestras aguas se explotan pesquerías comerciales de alto valor económico como lo son la langosta, el camarón, el caracol y especies finas de escama en las cuales se sustenta la economía pesquera del Estado con alrededor de 123 millones de pesos.

Existe una visión clara de la situación en que se encuentran las pesquerías en la entidad, por un lado la escama que presenta posibilidad de incrementar sus niveles de aprovechamiento y por otro, aquellas cuya explotación se encuentra en su máximo rendimiento como el caracol, el camarón y la langosta en las cuales se procura mantener los índices de producción alcanzados en los últimos años.

Caracol

En cuanto a este recurso, participan fundamentalmente tres sociedades cooperativas en la zona Sur del Estado y una Organización Social en el banco de Cozumel de acuerdo con el esfuerzo máximo aplicable.

Para el aprovechamiento de esta especie, se ha observado el régimen de captura por medio de cuotas mensuales manteniéndose un volumen a peso desembarcado de 30 toneladas en el Banco Chinchorro y 12 toneladas en Cozumel con base en la opinión técnica emitida por el Centro Regional de Investigaciones Pesqueras.

Langosta

Langosta representa un recurso importante para la pesca artesanal que se realiza a lo largo de la Península de Yucatán, además de constituirse en una de las principales pesquerías que por su alto valor juega un papel importante en la economía del Sector Pesquero Estatal y Regional. Los volúmenes de captura registrados en los últimos años oscilan entre las 300 y 350 toneladas a peso vivo, cifra que tiende a una estabilización en los índices de aprovechamiento del crustáceo.

El Instituto Nacional de la Pesca trabaja en la elaboración del **Plan de Manejo Pesquero** en la Península de Yucatán para el período 2003-2008

Camarón

Respecto al camarón, no obstante las medidas de regulación que se han establecido a partir de 1995, este ha tenido un notable descenso en los últimos 6 años acusando una marcada declinación en 1997 y 1998 con una caída en la producción del 60% respecto a 1996. En 1999 la producción se recupera notablemente con un registro de 670 toneladas, 120% superior a 1998, en el 2000 disminuye nuevamente en un 31% respecto al año anterior, en 2001 se registra una moderada recuperación, sin embargo, la pesquería aun no alcanza los niveles de aprovechamiento de años anteriores cuyos volúmenes oscilaban entre las 1,200 y 1,400 toneladas anuales, el Instituto Nacional de la Pesca lleva a cabo los estudios correspondientes a efecto que se disponga de mayor información científica incorporándola a la norma oficial respectiva, que se analiza y actualiza anualmente con los agentes involucrados.

Tiburón

Tiburón en los últimos tres años la producción ha tenido un notable incremento con un volumen promedio anual de 300 toneladas, registrándose una cifra record para el estado de 431 toneladas en 1999. No obstante lo anterior, esta pesquería es de las menos desarrolladas en el Estado, considerada como complementaria de las otras, de allí que los volúmenes de captura sean moderados en relación a las demás pesquerías que se explotan en la entidad. Cabe destacar que de 1992 a 1997 no se había dado un crecimiento en los volúmenes de captura, lo cual significa que las medidas de restricción en cuanto al otorgamiento de permisos y limitar el crecimiento del esfuerzo pesquero establecido al principio de este período, ha favorecido la recuperación del recurso, sin embargo, de acuerdo con la Norma Oficial que regula esta pesquería, estas restricciones deberán continuar de manera indefinida.

Escama

Escama se ha mantenido estable en los últimos 6 años con un registro promedio de captura entre 2500 y 3000 toneladas. A pesar de que no ha sufrido bajas importantes en los volúmenes, tampoco ha mantenido un crecimiento fuerte, lo cual refleja un desarrollo moderado. Entre las principales especies de escama producidas en la entidad sobresalen el abadejo, boquinete, coronado, chacchi, guachinango, mojarra, pargo, picuda, robalo y mero que en conjunto representan el 77% de la producción de escama; Siendo este último el de mayor aportación, representando el 43% del volumen global de este grupo de especies y el 33% del total de escama producido en el Estado.

Tabla 1. Producción por principales especies. Toneladas a peso vivo 1995-2001

ESPECIES	1995	1996	1997	1998	1999	2000	2001
Camarón	1,214	810	318	304	670	458	525
Caracol	315	328	414	308	294	298	266
Langosta	505	450	392	307	354	350	340
Tiburón	134	156	136	242	431	315	136
Escama	3,038	3,026	3,270	2,486	2,595	2,427	2,008
Producción sin Registro oficial	712	638	787	570	546	556	459
Uso industrial	15	28	27	52	37	44	47
Total	5,933	5,436	5,344	4,269	4,927	4,448	3,781

Peso Desembarcado

Se refiere al que conserva el producto al ser declarado en sus diversas modalidades; descabezado, fileteado, eviscerado, en pulpa, y otras.

Peso Vivo

Peso total del producto en el momento de obtenerse de su medio natural; se determina con base en el peso desembarcado, aplicando factores de conversión establecidos por el Instituto Nacional de la Pesca de acuerdo a la metodología universalmente empleada por la FAO.

Inspección y Vigilancia

Uno de los aspectos fundamentales en la preservación de los recursos es la inspección y vigilancia. Poco efecto tienen los programas de investigación y normas de aprovechamiento si estos no se garantizan con acciones específicas y enérgicas.

COMPROMISOS Y ACCIONES

Inspección y Vigilancia Pesquera (Enero – octubre de 2002)

Se han realizado un total de 117 acciones, mediante 47 operativos, de los cuales 30 fueron terrestres y 17 marinos, 1 punto de revisión y 69 visitas de verificación física y documental de legal procedencia a plantas industriales, productores, comerciantes, vehículos y embarcaciones que capturaban o transportaban productos pesqueros.

Quintana Roo

Total de Actas levantadas = 72

Actas solventadas = 54

Actas en proceso jurídico = 18

Retenciones Provisionales

Se han retenido productos marinos con un volumen de alrededor de 800 kilogramos de especies de alto valor comercial como la langosta y el caracol.

Los bienes retenidos alcanzan un valor aproximado a los 950 mil pesos que consisten básicamente en vehículos marítimos y terrestres, equipos y accesorios de pesca.

Se ha modificado el Código Penal Federal, con sanciones más fuertes

Existe pena de 1 a 9 años de prisión a quien posea, transporte, almacene, capture o comercialice especies en veda, se incrementa a 12 años si el delito se comete en un Área Natural Protegida y se convierte en pena grave sin fianza.

PERSPECTIVAS 2003

i) Fortalecer la Investigación.
ii) Seguimiento las pesquerías regionales.
iii) Vigilar de manera estricta el cumplimiento de las vedas, y se observen las disposiciones legales aplicables.
iv) Impulsar investigación especializada para eficientar la producción acuícola.
v) Mantener y regular la población y flota pesquera, a efecto de evitar una explotación inadecuada de las especies marinas.
vi) Capacitar a los pescadores para un mejor aprovechamiento de los recursos pesqueros.
vii) Promover y gestionar infraestructura pesquera y portuaria que permita mayor seguridad a nuestra flota y facilitar las tareas de avituallamiento.
viii) Promover con los estados y los municipios la Pesca deportivo-recreativa en especial la de liberación como fuente de ingresos y divisas

En la conservación y aprovechamiento sustentable de los recursos pesqueros es necesario pasar de las buenas intenciones a las acciones, traducir en políticas públicas la investigación con los componentes social y económico.

A Description of Fisheries Management in the Turks and Caicos Islands: An Overview of the Problems and Suggestions for Mitigation

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ABSTRACT

Fisheries management is a highly complex and emotive issue in virtually every country in the world. This paper uses the Turks and Caicos Islands and its fisheries as a case study to highlight some of the issues that face fisheries managers though out the Caribbean. The Turks and Caicos Islands fisheries are dominated by free divers collecting Caribbean Spiny Lobster (*Panularis argus*) and Queen Conch (*Strombus gigas*), additionally there are several boats deploying lobster pots and fish traps. There is no significant commercial pressure on the scale-fish stocks, which make the TCI almost unique in the Caribbean, and there are only several commercial game fishing operations at present within the TCI. Overfishing of the lobster and conch populations is a major concern of the Department of Environment and Coastal Resources (DECR) tasked with managing the natural resources of the TCI.

In order for the DECR to meet these challenges, the implementation of several measure are key. These include:

i) The removal of lobster from restaurant and hotel menus during the closed season;
ii) A reduction in the number of foreign fishermen;
iii) Banning of the hook used to catch crawfish;
iv) Development of a method to detect the use of noxious substances used to catch crawfish.

In order for these actions to be implemented, the DECR requires strong political support which needs to be fostered through a comprehensive environmental education program aimed at policy makers, fishermen and the general public. This is especially important because rapid development of the TCI is stretching the resources and capability of the DECR to fulfill its requirements. The rapid growth of the TCI's economy is worrisome for the environment as it is easy to lose sight of the value and importance of the environment both economically in a country where the tag line is "beautiful by nature" and socially where entire communities are dependent upon the viability of the marine resources for there livelihood. Development needs to occur but at a pace where appropriate importance is placed on the natural environment. The TCI is at a crossroads right now because its fisheries are currently in decline but are still among the healthiest in the Caribbean.

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If the TCI does not learn from other Caribbean nations that have already been through a similar rapid development and economic growth phase, then the future of the fisheries resources looks bleak.

KEY WORDS: Conch, fishermen, fisheries management, lobster

Una Descripción del Manejo de las Industrias Pesqueras en Islas Turcos y las Islas de Caicos: Una Descripción de los Problemas y de las Sugerencias para la Mitigación

La Administración de las industrias pesqueras es un asunto altamente complejo y muy emotivo en virtualmente cualquier país del mundo. Este trabajo utiliza a las islas turcos y las islas de Caicos (TCI)y sus industrias pesqueras como caso de estudio para destacar algunas de los asuntos que enfrentan los administradores de los recursos pesqueros a través del Caribe. Las pesquerías de las islas Turcos y Caicos esta dominada por buceadores a pulmón libre los cuales captura la langosta espinosa del Caribe (*Panularis argus*) y el caracol reina (*Strombus gigas*), y además hay varios barcos que pescan con nasas de peces y langosta. No existe una presión comercial significativa en la pesquería de peces lo que hacen al TCI un caso único en el Caribe. Sin embargo la sobre pesca de las poblaciones de la langosta y del caracol es una preocupación muy grande para el Departamento del Ambiente y de los Recursos Costeros (DECR) encargados del manejo de los recursos naturales del TCI.

En la orden para que el DECR resuelva estos desafíos, la puesta en práctica de varias medidas es fundamental. Éstos incluyen:

i) El retiro de la langosta de menús de restaurantes y del hoteles durante la temporada de veda;

ii) Una reducción en el número de pescadores extranjeros;

iii) La prohibición del anzuelo de capturar langosta;

iv) El desarrollo de un método para detectar el uso de sustancias nocivas para capturar langosta.

Para que estas practicas puedan ser implementadas el DECR requiere de una fuerte ayuda política que debe ser fomentado a través de un programa de educación ambiental comprensivo dirigido a políticos, pescadores y al publico en general. Esto es especialmente importante porque el desarrollo rápido del TCI está estirando los recursos y la capacidad del DECR para cumplir con sus obligaciones. El crecimiento rápido de la economía de TCI es preocupante para el ambiente pues es fácil perder de vista el valor y la importancia del ambiente desde el punto de vista económico y social, especialmente en un país donde su emblema es "bello por naturaleza" y que depende de los recursos marinos para su sustento. El desarrollo necesita ocurrir pero a un paso donde se le de la importancia apropiada al medio ambiente natural. El TCI está en una encrucijada ahora porque sus industrias pesqueras están actualmente en declinación pero todavía está entre los más sano del Caribe. Si el TCI no aprende de

otras naciones del Caribe que han pasado por una fase similar de rápido desarrollo y crecimiento económico, entonces el futuro de los recursos pesqueros de nuestro país parece muy oscuro.

PALABRAS CLAVES: Langosta, caracol, pesquerias, manejo de pesquerias

INTRODUCTION

The Turks and Caicos Islands are an archipelagic overseas territory of the United Kingdom located in the British West Indies (Figure 1) (Sadler 1997). Scale-fish are caught for subsistence usage as a by-product of the principle commercial fisheries of lobster and conch (Clerveaux 2001c).

The effective management of any fishery relies upon the application of restrictions based on the life histories, location and abundance of target species and considerations regarding the number and efficiency of fishermen operating in the fishery. An understanding of the political, social and economic environment that the fishery operates in is also important (Jennings 2001, King 1995). This paper uses the fishery of the Turks and Caicos Islands to highlight some of the problems facing fisheries managers and suggests some solutions that may be acted upon to ensure the continued existence of a viable fishery in the TCI.

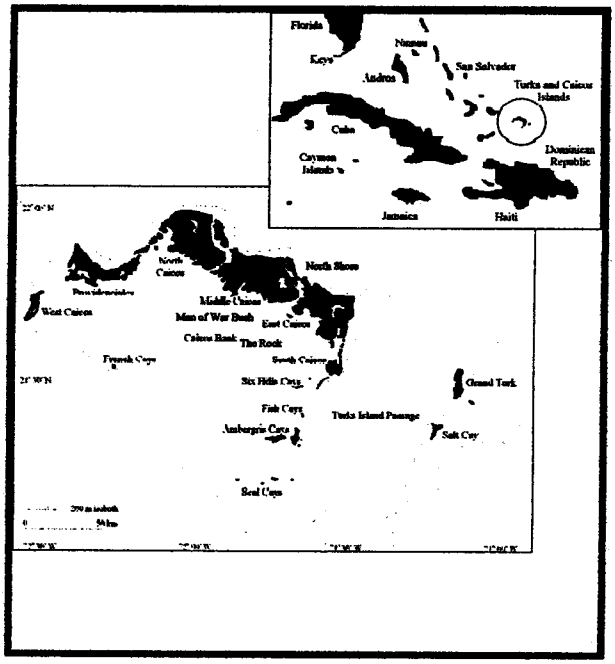

Figure 1. The location of the Turks and Caicos Islands in the British West Indies

RESPONSIBILITY OF THE FISHERY

The Ministry for Natural Resources controls the management of the fisheries by delegating day to day responsibility to the Department of Environment and Coastal Resources, encompassing the Fisheries Department (FD) and the Protected Areas Department (PAD). There are three DECR offices throughout the islands (Grand Turk, South Caicos, and Providenciales) at which Fisheries Officers operate and a National Environmental Center on Providenciales at which the PAD is based. The Director of the DECR is based on Grand Turk (the governmental administrative center) whereas the Chief Fisheries Officer is based on South Caicos (the fishing capital) (Bennett 2000). Both Fisheries Officers and Protected Area Officers have extensive law enforcement powers. Police Officers and members of Her Majesties Navy are also conferred the powers of Fisheries Officers. There is a Marine Branch of the Royal Turks and Caicos Islands Police Force (RTCIPF) that assists in Fisheries Enforcement with personnel (armed support), a spotter aircraft and offshore capable vessels (Table 1). The Environmental Health Department is involved in the management of the fishery by determining and enforcing the sanitary standards that the processing plants and seafood markets have to operate under.

Table 1. Law enforcement capabilities of the Department of Environment and Coastal Resources and the location of these assets and personnel throughout the Turks and Caicos Islands.

Assets/Personnel	South Caicos	Providenciales	Grand Turk
Fisheries Officers	4	5	2
Environment Officers	1	0	1
Scientific Officers	1	1	1
Protected Areas Officers	4	0	0
Research vessels	2	1	0
Protected areas patrol vessels	2	0	0
Fisheries patrol vessels	3	2	1
Patrol vehicles	1	2	1
Administrative personnel	1	4	3

Stakeholder involvement in the management of the fishery is encouraged through regular public fishermen meetings hosted by the DECR. In addition to this, bimonthly meetings are held by the Fisheries Advisory Committee (FAC) which are used to advise the Minister for Natural Resources on activities within the fishery (Bennett 2000). The FAC consists of retired and active commercial fishermen, processing plant owners, a representative from the national parks committee and representatives from the Ministry for Natural Resources and the DECR. The FAC is facilitated by the DECR, but is deliberately not lead by it since the aim of this committee is to provide stakeholders with an opportunity to assist in the management of the fishery and to create a forum for stakeholders to raise concerns within the fishery. The FAC also uses this opportunity to direct research conducted by the DECR.

An additional committee involved in the management of the conch fishery is the Convention in Trade in Endangered Species of Wild Flora and Fauna (CITES) Management Authority (Bennett 2000). The TCI CITES Management Authority is used to review scientific research and recommendations by the DECR pertaining to the annual conch quota. The committee sets the: amount of conch that can be landed; total amount of conch and conch trimmings that can be exported; and reviews size limits and the closed season for conch, in addition to ensuring that monitoring of exports and record keeping are conducted to comply with CITES. The TCI is not a full party to CITES, but adheres to the convention since it exports virtually its entire conch product to countries that are full parties to CITES (e.g. 99 % to the USA).

THE FISHERY

The TCI fishery can be characterized as a predominately commercial fishery utilizing free divers to collect Caribbean spiny lobster and Queen conch (Table 2) with a small amount of scale fish caught as a by-product of the free diving operations for subsistence usage (Béné 2001). Use of pots and traps by fishermen to catch lobster and scale-fish respectively is limited. There are limited game fishing activities throughout the islands, primarily on Providenciales whereas commercial fishing for lobster and conch is based on South Caicos and Providenciales with a small number of fishermen and vessels operating from Grand Turk (Table 3). There are no operational commercial, scale-fish/ pelagic/ aquarium/ live-rock/ sponge/ bêche-de-mer fisheries within the islands. Virtually all of the fish sold in restaurants and hotels throughout the islands is imported from the United States. There is one commercial conch mariculture operation located on Providenciales which collects conch egg masses from the wild and then raises the conch for export.

Table 2. Catch and export figures for the lobster, conch and scale-fish fisheries of the Turks and Caicos Islands.

Year	Lobster landings (kg)	Conch landings (kg)	Scale-fish landings (kg)
2000-2001	288,852	810,502	625
1999-2000	252,889	730,770	1,084
1998-1999	310,878	640,310	0
1997-1998	228,285	781,425	0
1996-1997	179,505	730,935	2,065
1995-1996	307,665	956,925	1,058
1994-1995	373,860	946,305	13,356

Source: Department of Environment and Coastal Resources landing sheets and export data sheets.

Table 3. Commercial fishing effort within the Turks and Caicos Islands.

License period 2001-2002	South Caicos	Providenciales	Grand Turk
Commercial Fishermen	163	175	38
Commercial fishing vessels	76	92	18
Game fishing vessels	3	28	6
Processing plants	3	2	0

Source: Department of Environment and Coastal Resources commercial fishing vessel license application forms.

Caribbean Spiny Lobster (*Panularis argus*)

Caribbean spiny lobster is the species that fishermen concentrate upon during its open season (1st August – 31st March) due to the high economic value of this species (approx. $7.22/kg landed live weight at the processing plants). Lobster (legal size 8.3cm carapace length) are caught by fishermen free diving using fins and a snorkel enabling them to reach depths sometimes in excess of 18m (Clerveaux 2001c, Bennett 2000, Anon. 1998). When diving, the fishermen utilize a fishing hook attached to a fiberglass rod to impale the lobster and bring it to the surface. About 90 % of crawfish are caught during the 2001-2002 season using the hook. This practice - although illegal according to the Fisheries Protection Ordinance - has been ignored by the DECR since the expiration of a temporary waver in 1990. Fishermen utilize the hook because this is more efficient than either the bully and net or the toss. Unfortunately once a lobster is "hooked" in the abdomen it often dies. Due to almost total mortality of lobster following hooking, little can be done if the lobster is subsequently found to be either egg bearing, undersize or tar spotted (possession of lobster exhibiting any of these traits is prohibited) (Bennett 2000). Undersize lobster caught intentionally/unintentionally are not usually landed at the processing plants, as this is where Fisheries Officers conduct most of their inspections. Illegal lobsters are either consumed by the fishermen and their families or sold on the "black market" to hotels and restaurants which serve the lobster as "lobster hash". To ensure a closed season, the DECR requires establishments selling lobster to file an annual return on the last day of the season stating how much lobster they have in their possession (the aim of this is to remove the "black market" demand for lobster during the closed season). However, this does not work. Commonly the lobster holdings of the establishment selling lobster do not diminish. To negate this problem and to reduce fishing effort during the closed season on lobster, lobster should be removed from the menu on restaurants and hotels, as has been done in other Caribbean countries. Unfortunately this is proving difficult to garner political support for as it is thought that this may effect tourist revenue – despite the fact that this scenario not been experienced by other Caribbean nations that do not allow the sale of crawfish by restaurants during their closed seasons.

Another deleterious practice occurring commonly in conjunction with the use of the hook is the use of gasoline, bleach or washing up liquid. The liquid is squirted into cracks and crevices to irritate the lobster into coming out into the open so they

can be easily caught. The introduction of hydrocarbons, chlorine or phosphates (from the washing up liquid) may have deleterious effects upon the flora and fauna comprising the substrate in the immediate vicinity of the use of this liquid (Bennett 2001, Bennett 2000). The fishing community is highly vocal about this method of catching lobster, with many of the older fishermen being opposed to its use and stating that reefs are dying due to this reason. The DECR is researching a technique to identify lobsters caught with bleach to provide a method of enforcing legislation that already bans the use of noxious substances to catch marine products. Bleach or gasoline is also used to wash off the eggs on berried lobster. Evidence of fishermen using bleach to catch lobster can often be observed as the clothes of the fishermen are often covered in bleach stains (Vaughan 2001 pers. obs).

Conch (*Strombus gigas*)

Conch is the staple protein for the population of the TCI (Sadler 1997). Conch is collected by free divers and is "knocked" (shelled) onboard the fishing vessel (vessels used by fishermen throughout the TCI for the harvest of lobster and conch are predominately 5m Boston Whaler type hulls with a center console and a 75hp outboard engine with a crew of three) (Clerveaux 2001c). The meat is then landed at processing plants where fishermen are paid approximately $1.80/kg. Conch is managed by a closed season for export (15th July - 14th October), size restrictions and a quota for 2002-2003 currently set at 747,776kg of landed product (meat plus trimmings), which is divided between the five processing plants. The processing plants then clean the meat obtaining 37 % meat 10 % trimmings and 43 % waste (Bennett 2001). The meat and the trimmings are then either sold locally or exported. Fisheries Officers regularly conduct inspections of the processing plants and the exported marine product. A backwards step in the management of the fishery was made in 2002 with a decision to revoke a requirement that all exported marine product had to be inspected and taped by a Fisheries Officer prior to export. This requirement had been in place for one year and allowed accurate tracking of the conch export, as well as ensuring that no illegal export of conch could occur.

Illegal Fishing

Poaching (the collection of marine product) by unlicensed fishermen is a considerable problem in the TCI. The problem originates from two sources – fishermen from within the islands and fishermen based outside of the TCI. In the first instance, fishermen (predominantly Haitian illegal immigrants) go out to sea and fish either together or with a licensed foreign commercial fisherman (the licensed foreign commercial fishermen are also illegally fishing as they must fish with a "Belonger" on board the fishing vessel). These illegal fishermen exert considerable fishing effort since they also fish even in the worst weather when the DECR and other fishing vessels do not venture out to sea to either apprehend or report them (Bennett 2001, Bennett 2000).

A further problem for the TCI fishery and other Caribbean nations is the high incidence of poaching by fishermen from the Dominican Republic (DR). During the

2000-2002, nine vessels and approximately forty dinghies with hooka compressors with a total of one hundred fishermen were apprehended (the captain and engineer from each vessel received custodial sentences with the remainder of the crew being repatriated). The DECR subsequently confiscated and either sold or sunk the vessels. The development of a policy under which each poacher vessel is sunk is desperately needed since many of these vessels sold to Belongers find there way back to the DR only to reappear within TCI waters poaching again. The Marine Branch of the RTCPF conduct joint operations with the DECR utilizing offshore capable patrol vessels. Location of poaching vessels is achieved using a Fisheries Officer as a spotter in the Police aeroplane that conducts regular patrols of the TCI economic exclusive zone. A further concern is that foreign fishermen employed legally to assist TCI fishermen gain a great deal of knowledge regarding the fishing grounds of the TCI and can pass on this information to the poachers. The Dominican poachers conduct their fishing activities using hooka and spear guns (both of which are illegal in the TCI). A major problem with illegal fishermen based both in/outside the TCI is that they plan only to be fishing in the TCI over a limited time frame (months or hours). Therefore they do not have a long-term interest in the health of the fishery, demonstrated by the fact that the majority of their catches consist of undersize, out of season, berried crawfish taken by illegal methods.

THE STATE OF THE FISHERY

The lobster fishery is exhibiting signs of overfishing, Clerveaux (2001c) demonstrated that the ratchet effect of increasing effort to maintain fishing yields is occurring with fishermen deploying faster larger vessels and travelling further afield to land comparable amounts of lobster. Bioeconomic analysis of the lobster fishery advocates a reduction in the number of fishing vessels gradually from 198 in 2002 to 73 by 2010 with no concomitant increase in vessel size or numbers of fishermen (Puga 2002). It is clear from mathematical modeling that the MSY for lobster in the TCI has been surpassed and that increased effort maintaining catches is actually masking a decline in the lobster stocks. It is therefore of grave concern that the lobster fishery will subsequently crash, placing additional pressures on the conch and scale-fish populations if fishing effort is not reduced. At present the conch stocks are healthy and well managed by a quota: determined by a recent nationwide visual census and mathematical modeling (Clerveaux 2001a, Clerveaux 2001b, Medley 1999, Ninnes 1994, Berg JR 1989). However, there is no room for increasing the quota, which both processing plant operators and the fishermen will advocate to maintain marine product landings and revenue. Furthermore, the high percentage of legal foreign fishermen and the trend for Belonger fishermen upon retiring applying for and obtaining permits for foreign fishermen to work for them is a worrying trend as fishing effort continues to increase (Table 4). Scale-fish populations are not fished commercially to any extent, offering an opportunity for fishermen to diversify into. Although for a scale-fish operation to be financially viable, a significant investment by fishermen in time and labor is required. There is currently little expertise in the

islands amongst the local population to operate a commercial scale-fish, fishing vessel. For a scale-fish fishing vessel to be economically viable, it must stay at sea fishing for several days. This is a big hindrance to the local fishing populace who are used to spending no more than eight hours at sea each day and have no desire to change this.

Table 4. Number and percentage of licensed commercial foreign fishermen exerting effort within the TCI fishery.

Year	Commercial fishermen	Foreign fishermen	Percentage of foreign fishermen
2001-2002	376	52	13
2000-2001	350	59	17

Source: Department of Environment and Coastal Resources license application forms.

APPROACH TAKEN TO MANAGE THE FISHERY

During 2001 a more rigorous approach to enforcement of fisheries legislation was taken. The decision to take a top down approach was taken as fishermen were blatantly flouting the fisheries legislation, especially with regard to the landing of undersize lobster (up to 70 % were undersize on the 1st of August 2001). A successful prosecution of a processing plant and a Belonger fisherman lead to a dramatic reduction in the undersize lobster being landed (Vaughan 2001 pers. obs.). Fisheries Officers are often constrained in their jobs by strong family and fishing ties inherent within the islands, indeed many of the Fisheries Officers are ex-commercial fishermen. Therefore, warnings are commonly given rather than legal action, acting as little future deterrent to the fisherman. By stressing that each Fisheries Officer has a duty to enforce the legislation, and establishing an environmental education program which started with the establishment of two Environment Officers, the DECR started to take a holistic approach to fisheries management in 2001. The Environment Officers were tasked with raising environmental awareness amongst the general public and running a turtle tagging/monitoring program. Awareness of the importance of leaving undersize lobsters was stressed by issuing each commercial fisherman with an information sheet and a plastic caliper to measure the lobsters carapace length.

To improve the effectiveness of the extensive MPA system throughout the country (established to protect lobster, scale-fish and conch stocks and to provide managers with a tool to regulate development), the MPA boundaries were depicted for the first time in 2003 on commercial readily available/affordable navigation charts. Substantial effort and expense has been channeled into demarcating the MPA boundaries - this process is ongoing. A review of the Fisheries Protection Ordinance was conducted in 2002. Alterations to tighten up the legislation are under consideration with the Attorney General. Once reviewed the changes will go to the FAC for discussion and for the members to gather comments from other stakeholders.

The DECR is fairly well funded and equipped compared with other Caribbean

nations (Gravestock 2002), nevertheless the extent and number of MPAs precludes thorough and effective management. Indeed, the very fact that so much of the territorial waters are protected causes a great deal of conflict between the DECR and fishermen.

Rapid development throughout the islands, and the governmental view that cruise ship tourism is the way for the islands to press ahead economically, will further stretch the resources of the DECR; this in turn compromises its' ability to secure the sustainable and wise use of the natural resources of the TCI for future generations unless the DECR is further strengthened with personnel, equipment and expertise.

CONCLUSION

In order to maintain an economically and ecologically viable fishery, several steps need to be taken to reduce effort within the fishery and to ensure that the local people, who have a long-term stake in the environmental integrity of the fishery, are those that benefit directly from the fishery. Rapid development of the TCI, in conjunction with rapidly increasing fishing efficiency and effort through the use of foreign fishermen, larger vessels, larger engines etc. are the main threats to the marine resources of the islands.

In order to constrain fishing effort emphasis should be on:

i) The implementation of a cap on the number of commercial foreign fishermen that are issued licenses - these fishermen should only be issued licenses in accordance with the existing legislation: i.e. they are to assist an elderly or infirm "Belonger" fisherman. The assistance should be limited to one commercial foreign fisherman to each such person and no foreign fisherman should be issued if the "Belonger" ceases to fish.

ii) Removal of the power to issue foreign fishermen licenses from the Minister for Natural Resources. This capability should be transferred to the FAC to negate political pressure being exerted on the Minister each year by "Belongers" wanting foreign fishermen to work for them.

iii) Banning hooking to catch lobster, implemented within a year following an extensive retraining program whereby the older fishermen (proficient in the use of the toss and the bully to catch lobster) are used to train fishermen that have no experience with this gear type.

iv) Continue the process of demarcating the boundaries of the marine protected areas and follow through with the campaign to raise awareness of their use and purpose amongst marine resource users.

v) Ban the sale of lobster at markets, restaurants, shops and hotels during the closed season, thereby reducing the incentive for fishermen to poach off season since the demand for this product is immediately removed.

Development is already eroding the integrity of the MPA system within the TCI; this is due to the fact that the islands have become very accessible due to the high number of scheduled flights from the USA and Europe. Tourism brings with it benefits for a country's economy, however a country must decide at what part of the

spectrum is it most suited for economically, environmentally and socially. With a country aiming for exclusive tourism, the economic benefits can be high and although the environmental resources per tourist are also high, the overall impact upon the environment is much less than in a situation where a country aims for mass marketing and medium/low end tourism, i.e. package holidays and cruise ship developments. With cruise ships now docking on a regular basis on Grand Turk, the pressure upon MPAs around Grand Turk is mounting. As tourism increases throughout the islands and economics favor the development of scale-fish resources, then this resource will come under pressure. Unfortunately this resource is likely to be exploited by a select few people utilizing foreign labor to catch the fish. This, in turn, allows the common marine resources of the islands to be eroded by those that have little or no long-term stake in the environmental integrity of the Turks and Caicos Islands.

It is the continued commitment and effort of those people in the TCI acting as the stewards of the marine resources that hold the key to the long-term protection and utilization of those resources for future generations. A holistic approach to management that encompasses the involvement of stakeholders through the utilization of an effective FAC and regular fishermen's meetings, and the continued active enforcement of fisheries/national parks legislation through a "top down" approach to management should be continued. This, in-conjunction with the environmental education and outreach approach "bottom up" offers the most hope for the sustainable and wise use of the marine resources of the TCI.

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Coastal Resources and Livelihoods in the Grenadine Islands: Facilitating Change in Self-organising Systems

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ABSTRACT

The Grenadine Islands lie on the Grenadine Bank extending some 120 km between Grenada and St. Vincent, and occupy about 1,500 km^2 of the bank. This area supports the most extensive coral reefs and related habitats in the south-eastern Caribbean. The international boundary between Grenada and St. Vincent and the Grenadines lies about midway down the bank. The largest islands have towns and communities. Others are resort islands. Most are visited by yachters and fishers. Tourism and fishing are the major sources of employment in the area. Tourism development is proceeding apace, while fishery resources appear to be fully or overexploited. Governments of both countries perceive their Grenadine Islands as having high potential for tourism and associated development. They also recognise the vulnerability of the marine and terrestrial ecosystems of the area to environmental degradation and that sustainable development depends on conservation of the resources. There the emerging view that the entire area should be a transboundary World Heritage Site. The Tobago Cays Marine Park has been established and other MPAs are planned, but a broader approach is needed. Achieving sustainable livelihoods from marine and coastal resources will need organisational change at many levels. There is a complex interplay of local and international private interests, local, national, and international NGOs, as well as tensions between main island government and local inhabitants. Therefore, conventionally planned change is difficult to implement. The model of organisational change that is most likely to be applicable is one based the science of complex adaptive systems and chaos theory. Intervention should employ 'containers', 'significant differences', and 'transforming exchanges' to increase the capacity for self-organisation among stakeholders. Understanding of other chaos elements such as boundaries, butterfly effects, coupling and attractors can be used to encourage self-organization

KEY WORDS: Caribbean, coastal, livelihoods, co-management, transboundary, self-organisation, complex adaptive systems, chaos theory

Recursos y Sustentos Costeros en las Islas de Grenadine: Facilitando el Cambio en Sistemas Individuales de Organizacion

Las islas de Grenadine se encunetran en el banco de Grenadine que amplía alguno 120 kilómetros entre Grenada y St. Vincent, y ocupa cerca de 1.500 km2 del banco. Esta área apoya los arrecife coralinos más extensos y los habitat relacionados del Caribe south-eastern. El límite internacional entre Grenada y St. Vincent y el Grenadines miente sobre mitad del camino centraa abajo del banco. Las islas más grandes tienen ciudades y las comunidades. Otras son islas del recurso. La mayoría son visitadas por yachters, y los pescadores. El turismo y la pesca son las fuentes principales del empleo en el área. El desarrollo del turismo es apace que procede, mientras que los recursos de la industria pesquera aparecen estar completamente u overexploited. Los gobiernos de ambos países perciben sus islas de Grenadine como teniendo alto potencial para el turismo y desarrollo asociado. También reconocen la vulnerabilidad del marina y los ecosistemas terrestres del área a la degradación ambiental y ese desarrollo sostenible dependen de la conservación de los recursos. Allí la visión que emerge que el área entera debe ser un sitio transfronterizo de la herencia del mundo. Se ha establecido el parque marina de Trinidad y Tobago Cays y se planea el otro MPAs, pero un acercamiento más amplio es necesario. La realización de sustentos sostenibles de recursos marinas y costeros necesitará el cambio de organización en muchos niveles. Hay una interacción compleja de los nGOs privados locales e internacionales de los intereses, locales, nacionales e internacionales así como tensiones entre el gobierno principal de la isla y los habitantes locales. Por lo tanto, el cambio estructurado, previsto es difícil de poner en ejecucio'n. El modelo del cambio de organización que es más probable ser aplicable es uno basado en teoría del caos y la ciencia de sistemas adaptantes complejos. La intervención debe intentar aumentar la capacidad para la uno mismo-organizacio'n entre tenedores de apuestas. Debe identificar elementos tales como efectos de la mariposa, envases, e intercambios que transforman que desempeñen un papel en la uno mismo-organizacio'n y con éstos para amplificar efectos positivos y para humedecer la negativa unas.

PALABRAS CLAVES: Del Caribe, costero, sustentos, co-gerencia, transfronteriza

INTRODUCTION

The Grenadine Islands

The area to be addressed in this project includes the Grenadine islands which lie on the Grenadine Bank extending some 120 km between Grenada and St. Vincent and the adjacent marine habitats of the bank itself (Figures 1a and b). In this area, there are over 20 islands, of which nine have permanent settlements. The largest islands – Bequia, Canouan, Mayreau, Union I., Petit Martinique and Carriacou have towns and communities with public (schools, clinics, utilities) and private supporting

infrastructure (Table 1). Others are resort islands – Palm I, Petit St. Vincent. Most others are visited by yachters and fishers.

Table 1. The inhabited Grenadine Islands.

Island	Area (km^2)	Population (approx.)
Bequia	8.1	4400
Mustique	5.2	1300
Canouan	7.8	1800
Mayreau	2.6	200
Union I.	8.3	1900
Palm I.	0.5	Resort I.
Petite St. Vincent	0.5	Resort I.
Petite Martinique	2.3	600
Carriacou	33.7	8,000
Total	67.0	18,200

There is access by air to Bequia, Mustique, Canouan, Union I., and Carriacou which have airstrips for small commuter aircraft. The area is also served by two passenger and vehicle ferry systems: one between St. Vincent and the islands of St. Vincent and the Grenadines (SVG); the other between Grenada and its two Grenadine Islands. Small cargo vessels and water taxis (speedboats) operate throughout the area.

The area of bank occupied by the Grenadine Islands is about 1,500 km^2 most of which is shallower than 50 m. Thus, the area supports the most extensive coral reefs and related habitats in the south-eastern Caribbean. All islands have a variety of surrounding fringing, patch and barrier reefs, and there are numerous offshore reef shoals on the bank. There are reef-related seagrass and lagoon habitats and areas of extensive mangrove forests.

The international boundary between Grenada and St. Vincent and the Grenadines runs east to west across the bank between Petit Martinique and Petit St. Vincent (Figure 1). Nonetheless, the linkages among all the Grenadine Islands on both sides of the boundary are historically strong and continue to be active. Fishing, informal trade, tourism and island social life proceed with little attention to the boundary. In both countries 'mainlanders' concede that the connections among the Grenadine islands are in most cases stronger than those with the main island.

Development Potential and Problems

The entire Grenadines area is noted for its beautiful scenery, spectacular beaches, and diverse marine habitats that include coral reefs, mangroves and seabird colonies. There, the emerging view by many is that the entire area be declared a transboundary World Heritage Conservation Site.

Marine-based activities are the mainstay of the economy of the area. Tourism is a major source of employment and tourism development is proceeding apace. Private sector actives include: resorts, hotels, guest houses, restaurants, SCUBA dive operators, day and longer-term cruise operators, crafts, and shops. There are

also under-utilised land-based opportunities for earnings through cultural and heritage developments that would diversify the tourism sector. Fishing is the other major source of employment in the area and has long been a source of exports to neighbouring islands (Table 2).

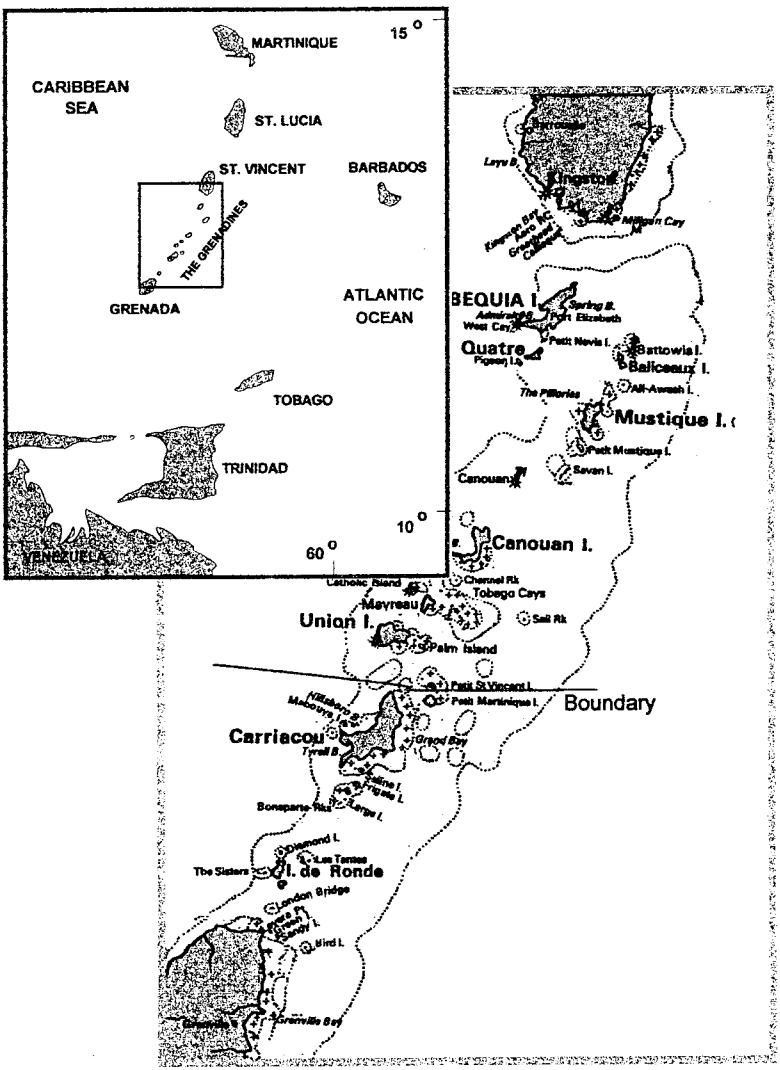

Figure 1. The location and details of the Grenadine Islands.

Table 2. Main source of income for residents in three Grenadine Island communities (from Canada/SVG Fisheries Development Project. 1992)

Source of Income	Paget Farm - Bequia	Canouan	Clifton Union I.
Tourism	25%	25%	38%
Fishing	33%	25%	8%

The Governments of both countries perceive their Grenadine Islands as having high potential for earning foreign exchange through tourism and associated development. Both Governments also recognise the high vulnerability of the marine and terrestrial resource systems of the area to environmental degradation and the dependency of sustainable development on conservation of the resources.

Unplanned development and unregulated use of terrestrial and marine habitats and resources have already led to significant degradation in many areas. There are problems with:

i) Overfishing,
ii) Near shore habitat destruction and degradation,
iii) Terrestrial devegetation and overgrazing,
iv) Sedimentation,
v) Solid waste disposal from land and boat sources,
vi) Sewage disposal from land and boat sources, and
vii) Recreational abuse of coral reefs.

There is no integrated framework within which to pursue development and conservation. Local governmental and non-governmental organizations lack the capacity to develop the framework or to participate fully in its development.

Biodiversity and Marine Resource Conservation

Marine resource and biodiversity conservation are fundamental to sustainable livelihoods in the Grenadines. These are in turn affected by the land use practices on the islands. Thus, it necessary to consider both terrestrial and marine resource use practices in planning for biodiversity conservation.

The Government of SVG (GoSVG) has established the Tobago Cays Marine Park (TCMP) as both a major attraction and a means of conserving marine biodiversity. The TCMP is the focus of marine aquatic recreation (diving, day sailing, yachting) for the entire area. Private yachts visit the park, and the area in general, mainly from throughout the eastern Caribbean but also from beyond.

The TCMP was declared a regulated area in 1987 under the Fisheries Act, then supported by a Marine Parks Act in 1997, and regulations in 1998. There is a Board of Directors, a Park Manager, and a Management Plan. However, there has been little progress with implementing the Plan and enforcing the regulations. The extent of involvement of local NGOs in the park and the capacity of the board and management unit are of concern for the success of the TCMP. Other Marine

Protected Areas (MPAs) are being considered in other parts of the SVG Grenadines.

Several MPAs have also been identified as desirable for the Grenada Grenadines. These are proposed in an Integrated Physical Development and Environmental Management Plan for Carriacou and Petit Martinique prepared in 1998. Implementation of this plan has been hindered by lack of stakeholder buy-in and participation, and the capacity of NGOs to take part. One NGO, The Carriacou Environmental Committee, has taken the lead in establishing one of the MPAs off Hillsborough, Carriacou. Support through linkages with other MPAs, organisational capacity building and access to technical information on MPAs would greatly facilitate its progress with the MPA.

Summary of the Situation

Inhabitants of the Grenadine Islands area are highly dependent on the marine environment for sustainable livelihoods. The area has the potential to sustain these livelihoods while contributing to the national economies and to regional and global biodiversity conservation. These potentials are presently being eroded by unplanned and uncoordinated development and continuing negative impacts of the resource users, both extractive and non-extractive. There is a need to reorient the stakeholders in the Grenadines towards sustainable use of the marine resources. Land-use issues have bearing on this too, and a holistic approach is needed. This reorientation will involve full engagement of the stakeholders in the process, including strengthening their capacity to take part in planning and decision-making processes, as well as in the implementation of the plans.

THE PROJECT

A project to facilitate change is being developed. The goal of the project is:

> *"The integrated sustainable development of the Grenadine Islands area for the social and economic well being of the people who live there, as a contributor to the national economies, and to conserve their biodiversity."*

The primary purpose of this project is:

> *"To develop a participatory integrated sustainable development planning framework for the area and to implement those components of the plan that are directly associated with uses of the marine resources and environment."*

A secondary purpose is:

"To develop a model for participatory integrated sustainable development in small island systems that can be adapted and applied elsewhere."

The goal and purpose are entirely consistent with and guided by several of the "Principles of environmental sustainability in the OECS" (OECS 2001).

The Project Approach

The project is conceived for implementation in two phases:

Phase 1 — Stakeholder assessment and participatory project development -- will involve stakeholder assessment and mobilisation, including an appraisal of Government and NGO capacity for participation. A participatory strategic planning process will be used to develop an integrated framework, and to generate the information required to prepare the proposal for the 5-year program to be implemented in Phase 2.

The outputs from Phase 1 will be:

i) Increased stakeholder awareness and commitment for involvement;
ii) Information on the relative interests and capacities of stakeholders;
iii) Strategic and action plans;
iv) Identification of the stakeholder alliances needed to effect continuous change towards sustainable development in the Grenadines;
v) Proposal for funding of the of the 5-year core project;
vi) Related activities identified for subsequent proposal development.

Phase 2 — Implementation of the main elements of the 5-year core program -- is expected to include a substantial institutional capacity building component for local NGOs and government departments. It will focus on the establishment of management and co-management systems required for sustainable resource use and management. There may be some elements of infrastructure development. It will also include the preparation of proposals for related elements that exceed the budget and immediate scope of the core project.

The Desired Impact of the Project

This integrated project is expected to have broad positive impacts on the conservation of marine resources and biodiversity in the Grenadines and on the sustainability of the livelihoods of the people who depend on those resources. It is expected to achieve this by:

i) Strengthening the capacity of NGOs, government and the private sector to work together to develop and implement projects;
ii) Demonstrating the benefits of comanagement arrangements where NGOs can become partners in the management of resources, such as fisheries and MPAs;

iii) Increasing, throughout the Grenadines, an awareness of their dependency of marine resources, the vulnerability of the marine environment and commitment to conservation and sustainable use;
iv) Enhancing the environment for sustainable economic opportunities and development of both human and physical capital;
v) Providing multi-faceted linkages between individual, community, national and transboundary developmental goals and the means of achieving their specific objectives;
vi) Improving understanding by 'main island' government partners in St. Vincent and Grenada of the issues and special needs in the Grenadines;
vii) Promoting the Grenadines nationally, regionally and globally as a well-managed area of special scenic beauty and biodiversity.

CHANGE IN SELF-ORGANISING SYTEMS

Increasingly, the field of organization development is being influenced by breakthroughs in physics, biology, chemistry, and chaos theory which spans several disciplines. A turning point was in 1977 when Ilya Prigogene won the Nobel Prize in 1977 for demonstrating how certain chemical systems (dissipative structures) will regenerate to higher levels of self-organization in response to environmental demands.

Self-organization in human systems is explored by Olson and Eoyang (2001) in Facilitating Organizational Change. In Coping with Chaos, Eoyang (1997) makes the point that the17th century Newtonian world view no longer applies to today's fast-paced organizational dynamics (Figure 2). From the old view, managers tended to separate organisations into hierarchical parts, rely on exerting force for change, and to plan for a world that was expected to be predictable.

Newtonian perspective		Complex perspective
Machine-like	⟷	Organism-like
Linear	⟷	Non-linear
Predictable	⟷	Surprising
Orderly	⟷	Patterned
Controlled or controlling	⟷	Adaptable or adapting
Designed	⟷	Emergent or self-organising

Figure 2. Characteristics of the common Newtonian perspective and the complexity perspective on organisational systems (after Eoyang 1997).

Through the new sciences a different world view is emerging – one that focuses on patterns and connections, and one that regards the whole of things and the importance of relationships (Wheatley 1992). When this is applied to human organizations, change can be seen as a spontaneous, evolving, iterative process in which patterns emerge and influence behavior which then generate new patterns which influence further change.

Olson and Eoyang (2001) note that self-organization represents the tendency of a system to generate new structures and patterns based on its own internal dynamics. Pattern, in this context, refers to any coherent structure that emerges from a self-organizing process. In this mode, organization change patterns are not imposed from above or outside but emerge from the interactions of the agents of the system.

Because of human pressures and practices in the Grenadines Islands there has been some concern about whether patterns of sustainable development are emerging fast enough to offset environmental degradation. The agents of the system in the Grenadine Islands are its stakeholders: Government, private sector and civil society (individuals and NGOs). This project aimed to bring these agents together and to stimulate the process of self-organization.

Left alone, organizations and groups will self-organize, but there is no guarantee that those changes will be desirable; i.e. towards sustainable development in the context of this initiative. However, with an understanding of systems dynamics a change agent, who is internal or external to the system may consciously influence the direction in which the system self-organizes.

Conventional change measures based on the Newtonian view are leader driven, or top-down, however these measures often fail when they meet resistance from other participants in the system. In a self-organizing system the leader plays an important role, but long-lasting, meaningful change depends on the work of many individuals at different levels of the system.

Change agents who want to influence a system toward new and innovative patterns can formulate their inputs with reference to three system characteristics that are critical determinants of self-organization: **'container'**, **'significant difference'**, and **'transforming exchanges'** (Eoyang 2001).

The concept of the **'container'** refers to the limits that define the self-organizing system or its sub-systems. A 'container' may be physical, as in a geographical area, organizational as in an NGO, or conceptual as in an identity, a shared vision or an operating procedure. A system may comprise several containers which may overlap, awareness of these is crucial to influencing change.

'Significant differences' are the differences that occur normally in systems; namely heterogeneity or diversity. These 'significant differences' may relate to power, levels of expertise, gender, race, educational background and so forth. The nature of these 'significant differences', as well as the level to which they are appreciated may greatly influence the emergence of patterns and structure that are beneficial.

'Transforming exchanges' consist of the active connections between participants in a system. These exchanges may include information, money, energy or other resources that flow from person to person resulting in each of them being transformed in some way. Examples of transforming exchanges include meetings, emails, financial transactions, phone calls, etc. Feedback loops, or bidirectional exchanges are particularly high impact 'transforming exchanges'.
The conditions that are most favourable for self-organisation are high diversity and active feedback (Figure 3). The Grenadines appears to be in a state of moderately high diversity and low feedback.

	High diversity	**Low diversity**
Active feedback loops	Self-organisation	Reinforcement and revitalisation
No feedback loops	Unresolved conflict	Organisational rest

Figure 3. Organisational outcomes resulting from various combinations of organisational diversity and feedback (adapted from Eoyang 1997)

The proposed approach to 'Sustainable Integrated Development and Biodiversity Conservation in the Grenadine Islands' will seek to encourage sustainable development by influencing the above three conditions for Grenadines stakeholders or system agents. Many of those stakeholders have been working toward sustainable development in isolation from each other. In particular, the larger system which spans the two countries to which the Grenadines belong is a recognisable, but poorly defined container.

To address the diffuse nature of the efforts thus far, this project will attempt to define or enhance 'containers' within which the sytem agents can be brought together. 'Containers' may include the project framework itself, subprojects, meetings and various interest groups. Appreciation of the value of 'significant differences' will be enhanced by bringing together a number of people with different perspectives, experiences and levels of expertise. 'Transforming exchanges' will be facilitated by an emphasis on participatory planning processes (generation of ideas and consensus building), and on communication networks.

Other aspects of chaos and complexity science can be applied when trying to facilitate change toward sustainable development. (Table 3). Facilitators of change towards sustainability through self-organisation in complex systems such as the Grenadines islands can benefit from an understanding of chaos and complexity science as applied to organisations.

Table 3. Elements of chaos theory that are relevant to organisational change and how they may be used by change agents (based on Eoyang (1997)).

Chaos element	Explanation	Example of possible by change agent
'Butterfly effect'	A small change that can have a profound positive or negative effect on a system An example would be a rumour.	Seek ways to prevent the spread of negative butterflies and look for ways to enhance positive ones.
'Boundaries'	The area that lies between parts of a system that have different characteristics. Organisational examples: cultural backgrounds, learning styles, gender and committee distinctions. Changes resulting from them can be pleasant or unpleasant. Types include: clear and distinct, indistinct, partially permeable and impermeable. 'Boundaries' can overlap, and they can shift.	A change agent can increase awareness in the sytem of boundaries and their nature. This can serve to increase information flows across boundaries. Indistinct boundaries between very different system elements can be areas of innovation and creativity.
'Attractors'	Attractors can be used to describe and understand the behaviour of complex systems. 'Point attractors' focus activities to a single point. 'Periodic attractors' indicate repetition of behaviour at regular time intervals. 'Strange attractors' indicate apparently random behaviour in a system that can ultimately be recognised as a pattern.	Goal setting can provide productive 'point attractors' for an organisation. Regular financial record keeping is an example of a 'periodic attractor'. Although 'strange attractors' are harder to identify in organisations a change agent can be observant to behaviour that is slightly different or more complex than usual and reinforce it toward the benefit of the system.
Coupling	Parts of a system may be coupled in various ways. 'Tightly coupled' components change greatly, but not necessarily predictably, when there is a change in the other component. 'Loose couples' respond more gradually to information exchange. 'Uncouples' have little or no influence on each other.	Awareness of coupling can assist is determining where a system may be most effectively influenced. 'Tight couples' can be managed to enhance transforming feedback and minimise the effects of disruptive unpredictable responses. Attention can be paid to enhancing coupling in uncouples that would benefit from coupling.

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Caribbean Women in Fishing Economies

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ABSTRACT

There is little information in the literature on the role of women in fishing communities in the Caribbean and in much of the world. From the information available, women are involved directly in some aspects of fishing, community work that supports the fishing economy in general, and household work that provides a support system for fishers. When Fisheries Officers in 13 Caribbean countries were asked their perception and assessment on the role of women in fishing economies, they ranked women's participation "high" for marketing and processing, "low" for fishing and "medium" for investing. In the Caribbean, there is little or no recognition of women's work in fishing communities. However, their contribution to some aspects of the fishing economy may be significant and warrants attention.

KEY WORDS: Caribbean, fishing economies, women fishing

Mujeres del Caribe en la Economía Pesquera

Las mujeres en economías del Caribe de la pesca están implicadas activamente en la comercialización y distribución, procesando, invirtiendo, y pescando en un grado inferior. En el Caribe, como el resto del mundo, hay poco o nada de reconocimiento del trabajo de las mujeres en comunidades de la pesca. Su contribución se ha descrito como insignificante. Pero estas mujeres insignificantes e invisibles deben participar en el planeamiento de la gerencia de las industrias pesqueras y policy-making, pues son el corazón de las comunidades de la pesca.

PALABRAS CLAVES: Caribe, economías pesqueras, pescadoras

INTRODUCTION

Women in some parts of the world and the Caribbean make invisible yet important contribution to fishing communities (Nadel-Klein and Davis 1998, Jentoft 1999). From the sparse information available in the literature, women are involved in community and household work, personal care, and fishing economies.

In the rest of the world, women's contribution includes community work (culture, politics, social class, kin organization), household work (taking care of the family unit), individual care (self-esteem, social honour), and being involved in fishing economies (marketing, processing, fishing). At the community, household, and individual levels, the roles which women play in establishing the family and developing kinship within community are often underrated (Jentoft 1999). Kinship

is the basis of economic cooperation and social structure (Nadel-Klein and Davis 1998). Women's non-monetary work within the household and community also support and strengthen community cohesiveness (Pramanik 1994, 1996, Larkin 1995, Norr and Norr 1997).

Women's roles in fishing economies are important contribution to the livelihood strategies adopted by the household. Marketing and distribution can be specific to different cultures and/or country. In some fishing communities, women are solely responsible for the fish once they are landed (Nadel-Klein and Davis 1988, Schweitzer de Grys 1988, Johnsen 1992, Geheb 1995, Norr and Norr 1997). While in other cultures, men are solely responsible for marketing and distribution. Women are also involved in fish processing, such as gutting, sun-drying, smoking, salting, canning, and freezing. In some communities women are wage labourers in fish processing plants (Muszynski 1987, Nadel-Klein and Davis 1988, Gulati 1988, Silk 1994). Women play an active role in subsistence, non-commercial, and commercial fishing. They exploit marine and riverine finfish and shellfish (Chapman 1987, Nadel-Klein and Davis 1988, Pramanik 1994, 1996, Jentoft 1999, White et al. 2000, Pramanik and Nandi 2001, Fields, 2001). Women have been known to captain boats (Nadel and Davis 1988), work aboard vessels as cooks, deck hand and crew (Allison 1988), and perform minor tasks to support fishing activities e.g. net repair and making (Pramanik 1994, Norr and Norr 1997). Women active in processing and marketing have also moved into positions as entrepreneurs who finance their own boat and gears (Gulati 1988). Some are involved in non-fishing economic activities, part of the economic support system of fishing communities. A few women are involved in giving loans to fishermen, operating small enterprises such as small snack stores, bars, restaurants and making and selling alcohol (Norr and Norr 1997).

As in the rest of the world, Caribbean women play a central role in fishing communities (Williams 1827, Wojtowicz 1950, Davenport 1954, Comitas 1962, Aronoff 1967, Rudder 1987, Williams 1990, Smith and Koester 2001). The objective of this paper is to summarize available information on the roles of women in Caribbean fisheries and to document the perceived roles of women in Caribbean fishing economies.

METHODS

A literature review was conducted to obtain information on Caribbean women in fishing communities. Since information in the literature was sparse, a survey was undertaken. Directors of Fisheries, Fisheries Officers, and knowledgeable individuals in 13 Caribbean countries were asked to give their perception on the roles of women in fishing economies. Officers from Antigua and Barbuda (ANT), Barbados (BAR), Belize (BZE), Commonwealth of Dominica (DOM), Grenada (GRE), Guyana (GUY), Jamaica (JAM), St. Kitts (SKN) and Nevis (NEV), St. Lucia (SLU), St. Vincent and the Grenadines (SVG), and Trinidad (TRI) & Tobago (TOB) were asked to complete a short questionnaire. The information generated provided baseline information on women in Caribbean fishing communities. Further

work is being carried out to obtain information on social and economic contribution of women in Gouyave, Grenada, as part of a larger study.

RESULTS

Literature Contribution on Women in Caribbean Fishing Communities

In the Caribbean, few studies have been done on women's roles in fishing communities. Some information was available on women's roles in fishing economies, but very little of their social contribution. In many instances, the literature did not separate information by gender.

Community and Household Work — There was very little information on women's community, individual, and household work in fishing communities. McConney (1995) pointed out that networking and reciprocity seem to differ by gender, but stated that these concepts have not been applied to eastern Caribbean fishing industry.

In many fishing communities, the primary occupation of males is harvesting. Women's roles are multiple and diverse. They not only participates in increasing the outputs from fishing economy, but they engage in other livelihood activities, such as, managing household finances and taking care of the family. Rudder (1987) wrote about "Jean", a 45 year old woman who has 2 daughters and 1 son and lives with her husband in Vieux Fort, St. Lucia. She purchased fish wholesale; managed her husband's four boats; owned a grocery store, a bakery, and a restaurant, and was a member of the fisherman's cooperative. In this example, Jean took care of her family, provided employment for community members, and managed the fishing business.

Fishing Economies — The literature gives many examples of women's involvement in marketing and distribution. In Antigua and Barbuda, marketing was the main activity in which women were engaged (Williams 1990). Some 63 of the women interviewed were involved in marketing of fish. Williams, 1990 noted that some 20 of persons who owned large fish-marketing operations, were women. In Lances Bay Jamaica, there was a pattern of cooperation between fishing crews and women market agents in the village (Comitas 1962). In Dieppe Bay, St. Kitts, fishers gave their fish to women who worked full time at selling them (Aronoff 1967). In St. Lucia, women were involved in both wholesale and retail marketing of fish (Rudder 1987). In The Virgin Island USA, women would sit all day in the markets with their straps of 'bright-hued' fish (Wojtowicz 1950). Williams (1990) reported that in Antigua and Barbuda 80 percent of women in the study were involved in processing. They used two methods of processing — icing and cooking. Regarding women investors, there was little information in the literature. In Barbados, females owned 7.6 of day boats, and 8.5 of the "iceboats" (boats which carry ice and do multi-day

trips) and longliners (McConney 1995). In Jamaica 7 of registered boat owners were female (Fisheries Division 2002).

To a lesser extent, women, were also involved in fishing. On the island of Caye Caulker, Belize, Sutherland (1986: 88) reported,

> *"Women may line fish at times, learn to spot lobster traps, or clean the inside of a boat, but they do not become fishermen".*

Williams (1990) noted that very few Antiguan women were involved in fish harvesting. Those actively fishing were involved in spearfishing, SCUBA diving, beachseine, and sport fishing. In Jamaica only 1 of registered crew members were female (Fisheries Divisio 2002). In St. Lucia, women and teenagers often dived for sea urchins ("sea eggs"); children would break the shells, and both men and women prepared them (Smith and Koester 2001).

Perception of Women's Roles in Caribbean Fishing Economies

This section presents perceptions from Caribbean area Fisheries Officers and Director of Fisheries of women's roles in fishing economies. The main areas of involvement - mean rank from 1 high involvement to 4 low involvement - were marketing and distribution (1.5), processing (1.9), investing (2.7), and fishing (3.8) (Table 1). In Belize, Guyana, Nevis, Trinidad, and Tobago processing was the main area of involvement.

Table 1. Perceived ranked order of female involvement in fishing economies in 13 Caribbean countries.

Activities	ANT	BAR	BZE	DOM	GRE	GUY	JAM	SKN	NEV	SLU	SVG	TRI	TOB	N	Mean rank
Marketing & Distribution	1	1	2	1	1	2	1	1	2	1	1	2	3	13	1.5
Processing	2	2	1	2	2	1	2	4	1	2	4	1	1	13	1.9
Investing	3	3		3	3	3	3	2		3	2	3	2	11	2.7
Fishing	4	4		4	4		4	3		4	3	4	4	10	3.8

(KEY: 1-high involvement to 4-low involvement)

Marketing and Distribution — Caribbean women were mainly involved in wholesale and retail marketing and distribution of fishery products. In all 13 countries women retailed fish (Table 2).

Table 2. Perceived women's involvement in marketing and distribution

Activities	ANT	BAR	BZE	DOM	GRE	GUY	JAM	SKN	NEV	SLU	SVG	TRI	TOB	Countries involved N = 13
Wholesale	✔	✔		✔	✔	✔	✔			✔		✔	✔	69
Retail	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	100

Processing—Fish processing methods includes icing, salting, smoking, drying, and the making of fish paste, fish crackers, and fish balls. Women either earned wages in processing plants, or processed fish (gutting, fillets) in the markets or fish landing sites. Demersal finfish, flying fish, and offshore pelagics were the main fish types processed in plants (Table 3).

Table 3. Perception of women's activities in fish processing, markets, and fish plants.

Fish Type	ANT	BAR	BZE	DOM	GRE	GUY	JAM	SKN	NEV	SLU	SVG	TRI	TOB
Demersal finfish	b	b	b				b	b	b			b	
Flying fish		b		b						b		b	b
Offshore pelagics		b			b				b	b	b	b	b
Conch			b				b	b			b		
Lobster			b				b				b		
Shrimp & groundfish						b						b	
Shark										b			

Investing — Women invested in boats and gear, processing establishment, export companies, gear and tackle store, and vehicles for distribution. Of all the countries investigated 85 percent reported that women owned boats and gear (Table 4). This suggests that although women were not actively involved in fishing, they owned the boats from which men fished.

Table 4. Perceived investment of women in Caribbean fishing economies

Activities	ANT	BAR	DOM	GRE	GUY	JAM	SKN	SLU	SVG	TRI	TOB	Total Countries N = 13
Boat and gear owner	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	85
Processing establishment owner				✔				✔		✔		23
Export company owner										✔		6
Gear & tackle shop owner						✔				✔		15
Vehicle owners in distribution		✔				✔						15

Fishing— Of the four kinds of economic activities, fishing was the least active area for women's involvement. Eighty-five percent of the countries reported that women were involved in fishing in some way, but only occasionally (Table 5). Officers in Guyana and Nevis reported that women did not fish. Officers in Antigua & Barbuda (beachseine, gillnet) and St. Kitts (line, fish trap) reported that women were usually involved in fishing. Officers in the other countries reported that women fished occasionally. Horsford (Personal Communication 2002) noted that women in Barbuda would take along their speargun to catch fish if the occasion arose while diving for lobster and conch. Guiste (Personal Communication, 2002) pointed out that there are only two women in the entire Commonwealth of Dominica that fished. In Grenada seven of over 200 longline fishers were female (longline fisher, Grenada). Of the countries reported that women fished, the main gear types used were line and beachseine (Table 5).

Table 5. Perceived women's involvement in fishing

Activities	ANT	BAR	DOM	GRE	JAM	SKN	SLU	SVG	TRI	TOB	Total Countries Involved N = 10
Line (trolling, handline, longline)	*	*		*	*	** *	*		*	*	8
Beachseine	** *		*	*		*		*			5
Gillnet	** *	*			*						3
Shrimp Trawling									*		1
Diving	*						*				1
Fish Traps						** *					1

(KEY: *-occasionally; ***-usually)

Other Areas of Involvement — All countries, except Nevis, reported that women are involved in fishers' association/groups/cooperatives. In Barbados, women were actively involved in the Barbados National Union Fisherfolk Organization (McConney, et al. 2002). Also, in Jamaica woman are members of fisherman's cooperative and associations. Barbados and Tobago also mentioned other areas of women's involvement, e.g. research, management, and training.

DISCUSSION

Accounts in the literature and opinions of Fisheries Officers point to the fact that women are involved in a substantial way in some Caribbean fisheries. However, the details of the extent of their involvement are unknown. No detailed studies were available on social and economic contribution of women to fishing

communities. Women were involved in marketing, distribution, processing, investing, and to a lesser extent fishing. But no systematic studies have been conducted in the Caribbean area on these topics. Although the survey reported in this paper is based on the perceptions of Fisheries Officers, the results of the survey can be further supported by my own work in three of the 13 Caribbean countries — Jamaica, Grenada, and Belize.

The impact of women's contribution to Caribbean fishing communities generally goes unnoticed. At times Fisheries Officers in the region assumed fishermen controlled all fishing operations, and owned and operated the vessels from which they fished, this is not always so. Take the case of the implementation phase of the data collection programme in Pagee, St. Mary, Jamaica. Staff at the Fisheries Division (FD) discussed the data collection plan, benefits and data use with fishermen. Fishermen agreed to participate with FD staff during the actual collection of catch, effort, and biological data. When the data collection started, some fishermen refused to give information or allowed FD staff to measure their fish. Later the fishermen told staff that female boat owners did not want them to talk with 'government people'. In addition, female vendors told them that they would not purchase fish handled (weighed and measured) by 'government people'. In many instances, the vendors 'own' the fish, i.e. many fishers have informal arrangements with them. One fisher said that he does not have to worry about the sale of his fish; he always sold it to one vendor. She takes the catch when demand is high and low. Sometimes when he does not have any money to purchase gas, the vendor gives him the money and credits it from the sale of his fish. At other times when the catch is bad, the vendor gives him money so he can provide for his family. Thus, fishers can be highly dependent on the vendors. Thus, when providing information on data collection activities, both male and female boat owners, vendors, fishers and (where appropriate) processors should be consulted.

Jentoft (1999) argued that women's issues, interests, and knowledge are not integrated in fisheries management. The first Maritime Conference for Women and the Fishery in Canada, identified the main strengths and limitations of women participating in policy making (Larkin 1995). The obstacles identified were: lack of confidence and low self-esteem; fear of defending their rights; and fear of large companies and international markets that dictates to government how they should manage resources. The strengths identified were: the ability to listen to the community and family; role as educators and organizers of their communities; having a sense of reality; flexibility and ability to easily adjust to change; and working for their communities. These strengths can increase networking and facilitate the integration of women's concerns in policy-making. In all the Caribbean countries studied, except Nevis, Fisheries Officers stated that women were involved in fisher associations, groups, or cooperatives. However, to what extent are they shaping fisheries policies and mobilizing communities to participate in planning in the region? Judging from the available information, the answer is, "not to any extent"; however, there are some exceptions. For example, in Jamaica, women were actively involved in management planning and policy development of the conch fishery.

In conclusion, women in the Caribbean, as in much of the world, are actively involved in fishing communities, but their activities are largely invisible to fishery managers. If the contributions of women to fishing households, communities, and fishing economies were taken into consideration, it would improve fisheries management and policy-making. So the next time you visit a fishing community, landing site, or fish market, remember the invisible women, observe closely their activities and contributions.

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Understanding the Texas Shrimping Industry Using Social and Economic Indicators

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ABSTRACT

Shrimping is big business in Texas. In 2001, commercial landings of all shrimp species totaled 37,326.3 metric tons with a value of US$195,006,060. This, however, does not mean that Texas shrimpers are having an "easy time of it." In its 2001 session, the Texas Legislature mandated a study of the shrimp industry and its fishery resources, including the "social and economic health" of the industry. To fulfill these requirements, a mail survey was conducted of all Texas shrimp fishers that held a Gulf, bay, and/or bait shrimp license in 2001. Rather than trying to get detailed business information from each licensee, an indicator approach was used to gauge how the industry was doing in social and economic terms. Questions that would yield conclusions regarding the health of the industry were asked in an effort to not be too obtrusive. Some reported their operation was profitable (49 %) but indicators showed the industry and its participants may be economically marginal. For example, 47 % indicated they did not have insurance for themselves or their families and 63 % reported no insurance on their primary boat. Further, 83 % would not encourage young people to enter the shrimping business. Almost one-half (48 %) reported a gross household income of less than US$40,000. Results on other variables were fairly consistent with those from previous social science studies of the shrimping industry in the region.

KEY WORDS: shrimping, socio-economic indicators, Texas

El Estudio de la Industria Camaronera de Tejas Atravez del Uso de Indicadores Económicos

Los camarones son un negocio muy grande en Tejas. En 2000, los aterrizajes comerciales de todas las especies del camarón sumaron 93.420.567 libras, con un valor de $267.114.510. Esto, sin embargo, esto no significa que los camorneros en Texas esten pasando por un buen periodo. En su sesión 2001, de Tejas legislatura asignó un estudio por mandato incluyendo la de la industria del camarón y sus recursos, del social y salud económica. de la industria. Para satisfacer estos requisitos, terminamos una encuesta sobre correo de todo el camarón de Tejas que ladran los pescadores que sostuvo un golfo, y/o licencia del camarón del cebo en 2001. Mientras que las entrevistas personales pudieron haber producido understandings más ricos la industria y su estado económico, de los costes y del

tiempo requeridos eran demasiado grandes para los plazos de la reunión impuestos por la legislatura de Tejas. Más bien que intentando conseguir la información detallada de cada concesionario, que del negocio habría conducido a un non_response más alto, utilizamos un acercamiento del indicador para calibrar cómo la industria hacía en términos sociales y económicos. Intentamos ser tan discretos como sea posible; preguntamos por consiguiente las preguntas que rendirían conclusiones con respecto a la salud de la industria, es decir si tenían seguro en su negocio y para sí mismos y/o sus familias. Los resultados demuestran que la industria pueden ser según se informa provechosos para algún (el 49 %) pero los indicadores demostraron esta industria y sus participantes pueden ser económicamente marginales. Por ejemplo, el 47 % lo indicaron no tenían seguro para sí mismos o sus familias y 63 % divulgaron no tener seguro en su barco primario. Además, el 83 % no animarían a gente joven que incorporara el negocio shrimping. Casi una mitad (el 48 %) divulgó una renta gruesa de la casa de menos de $40.000. Los resultados en otras variables eran bastante constantes con estudios sociales anteriores de la ciencia de la industria comercial a lo largo de la costa del golfo. Las recomendaciones para los estudios futuros se proporcionan junto con las implicaciones de la gerencia de los resultados.

PALABRAS CLAVES: Industria pesquera del camarón, indicadores económicos, Tejas

INTRODUCTION

Shrimping is big business in Texas. In 2001, commercial landings of all shrimp species totaled 37,326.3 metric tons with a value of US$195,006,060 (NMFS 2002). The Texas commercial shrimp fishery includes the shrimp fishery resource itself, habitat, harvesters in three license categories (Gulf, bay, and bait), and those involved in the sale (wholesale and bait shrimp dealers), distribution, and processing of shrimp for the market place. Just as it is not possible to know everything about the quality and quantity of shrimp resources in one single study, no one study can provide all possible social and economic insights to the Texas shrimp industry. The purpose of this paper was to investigate some basic indicators of the social and economic health of the Texas shrimp fishery.

In its 2001 session, the Texas Legislature mandated a Texas Parks and Wildlife Department (TPWD) sponsored study and legislative report on the "shrimp industry and resources." In addition to the more traditional study focus on the status of shrimp populations, marine resources, habitat, and conservation measures, the Legislature addressed the need for a social and economic perspective too, one that focused on "the economic health of the shrimp industry" and solicited feedback from a wide range of stakeholders.

METHODS

To fulfill the study requirements of the Texas legislature, a mail survey was sent to each license holder that held one or more of three commercial shrimp licenses in 2001: a Gulf shrimp license, a bay shrimp license, and/or a bait shrimp license. In order to complete the study and have a report available to TPWD in June 2002, a mail survey design was used rather than personal interviews. The latter approach has been used most frequently for studying commercial fisheries previously. To enhance rate of response, since shrimp fishers often held more than one license, each shrimper was sent only one questionnaire regardless of how many licenses they held.

Texas Parks and Wildlife provided us with a complete list of the aforementioned shrimp license holders for fiscal year 2001(September 1, 2000-August 31, 2001). The survey was sent to the entire population of license holders to elicit as large a sample as possible. This provided each shrimper an opportunity to be heard on the issues rather than just those able to attend public hearings or those that would have been selected if we had sampled the population. The questionnaire was developed in response to the language provided by the Texas Legislature and made use of questions used previously in other studies of commercial fisheries in the U.S. Gulf of Mexico. Input was also received from personnel in the TPWD Coastal Fisheries Division as to their particular data needs in support of the decision making process. The questionnaire was seven pages in length (two legal sized sheets of paper folded in a booklet format). The questionnaire was also translated into Vietnamese in an effort to increase response from this large segment of the shrimping industry.

Mail survey procedures recommended initially by Dillman (1978) and further refined by Salant and Dillman (1994) were used. All letters were mailed on Texas A&M letterhead designed specifically for this project. The envelope also had an identifier that made it clear that it contained a "Shrimp Fisherman Study" to enhance response rate. All mailings were personalized to the greatest extent possible; the names and addresses were printed directly on the envelope and the letters were addressed to "Dear Fred:" instead of "Dear Shrimper." A postage paid envelope was included with the questionnaire to facilitate the return of the survey to Texas A&M University.

The results presented in this paper are based on respondents only. Accordingly, results may be biased if non-respondents were found to differ from respondents. Names were randomly selected from the list of non-respondents and their phone numbers were located via the Internet. Names were randomly selected and telephoned until enough non-response surveys were completed to minimize Type I and Type II errors when testing for differences between the two groups. Overall, we contacted 98 non-respondents and asked only 12 questions from the questionnaire to maximize the likelihood they would answer our questions over the telephone.

There were statistically significant differences between non-respondents and respondents on the following three questions: the number of years they have been in commercial shrimping (d.f. = 392, $F = 8.84$, $p = 0.0031$), the average size of the crew on their primary boat "in the previous 12 months" (d.f. = 386, $F = 6.78$, $p =$

0.0096) and the type of business organization they have (d.f. = 5, $\chi^2 = 12.0571$, p = 0.034). Respondents had fewer years of experience in commercial shrimping, a larger sized crew on average, and were more likely to be corporations rather than sole owners. There were no statistically significant differences on the following three items which asked "since this time last year": whether they earned income from work other than shrimping, whether their spouse (if married) earned income from work other than shrimping, and the total number of days they have commercially shrimped on their primary boat in Texas waters. There were also no statistically significant differences on the following six items: the percentage of their gross household income that comes from shrimping activities, the percentage of their gross household income that comes from other commercial fishing activities, the percentage of their gross household income that comes from non-fishing activities, whether they consider themselves to be full-time or part-time shrimp fishers, the total pounds of shrimp harvested per year, and the estimated value of their primary boat.

We can make no claims as to the characteristics of non-respondents, only that there are statistically significant differences between respondents and non-respondents on those items collected from both groups. Therefore, generalizations about the population of shrimp fishers cannot be made.

RESULTS

Of the 2,309 questionnaires mailed to Texas shrimp fishers, responses were received from 361 individuals. Only 326 of these were returned usable; 441 questionnaires were returned by the U.S. Postal Service as non-deliverable. This resulted in an effective response rate of 19.3 %. Questionnaires that were returned but were unusable included refusals or those people that indicated they were no longer in the shrimping business. This response rate is extremely low compared to what Dillman (1978) indicates from other surveys using his "total design survey methodology" and response rates from other studies completed by the TAMU Human Dimensions of Fisheries Research Lab.

Most (33 %) shrimpers were between the ages of 41 and 50, with an average age of 52 years. A majority (96 %) were male. Most (58 %) graduated from high school, with the mean highest grade completed of 11th grade. It is notable that 42 % did not graduate from high school. A majority (64 %) considered themselves white and a sizable percentage (28 %) considered themselves Vietnamese. Most (38 %) have two persons living in their household, with an average of three persons (Table 1).

Table 1. Percent Distribution of Texas Shrimpers By Age, Grade Level, Race, And Number Of People in Household

AGE	% (n = 303)	GRADE LEVEL	% (n = 326)	RACE	% (n = 310)	NUMBER OF PEOPLE	% (n = 304)
21 to 30	2.6	Less than 8th grade	23.6	White	64.2	One	8.9
31 to 40	15.8	Some high school	18.7	Black or African American	1.3	Two	37.8
41 to 50	33.0	High school graduate	34.7	American Indian or Alaskan native	1.0	Three	16.5
51 to 60	24.4	Some college	15.3	Vietnamese	28.1	Four	13.8
61 to 70	14.5	College Graduate	5.5	Other Asian	1.3	Five	10.5
71 +	9.6	Graduate	2.2	Other race	4.2	Six +	12.5
TOTAL	100.0		100.0		100.0		100.0
Mean	51.6		11.2				3.3

Almost one-half (48 %) reported a gross household income of less than US$40,000. Most (47 %) Texas shrimp fishers reported that they did not have health insurance; 41 % reported that they had health insurance for themselves and their family (Table 2). A majority (59 %) of shrimpers did not earn any income from work other than shrimping "since this time last year." There were nearly equal proportions of shrimpers that indicated that their spouse (if married) earned income (44 %) or did not earn income (43 %) from work other than shrimping "since this time last year" (Table 3).

A majority (64 %) of shrimpers purchased their primary boat from another owner. For those shrimpers that bought their primary boat new (n = 112), most (30 %) bought it from 1979 to 1984; nearly equal percentages bought their boat prior to 1978 or within the last five years (24 % and 22 %, respectively). For those shrimpers that bought their primary boat from another owner (n = 195), most (43 %) of the boats were built prior to 1978 (Table 4).

Table 2. Percent distribution of Texas shrimpers by gross household income and whether they have health insurance for themselves and/or their family

Income	% (n = 280)	Insurance?	% (n = 311)
Under $39,999	47.5	No Insurance	46.9
$40,000 to $99,999	40.4	Self only	8.1
$100,000 to $159,999	8.2	Family only	4.2
Above $160,000	3.9	Self and family	40.8
Total	100.0		100.0

Table 3. Percent distribution of Texas shrimpers by whether they or their spouses earned any income from work other than shrimping "since this time last year"

Earned Income?	Themsleves (n = 314)	Their Spouse (n = 311)
Yes	40.8	43.7
No	59.2	43.1
No spouse	–	13.2
Total	100.0	100.0

Table 4. Percent distribution of those Texas shrimpers that bought their primary boat new (including having it built) or used by the year in which it was bought

Year	Bought New (n = 112)	Bought Used (n = 195)
Older than 1978	24.11	42.57
1979 to 1984	30.36	28.72
1985 to 1989	9.82	15.38
1990 to 1995	13.39	6.15
1996 to 2001	22.32	7.18
Total	100.00	100.00

Most (38 %) reported that between 91 % and 100 % of their household's gross annual income comes from shrimping activities. Similarly, a majority (85 %) indicated that none of their household's gross annual income comes from other commercial fishing activities, and half of the respondents indicated that none of their household's gross annual income comes from non-fishing activities (Table 5). It is notable that 11 % responded that between 91 % and 100 % of their income comes from non-fishing activities.

Table 5. Percent distribution of Texas shrimpers by the percentage of their household's gross annual income that comes from listed activities (n = 284)

Percentage	Shrimping Activities	Other Commercial Fishing Activities	Non-fishing Activities
0	9.9	85.5	50.0
1 to 10	9.2	5.3	3.9
11 to 20	3.5	1.4	5.6
21 to 30	7.4	1.4	4.2
31 to 40	3.2	0.7	3.9
41 to 50	9.5	1.8	5.3
51 to 60	5.6	1.4	2.5
61 to 70	3.9	0.7	4.2
71 to 80	7.0	0.7	4.9
81 to 90	2.8	0.4	4.6
91 to 100	38.0	0.7	10.9
Total	100.0	100.0	100.0

A majority (71 %) of shrimpers consider themselves to be full time. A majority (63 %) of shrimpers do not carry insurance on their primary boat. A majority (83 %) would not encourage young people to enter the shrimping business; however, the majority (77 %) of shrimpers do expect to be shrimping in four years. Finally, almost half (49 %) indicated that their shrimping operation is profitable (Table 6).

Table 6. Percent distribution of Texas shrimpers by selected economic indicators

Economic Indicator	Yes	no
Full time (n = 311)	71.4	28.6
Insurance on primary boat (n = 311)	37.3	62.7
Encourage young people to enter shrimping business (n = 316)	17.1	82.9
Expect to be shrimping in four years (n = 317)	77.3	22.7
My operation is profitable (n = 290)*	48.6	51.4

* This item was measured on a 5-point Likert type scale ranging from "Strongly Disagree" to "Strongly Agree." The percentage was calculated by summing "Agree" and "Strongly Agree" for 'Yes,' and "Neutral," "Disagree," and "Strongly Disagree" for 'No.'

DISCUSSION

Despite every effort at making the mail questionnaire as "user-friendly" as possible, a relatively low response rate was achieved. The low response rate, coupled with the differences between the respondents and the non-respondents, limits the ability to generalize these results to the entire population of license holders, but does provide valuable information in support of decision-making. Some shrimp industry leaders have suggested that the comprehensive data collection and longitudinal analysis approach currently being employed by Haby (2000) with a limited number of Gulf shrimp boat operators on the lower coast might be a more preferred method for this study. While Haby (2000) may provide a more in-depth profile, it also suffers from the ability to expand to the entire population and is a profile based on even fewer respondents. While our response rate is lower than preferred, it is similar to response rates to mail surveys used in previous commercial fisher studies (Acheson 2001 [24.5 %]; Guillory et al. 2001 [23 %]).

Despite the aforementioned limitations, many of our results are comparable to those from other social and economic studies of the commercial fishing industry in the region. This provides an additional check on non-respondent bias and some additional comfort with respondent data. In terms of the social and demographic characteristics of shrimpers, for instance, our finding that 74 % of Texas shrimp fishers were between 31 and 60 years of age is comparable to 75 % of commercial blue crab fishers being between the ages of 31 and 59 (Guillory et al. 2001). This study found differences from those of Maril (1983) as it reports 18 % of Texas shrimp fishers (overall) are under 40 years of age. The Maril (1983) study reported that 34 % of Gulf shrimp fishers are less than 35 years old, perhaps a result of the time lapse between studies. The mean age of Maril's (1995) sample was 42 years old; the mean age reported for this study was 52 years old. This is plausible given that the population of shrimpers is aging. Maril (1995) also reports that about one-third of his sample were 50 years or older; findings for this study indicate 49 % were in that category. A study of Louisiana fishers found similar results, as the average age reported for Louisiana shrimp fishers was 47 years old (Deseran 1997) compared to 51 years old for Texas shrimp fishers. In Louisiana, less than 17 % were under 35 years of age with more than 30 % over 54 year of age. Finally, the average age of Texas spotted seatrout and red drum commercial fishers was similar (44 years of age) (Ferguson 1986) to the average age of shrimpers in this study (52).

Level of education between our sample and those in previous studies can also be compared. In Louisiana, 43 % of the shrimp fishers reported they attained a high school diploma (Deseran 1997) compared to 58 % of the shrimpers in Texas. About 30 % of blue crab fishers did not graduate from high school (Guillory et al. 2001) with slightly more (42 %) Texas shrimp fishers in this same category. Commercial gill netters in Florida also reported limited education levels (Thunberg et al. 1994).

Maril (1995) reported that his sample of Texas bay shrimpers was 68 % white, 15 % Mexican, 10 % Vietnamese, and 7 % black or African-American. Similar results for all license holders were found in this study. Texas shrimp fishers license holders were 64 % white, 12 % Mexican-American, and only 1 % black or African-

American; 28 % considered themselves to be Vietnamese. This may be due to an increasing number of Vietnamese Gulf license holders; Maril (1983) reported no Vietnamese Gulf shrimpers in his sample. Also, as Deseran (1997) reported, most (29 %) Louisiana shrimp fishers have two persons in their household, which compared favorably with the finding that 38 % of Texas shrimp fishers have two persons in their household.

In Louisiana, 37 % earned income from work other than shrimping and 31 % of their spouses earned income from work other than shrimping (Deseran 1997); 41 % and 44 % were reported in these same categories, respectively, in Texas. Previously, Maril (1995) reported that only 24 % earned income from other kinds of work. The heavy dependence on the fishery for income is also comparable to commercial gill netters in Florida; the average percentage of the household income from their respective fishery was 73 % for commercial gill netters (Smith 1994) compared to 61 % for Texas shrimp fishers. The 41 % of Louisiana shrimp fishers that shrimp full time (Roberts 1989) is in sharp contrast to the 71 % of shrimp fishers that consider themselves full time shrimpers in Texas.

Whether or not shrimpers have some form of health care coverage in these times of rapidly escalating medical costs should indicate something about their ability to take care of themselves. While Maril (1995) reported that only 1 % of his sample had health insurance when he completed his study, 53 % reported they had some form of health insurance for themselves and/or their families. This may be due to TexCare, health insurance from the state of Texas for those families who make too much money to qualify for Medicare but cannot afford commercial health insurance. It is notable, however, that this type of insurance is only for children. Other explanations involving increased Medicare coverage could also be the reason for the improved coverage. Lastly, there may have been differences in the respondents between the two surveys with a higher percent of those having insurance choosing to respond or it could be based on different survey enumeration techniques.

Prior studies report that the median income for captains on Gulf shrimp boats was US$22,400 (1979 dollars, or US$58,500 when adjusted to 2001 dollars) (Maril 1983), current results indicate that most licensed shrimp fishers in Texas earn between US$20,000 and US$39,999. Maril (1995) reported that the average earnings from a bay shrimp boat to be around US$20,000 (1988 dollars, or US$29,900 when adjusted to 2001 dollars).

Not only is the population of shrimpers aging but so too are their vessels. As Haby et al. (2000) reported, "a large proportion of the boats that comprise the Gulf shrimp fleet are approaching twenty years of service." This is consistent with our findings: 54 % of the boats that were bought new were bought prior to 1985 and 71 % of the boats that were bought used were built prior to 1985. It is notable that most Louisiana shrimp boats were built in the 1970s or 1980s, or about the same time as most Texas shrimping vessels (Deseran 1997). Maril (1995, p.61) reported that "bay shrimp boats are not usually insured"; we found that 63 % of all shrimp boats are not insured. Whether they are unable to get insurance on their boats or to pay the high costs of boat insurance, the finding that nearly 2/3 of the boats are

uninsured provides insight to the economic health of this industry. Being able to cover the costs of fuel and labor is essential but apparently financial returns after expenses are insufficient to cover the cost of insuring their business facility.

The results of this study on some of the social and economic indicators can also be compared with Texas population estimates from the U.S. Census Bureau. For instance, 58 % of Texas shrimp fishers reported completing high school. The percentage of the Texas population age 25 years and over that graduated from high school was estimated at 79 % (U.S. Census Bureau 2000a). Also, it is estimated that 79 % of all Texans are covered by some sort of health insurance (U.S. Census Bureau 2000b). This is considerably higher than the 53 % of Texas shrimp fishers with some sort of health insurance.

These results indicate a certain amount of social and economic marginality for the shrimping industry, i.e. this is a group that appears to produce goods at a rate that barely covers production costs. It was surprising that about one-half (49 %) reported that their shrimping activity is profitable. Other indicators show that they may not have what some would consider basic necessities of life (i.e., health insurance). It is also disturbing that high percentages of this group would not encourage young people to enter into the business, perhaps a reflection of the growing complexities of fisheries management and realization that their profits are shrinking in an increasingly global economy. While many of the shrimpers and the industry that they support may not be able to work other jobs due to their lack of education, the next generation may feel that shrimping is not a viable work alternative. With the growing number of shrimp licenses being retired due to the limited entry program in Texas (TPWD 1999), perhaps they will see their profits will grow in the future. Only with future monitoring of the social and economic indicators presented here will decision makers be able to determine the effects of the many influences affecting the businesses of these commercial fishers. Regulations, imports, world markets, costs of fuel, ice, etc. all can affect their profitability and livelihoods.

MANAGEMENT IMPLICATIONS

If an indicator approach to understanding the economic health of the industry had not been used, but instead a survey of detailed social and economic data like that provided on income tax returns, the response rate for this study would probably have been even lower. A common refrain that was heard when talking about this survey to industry members was: "The more we talk to people like you [University and government researchers] and provide you with information and data, the more rules and regulations that affect shrimping get put in place." These conversations and comments provided by respondents and non-respondents indicate a distrust of government-sponsored studies relevant to this industry.

Due to the issues of mistrust, it may be extremely difficult to collect data with adequate sample sizes and comparability on this industry through time. Other data collection methods may have to be examined. Licensing requirements could require

a higher level of data reporting. Vessel monitoring systems to collect effort data may be an alternative to questionnaires. Use and refinement of this type of indicator approach may provide valuable insights into the health of the fishery while being more palatable to industry.

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A Review of Fisheries Management in the Dominican Republic

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ABSTRACT

The Dominican Republic shares the island of Hispaniola with Haiti. The country has a total area of 48,442 km^2, a narrow insular shelf of 9,484 km^2 and an EEZ of approximately 238,000 km^2. Around 10,000 artisanal fishers with a fleet of 3,750 boats, operate from the 1,575 km of coastline to exploit the fisheries resources of the country. The fisheries sector is made up mainly of artisanal fishers, with high levels of import accounting for more than 50 % of local fish consumption. With average annual production of 11,600 MT, the fishery is believed to be exploiting the traditional resources at or beyond their maximum sustainable yields. The main threats identified in the coastal zone include: overfishing, degradation of critical habitats; poorly managed boating, recreational diving, increased tourism, and stress from coastal development and population growth.

In June 2000 the CARICOM Fisheries Unit, in collaboration with the Government, initiated a program to improve management of fisheries. Preliminary assessments confirmed that there are major deficiencies in the institutional and organizational system for sustainable development and management of the fisheries and aquaculture resources. Significant improvements are needed in: the institutional arrangements and capacity for planning and policy formulation; the systems and capacity for research and collection of data; and the arrangements for extension services, monitoring, control and surveillance. There is also a need for greater organization and involvement of fishers in fisheries planning and decision-making regarding the fisheries. On the positive side there is strong political will to improve the fisheries sector with the support of national and international partners. In this paper a review of past and current management measures is undertaken and recommendations are provided for strengthening the sector.

KEY WORDS: Fisheries management, Dominican Republic

Una Revisión del Manejo Pesquero en la República Dominicana

La República Dominicana comparte la isla de La Hispaniola con Haití. El país tiene un área total de 48, 442 km^2, una plataforma insular estrecha con 9, 484 km^2 y una zona económica exclusiva de aproximadamente 238,000 km^2. Cerca de 10,000 pescadores artesanales, con una flota pesquera compuesta por unas 3,750 embarcaciones, operan desde los 1,575 km de línea costera para explotar los recursos pesqueros del país. El sector pesquero esta formado principalmente por pescadores artesanales, mientras el alto nivel de importación alcanza mas del 50%

del consumo total de pescado. Con una producción anual promedio de 11 600 TM, se considera que los recursos pesqueros están siendo explotados hasta o más allá de su rendimiento máximo sostenible.

Las principales amenazas identificadas en la zona costera incluyen: sobrepesca, degradación de habitats críticos, manejo inadecuado de las embarcaciones, buceo recreativo, incremento en el turismo, y estrés debido al desarrollo costero y al crecimiento de la población. En Junio del 2000 la Unidad de Pesca del CARICOM, en colaboración con el Gobierno, inició un programa para mejorar el ordenamiento de las pesquerías. Evaluaciones preliminares confirmaron que hay grandes deficiencias en el sistema institucional y organizativo para el desarrollo y manejo sostenible de los recursos pesqueros y la acuicultura.

Un mejoramiento significativo se hace necesario en lo siguiente: los arreglos institucionales y la capacidad para la planificación y la formulación de políticas; los sistemas y la capacidad para investigación y colecta de datos y en los arreglos para los servicios de extensión, monitoreo, control y vigilancia. Hay también una necesidad de una mayor organización y envolvimiento de los pescadores en la planificación y en la toma de decisiones con respecto a las pesquerías. En el lado positivo, hay un deseo político fuerte de mejorar el sector pesquero con el apoyo de agencias de colaboración internacional. En este documento se lleva a cabo una revisión de las medidas de manejo pasadas y presentes y se proveen recomendaciones para el fortalecimiento del sector.

PALABRAS CLAVES: Manejo pesquero, República Dominicana

INTRODUCTION

The Dominican Republic (DR) is located in the Caribbean (19^0 00' N, 70^0 40' W) occupying the eastern portion of the volcanic island of Hispaniola (the second largest island on the Antilles) which it shares with Haiti. The total area of the country is 48,442 km^2 and the total population has been estimated at 8.5 millions. The Dominican Republic is bordered by the Atlantic Ocean to the North, the Caribbean Sea to the South, Haiti to the West, and separated from Puerto Rico by the Mona Passage to the east. It has a continental platform of 9,484 km^2, an Exclusive Economic Zone of 238,000 km^2 and a coastline of 1,575 km. The biological diversity of the Dominican Republic includes broad areas of coastal lagoons, mangroves, sea grass beds, coral reefs, soft bottom areas and sandy beaches.

Under the fisheries component of the European Union funded Integrated Caribbean Regional Agriculture and Fisheries Development Programme (ICRAFD) in June 2000 the CARICOM Fisheries Unit (CFU) initiated a program to improve fisheries management, in collaboration with the government of the Dominican Republic. As part of the initiation process a fisheries country profile was prepared based on the literature available on the web and at the CFU library. A team of fisheries professionals from the CFU then visited the Dominican Republic in July

2000 to assess the situation on the ground, meet key stakeholders and gather information to prepare a five year work plan to strengthen fisheries management in the DR. The team gathered information through literature review of existing documents, discussion sessions with the Director and staff of the fisheries department, and meetings with policy makers and other stakeholders in the fisheries sector. Information was also collected through a multi-disciplinary survey, which was initiated during the mission. As a result of the review, consultations and survey, a 5-year work plan was prepared, jointly signed by the Minister responsible for fisheries and the CFU, and is in the process of implementation.

SURVEY AND LITERATURE REVIEW RESULTS

The fisheries sector contributes approximately 0.5 % of the country's GDP. The sector is made up mainly of small-scale operators with an average annual production of 13,000 MT and imports accounting for more than 50 % of local fish consumption. The most important problems in the coastal zone and in the fisheries sector in the Dominican Republic are: coastal development and population growth, inadequate monitoring, control and surveillance; poorly regulated boating, diving and tourism related activities, lack of economic support for fisheries management, overfishing, and environmental degradation resulting in stock depletion due to pollution and the use of destructive fishing gears and practices; lack of funds to acquire suitable equipment and accessories to experiment with innovative, and sustainable fishing techniques; lack of effective participation of resource users in fisheries governance; lack of appropriate technology and infrastructure for fish handling, storage and distribution of the catch, and problems with marketing the produce during certain seasons of the year.

Fishing Activities and Fishing Fleet

According to the fisheries department, there were around 10,000 artisanal fishers in 2000 who operated from a fleet of 3,750 boats [Dories: 2,136 (59 %), Kayak: 1,418 (37.8 %), *Bote*: 117 (3.1 %), *Pivote*: 19 (0.5 %), and *Ship*: 62 (1.6 %)] (Colom, et al. 1993; Department of Fisheries, 2002) and are involved in the exploitation of the marine fisheries resources of the country. The labor force in the secondary sector has been estimated at 2,500 while 46,500 persons are employed indirectly in the fishing sector. About 50 % of fishers have attained primary level education. Although fishing activity is mainly artisanal, there are also small semi-industrial and industrial fisheries that take place in the EEZ, on the high seas or in the waters of neighboring countries.

Marine fishers land their catch at approximately 200 landing sites in 16 coastal provinces. Silva (1991) reported that 324 species of fishes (287 bonefishes), crustaceans and mollusks have been identified in the coastal-artisanal fishery of the southwestern Dominican Republic. The main species groups targeted by the commercial fisheries are lobsters, conch, shrimp, shallow shelf and deep-slope reef fishes and coastal pelagic fishes.

According to the fisheries department statistics, from 1992-2000 the average annual production was 13,000 MT. For 1999 the import value was US$ 87,592,840. During 2001 the DR imported 39,637.80 MT of seafood products (36,172 MT of finfish, 970 MT of crustaceans, 1,538 MT of mollusks, 957 MT of fish food, and 23,877,163 units of other specimens (nauplius, larvae, turtles, etc). During the same year, the DR exported 393 MT of sea food plus 245,972 units of crabs, ornamental fishes, coral pieces, turtles, conch shell, etc. (Table 1)

Table 1. Reported total production from 1992-2000

Year:	Production (MT)
1992	13,169.0
1993	12,949.0
1994	13,028.6
1995	18,661.6
1996	13,192.6
1997	14,536.1
1998	10,069.2
1999	8,518.1
2000	13,153.6
Total for the period	117,277.8
Mean	13,030.9

Aquaculture operation is making a small but increasingly important contribution to the economy of the Dominican Republic. There are 167 hectares of aquaculture ponds in operation, 127 hectares of which are managed by the private sector. The main species cultured are tilapia, carps, and marine and freshwater shrimps. The aquaculture production is aimed at supplying both internal and external markets. The government operates a twenty hectare research and hatchery facility to produce juveniles to replenish dams, rivers and lakes, and also for the promotion of rural aquaculture. Aquaculture production in 2000 was approximately 488 MT.

Ornamental fishery is a small sub-sector of the marine fisheries. Three establishments located in Montecristi capture and export approximately 33 species of ornamental fishes. From 1996 - 2002 the average number of ornamental fishes exported from the Dominican Republic was 34,317 each year.

STATUS OF THE FISHERIES AND FISHERIES MANAGEMENT

The fisheries of the Dominican Republic are multi-species in nature. As a consequence, there is limited flexibility for managing individual species, except for conch, lobster and large pelagics. Management necessarily will have to be aimed at optimizing yield from the entire shelf and not on a species-specific basis (Appeldoorn and Meyers 1993). Overfishing, the use of destructive fishing techniques, rapid growth in fishing effort (number of fishermen, boats and fishing gears) are together driving a steady reduction in the abundance of commercially important species such as lobster, conch and finfish.

The queen conch (*Strombus gigas)* was up to the year 2000, the most important

fishery resource of the Dominican Republic in terms of volume of catch. It is exploited for both local consumption and export. Local stocks are believed to be overfished. Until 1995 the only specific regulation in place for the queen conch was Decree 312 of 1986, establishing a syphonal length of 25 cm as the legal minimum length. As a consequence of recommendations made by studies conducted by Appeldoorn and Meyers (1993), Tejeda (1994, 1995) and Posada and Mateo (1998), another Decree (No. 269-99) was promulgated in 1999 to strengthen the management framework for *Strombus gigas*. The decree introduced several specific measures to protect the stocks and regulate harvesting and sale, including establishing a nation-wide close season for fishing from the 1st of July to the 31st of October each year. The decree also prohibits the traffic, sale and export of conch meat during the close season, and the capture of queen conch, on a permanent basis, in certain critical habitats, including the Catuano Channel, situated between Palmillas and Catuano, and between Punta Aljibe and Punta Balajú, Parque Nacional del Este. Similarly, the decree prohibits conch fishing within the Southeast coast of Beata Island from the tide line to a depth of 50m.

Although Decree No. 269-99 came into force in 1999, it has not been adequately publicized and assimilated by the fishers and vendors. Neither the government nor the local NGO community has conducted public awareness and education programs to sensitize resource users and other stakeholders of the provisions of Decree 269-99, and consequently the level of compliance with this Decree is very low.

With lobster tail being sold in the local supermarkets for the equivalent US$12.00 per pound, and around 2,000 fishers involved in the fishery, the spiny lobster is the single most valuable fishery resource of the Dominican fishery. From January to May 2002 the landings of the spiny lobster amounted to 1,696 MT (Dirección de Recursos Pesqueros, 2002). The main lobster fishing ground is the southwest shelf around the area of Pedernales. There are decrees and law (Law 5914 of 1962; Decree 1345 of 1967; Law 565 of 1970; and law 64-00 of 2000) for the management of *Panulirus argus* and other fisheries in the Dominican Republic. These statues are designed to regulate the fishery by controlling the harvesting, possession and sale of female lobster from March 1-August 31 each year, establishing a minimum size for catch of 24 cm TL; and nation-wide close season from April 1st -July 31st.

The shrimp fishery in Samaná Bay is considered the most important unit of the coastal fishery in the Dominican Republic due to the large number of fishers (3,000) from the surrounding areas who are dependent on this fishery. Shrimps are caught using gill, dragging and circular nets. The use of dragging and gill nets are prohibited in Samaná Bay (Decrees 343 of 1987 & 334 of 1989), but are still commonly used in the shrimp fishery.

The main finfish families in the catch are Lutjanidae, Serranidae, Scombridae, and Haemulidae. The capture of groupers during the spawning season from January to June is prohibited by Decree 2099-84; however, groupers are common in the catch around the year. Also, the sale of barracudas, (*Sphyraena barracuda* and *S. picudilla)* and the jack, (*Seriola rivolana)* is prohibited by Decree 313 of 1986.

These regulations are largely ignored and the target species can generally be found in the local markets and restaurants throughout the year.

Fisheries Management Institutions in the Dominican Republic

There are several institutions in the Dominican Republic with overlapping responsibility for fisheries development and management, including the following:

i) The Directorate of Fisheries Resources (DOFR) is a part of the Ministry of Environment and Natural Resources which was created by Law 64-00 of 2000 after the establishment of the new government in August 2000.
ii) The Director of the DOFR reports to the Sub-secretary responsible for Coastal and Marine Resources. The Fisheries Department, Ministry of Agriculture is responsible for fisheries surveillance, aquaculture production, extension and promotion. This department is headed by a director of fisheries.
iii) The Office of a National Coordinator of Fisheries and Aquaculture who is responsible for overseeing and coordinating all projects and activities being undertaken by the 2 main fisheries departments mentioned above.
iv) The Department of Conservation and the Department of Environmental Education of the Ministry of the Environment are two other government departments which are involved in management of the fisheries sector.
v) The Navy is responsible for monitoring, surveillance and enforcement of fisheries laws and regulations.

The fragmented and overlapping responsibilities of these public sector agencies tend to create inefficiencies and even confusion in some cases. There is clearly a need for rationalization and improved coordination of actions among these agencies.

The DOFR appears to be the main fisheries management agency. The stated policy priorities are: sustainable management, fisheries development, full employment and environmental protection. The DOFR has a staffing of 30-40, and two main sub-divisions, the Department of Fisheries and the Department of Aquaculture. In addition there are two specialized regional agencies PROPESCAR-SUR in the Southwest, and CEDEP in the Northeast, which are responsible for extension and data collection activities in their respective locations.

The main functions of the Directorate of Fisheries include:

i) Licensing and registration of fishers
ii) data collection and monitoring of the fisheries
iii) research
iv) development of cooperatives
v) aquaculture development
vi) management of the ornamental fishery
vii) provision of extension services to the fisheries sector
viii) post-harvest technology, and
ix) quality assurance.

The DOFR is currently involved in the establishment of "Stations of Service and

Fisheries Administration" at different geographical areas across the country. The purpose of this new organizational system is to decentralize management and administration to improve sustainable development of fisheries and aquaculture. These new administrative units are expected to assist with mapping of habitat and resources within the areas under their responsibility, collecting basic statistical data and providing extension services to the community.

Legislation, Monitoring, Surveillance and Enforcement

The main legislation under which fisheries operate is the Fisheries Law 5914 of 1962. Fishermen and fishing boats are required by the law to be licensed and registered with the Ministry of Agriculture but only about half of the fisher and boats are believed to be so licensed and registered.

Fisheries surveillance and enforcement is under the responsibility of both the Fisheries Department and the Navy. Both organizations have Fishery Inspectors who are responsible for monitoring and enforcement. The stakeholders recognize the role and authority of both the military and the Fisheries Department in respect of surveillance and enforcement. They, however, consider the Fisheries Department ineffective in executing this responsibility. The military is considered more effective in enforcement but is also considered unnecessarily violent and arbitrary when handling offenders. Violators of the fisheries statutes are generally prosecuted under Article 47 of Law 5914 of 1962, but corruption, lack of equipment, insufficient logistical support, and very low fines, undermine the effectiveness of the legislation and management regulations. Enforcement of fisheries regulations is generally weak and compliance of resource users and traders with the regulations is also generally low.

Illegal and unregulated fishing and non-compliance with the laws and regulations designed to protect and conserve the resources in the Dominican Republic is regarded as a major problem that needs to be resolved in the near future to ensure long-term sustainability of the fish stocks.

The scarcity of resources to devote to monitoring, control, surveillance (MCS) and enforcement activities underscores the need to enhance involvement of fishers and their community in development and implementation on measures designed to protect and manage fisheries. Enforcement personnel should work more closely with resource users and their communities to ensure that they share greater responsibility for resource protection and management. Community policing techniques should be encouraged and promoted throughout the region (Haughton 2003).

In March 2000, a proposal for a new Fisheries and Aquaculture Law for the Dominican Republic was discussed by stakeholders. The main objective of the proposed law is the establishment of sustainable fisheries systems based on the principles of responsible fishing. With this purpose in mind, the legal and administrative arrangements related to exploitation of the fisheries resources should be based on the best available scientific information, using the best available technology and environmental practice, in order to guarantee the sustainability and

conservation of the ecosystem (COSERENAMA 1999).

The creation of a new organization, the Dominican Institute of Fisheries and Aquaculture, has been proposed to strengthen the national capacity for sustainable fisheries development. The proposed law also provides for the following measures and procedures:

i) Regulation of fishing activities and access of foreign fishing boats to Dominican Republic waters,
ii) Designation of areas for aquaculture development,
iii) Modification, suspension, and denial of fishing permits,
iv) Payment of taxes,
v) General measures for management of lakes,
vi) General prohibitions and measures for conservation and protection of aquatic and biological resources,
vii) Administration of protected and no-take reserves,
viii) Limitation of fishing effort,
ix) Protection of species,
x) Close seasons,
xi) Minimum length for capture, and
xii) Other measures to protect the fish stocks.

The new proposal seems to lack, clear definitions about what resources need to be protected and what specific resources should not be captured or commercialized. The proposal has been criticized for not providing enough detailed information about legal minimum sizes, close seasons to adequately protect and conserve key species, and, lack of specifications with respect to fishing gear permitted. This may be due to limitations and uncertainty regarding the biological and technical aspects of the resources in question. In any event such details could be addressed by subsidiary statutes made under the main law.

Policies and Plan for the Fisheries Sector

Government policies and plans for development and management have been articulated in the legislation and national plans. Several national fisheries plans have been prepared for the Dominican Republic since the early 1980s.

Fisheries Development Limited (1980) in coordination with the Instituto Dominicano de Tecnología Industrial (INDOTEC), prepared a comprehensive report on the fisheries with recommendations for development, addressing socio-economic and technological issues, harvesting, and research. ONAPLAN (1983) provided recommendations for scientific and technological policies for the sector.

The Japan International Cooperation Agency (JICA), in collaboration with the Ministry of Agriculture conducted a basic study of the coastal fisheries and prepared projects to address some of the issues identified (JICA/SEA 1992). The most recent work plan designed for the fisheries of the DR was prepared by CFU (2000) in collaboration with the Directorate of Fisheries Resources of the Ministry of Environment and Natural Resource. This plan addresses some of the necessary actions to improve fisheries management in the DR.

With the exception of the on-going CFU supported work plan the other plans have focused more on fisheries development rather than on management, and in consequence, the fisheries have experienced rapid growth during the past two decades. It is necessary to prepare and implement clear policies for the sector, based on knowledge of the status of the resources and their natural limitations, with full involvement of resource users and other stakeholders in the process.

Regional Organizations/Institutions of Fishery Cooperation

The Dominican Republic participates either as a member or observer in the activities of several fisheries cooperation organizations including: CARICOM, COPESCAL, IOCARIBE, ACS UNEP, PNUMA, COPACO, OLDEPESCA and WECAFC. The participation of the Dominican Republic in ICCAT would also be of great interest to fisheries management and to the protection of pelagic resources in Dominican waters, the Wider Caribbean and Atlantic Ocean (Rodriquez and Herrera 2001).

Policy Priority Areas

According to the results of the multidisciplinary survey conducted by the CFU, the policy priority areas for the fisheries authorities can be summarized as: sustainable management, fisheries development (including food self-sufficiency and full employment) and environmental protection.

Food self-sufficiency and full employment would tend to shift strategies in policy in favor of fisheries development, while environmental protection and sustainable management would lay emphasis conservation. The problem is how to balance these two apparent contradictory positions in the process of implementation. Strong managerial skills of the fisheries administrators, and the support and involvement of the resource user groups and stakeholders is critically needed (Brown 2001).

There are some transnational issues that the fishing sector of the Dominican Republic has to resolve. For example, a number of boats from the DR fish in foreign waters. Fishermen and fishing boats from the DR operate in the waters of The Bahamas, Turks and Caicos Islands, Jamaica, and the Saba Bank (Appeldoorn and Meyers 1993, CFU 2000). In some cases dozens of fishermen and other fisheries workers from the Dominican Republic are legally employed on Bahamian and Jamaican fishing boats. Unfortunately, that is not always the case, and the Dominican fishers are known for IUU fishing. Likewise fishermen from Haiti operate illegally in the Dominican Republic. Conflict resolution among stakeholders of the Dominican fishery industry and other CARIFORUM member states has been identified as a priority activity to be resolved through consultations and the establishment of bilateral agreements. The CFU has facilitated preliminary meetings between government officials from the DR and Turks and Caicos Islands, DR and Jamaica, and DR and The Bahamas. These meetings represent a good starting point to improve cooperation among the countries and reach formal agreement to fight IUU fishing.

The CFU Project

The CARICOM Fisheries Unit and the Directorate of Fisheries Resources prepared a five-year work plan in 2000, which is being implemented under the European Union funded Fisheries Component of the Integrated Caribbean Regional Agriculture and Fisheries Development Project (CFU 2000). The Work Plan is being implemented and is seeking to address some of the critical issues affecting the fisheries sector in the Dominican Republic by focusing on:

i) Development of clear and adequate planning and policies framework,
ii) Improving the fisheries database, information management systems and flow of information to stakeholders for planning and management decision making, and
iii) Strengthening human and institutional capacities for administration, fisheries research, resource management and conservation;

As a first step of the ICRAFD work plan for the Dominican Republic, a strategic review of the organizational structure of the DOFR was completed in 2001 (Rodriquez and Herrera 2001) and resources to assist with the implementation of the agreed recommendations have been provided. Also, a comprehensive review of the fisheries data collection system of the DOFR was conducted in 2001 (Medley, 2001) and support provided for implementation of the recommendations, including the provision of computer systems and training of data collectors. Long and short-term trainings scholarships have been provided to University students and fisheries officers of the Dominican Republic. A scholarship was provided to a DOFR fisheries officer to undertake a M.Sc. in Management of Coastal Resources in Spain and two university students are currently conducting of a review of historical fisheries data of the Dominican Republic. Several short-term training workshops have been delivered to fisheries field officers and other stakeholders covering topics such as capacity building workshops on socioeconomic aspects of fisheries, data collection and statistics, resource assessment, and resource management. At present, CFU in collaboration with the Directorate of Fisheries of the DR is in the process of finalization of a fisheries management plan with includes individual plans for the major fisheries resources. Other on-going activities include a nation-wide census of conch and lobster fisheries, arrangements for an underwater survey of lobster and conch, establishment of a national fisheries dialogue group involving stakeholders in the fisheries sector (CFU 2001, CFU 2003).

DISCUSSION AND CONCLUSION

The current situation of fisheries management in the Dominican Republic is still a challenge due to the overlapping functions among several governmental agencies and limited resources. Even though there is goodwill from the government authorities to develop the country's fisheries sector, these efforts need to be coordinated within a national management program; that will necessarily require improved knowledge of the status of the resources, capacity building and awareness

campaigns, empowerment, and greater involvement of the resource users and others stakeholders in all levels of fisheries management.

Nowadays, in many coastal areas tourism is replacing fisheries and agriculture by providing a new source of income for coastal communities. Yet, the low level of development, widespread poverty, lack of basic services and infra-structure, and environmental degradation characterize the situation of many of the Dominican coastal communities where large numbers of persons depend on the exploitation and commercialization of fisheries resources for survival. In many cases, fisheries continue to be their only source of livelihood.

This situation is further compounded by the lack of:

i) Adequate fisheries legislation, lack of capability for monitoring and enforcement; lack of financial resources for fisheries programs,
ii) Organization and institutional capability for fisheries development and management, and
iii) Physical office space and facilities.

The budgetary allocation of the Dominican Directorate of Fisheries is not enough to allow the fisheries administrators to undertake the necessary programs to improve fisheries resource management. On the positive side, however, the Dominican Republic is developing closer links with regional and international missions and organizations that are supporting the fisheries sector with technical and financial resources through specialized projects.

Fisheries managers need to continue to develop and implement carefully targeted programs to gradually improve the national and local capability for sustainable fisheries development and management, and consequently enhance the contribution of fisheries and aquaculture to the economic development of the country.

Interventions in the fisheries sector by themselves will not solve the problems unless they form part of a larger sustainable development program seeking to address the larger issues of improved governance, improved productivity, improved environmental management, and human development. Improvement in the basic socio-economic conditions and living standard are needed to reduce the heavy dependence on the already over-exploited fishery resources for survival.

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Overview of Puerto Rico's Small-Scale Fisheries Statistics 1998-2001

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ABSTRACT

A total of 13,620,481 pounds (6,178 metric tons) of fish and shellfish were reported in Puerto Rico during 1998-2001. The mentioned landings have a market value of approximately $27,407,302. The most important fish group, in terms of percentage of total pounds landed (fish and shellfish), for 1998 - 2001, were the deep water snappers (mainly *Lutjanus vivanus* and *Etelis oculatus)* 9 %, yellowtail snapper (*Ocyurus chrysurus*) 7 %, lane snapper (*Lutjanus synagris*) 7 %, mackerel species (*Scomberomorus cavalla* and *Scomberomorus regalis*) 5 %, various species of tuna 5 %, various species of grunts mainly the white grunt (*Haemulon plumieri*) 4 %, dolphinfish (*Coryphaena hippurus*) 4 %, groupers, principally red hinds (*Epinephelus guttatus*), reported 4 %, parrotfishes 3 %, and various species of trunkfish 3 %. The most important of the shellfish species were the spiny lobster (*Panulirus argus*) accounting for 9 % of total reported landings, and the queen conch (*Strombus gigas*) 8 %.

The gear type which accounted for the highest percentage of landings by weight of the total catch during 1998-2001, were lines (hand line, troll line, long line and rod and line) with 40 %. Lines were followed by traps (fish pot and lobster pot) with 24 %, nets (beach seine trammel net, gill net and cast net) with 21 % and diving (skin and SCUBA) with 14 %. Other gears were < 1 % of the total landings reported.

Highlights of the biostatistical data for most caught species in Puerto Rico's fishery will be discussed.

KEY WORDS: Biostatistical data, commercial fishery statistics, Puerto Rico.

Description de las Estadisticas de la Pesca Artesanal in Puerto Rico 1998-2001

Un total de 13.678.567 libras (6.204,6 toneladas métricas) de pescados y de crustáceos fue divulgado en Puerto Rico durante 1998-2001. Los aterrizajes mencionados tienen un valor comercial de $26.946.777. Los grupos más importantes de los pescados de términos del porcentaje de las libras totales aterrizadas (los pescados y los crustáceos incluidos) para 1998-2001, eran el snapper de rabo amarillo (chrysurus) de Ocyurus el 9 %, los snappers profundos del agua (principalmente vivanus de Lutjanus y oculatus de Etelis) el 7 %, la especie de la caballa (cavalla de Scomberomorus y los regalis del S.) el 5 %, varia especie del atún

el 5 %, dolphinfish (hippurus) de Coryphaena el 4 %, varia especie de los groupers (principalmente guttatus de Epinephelus) el 4 %, varia especie de parrtofishes el 3 % y varia especie del trunkfish el 3 %. Aterrizado más por los crustáceos del peso era la langosta espinosa (*Panulirus argus*) el 9 % y conch de la reina (gigas) de *Strombus* el 7 %. Los resultados de los aterrizajes de la especie por el engranaje y por la costa serán demostrados y discutidos. También, los toques de luz de los resultados biostatistical de los datos para la mayoría de las especies cogidas serán discutidos en este papel.

PALABRAS CLAVES: Industrias pesqueras en reducida escala, estadística de industrias pesqueras, Puerto Rico.

INTRODUCTION

The Fisheries Research Laboratory (FRL) of the Puerto Rico Department of Natural and Environmental Resources (DNER) monitors the commercial landings of fish and shellfish in Puerto Rico. The Fisheries Statistics Program (FSP) was implemented in 1967 under the Commercial Fisheries Research and Development Act of 1964 (PL 88-309) to collect data on the commercial fishery. Currently, this project is supported by the NOAA/National Marine Fisheries Service (NMFS) through the State/Federal Cooperative and Interjurisdictional Fisheries Programs and the DNER.

The objective of the Puerto Rico Fisheries Statistics Program is to maintain reporting services on the commercial finfish and shellfish resources of Puerto Rico, as well as manage and disseminate the fisheries statistics through coordination of activities between NMFS, FRL/DNER and other interested groups. The principal goals of this program are:

i) Collect landings data from the island of Puerto Rico ensuring coverage of all coastal municipalities and their major fishing centers.
ii) Determine the total weight of principal finfish and shellfish landed in Puerto Rico each month.
iii) Determine the ex-vessel value of principal finfish and shellfish species landed in Puerto Rico each month.
iv) Manage, correct, evaluate, summarize data and prepare semiannual and annual performance reports.
v) Collect and analyze biostatistical data of the Puerto Rico's commercial fishery.

PROCEDURES

Commercial Landings Data

Commercial fishery landings data were collected from Puerto Rico's fishermen, fish buyers and fishing associations, whom voluntarily cooperate with the FSP. Four

port samplers and the principal investigator visited the 42 coastal municipalities including the islands of Vieques and Culebra, and the 88 identified fishing centers. The data collected from January 1998 - December 2002 are presented in this paper. Efforts were made to collect the following data: fishing date, name of fish buyer, fisherman and/or helper (to avoid data duplication), municipality; fishing center (municipality landing area); number of trips; gear type; fishing effort (hours spent fishing); weight in pounds by species or taxonomic family; market value to the fisherman (price in U.S. dollars/pound); maximum and minimum fishing depth and fishing area. Trip tickets were completed using species common names and identification was possible by using an amended version of the bilingual technical report "Common Names of Fishes in Puerto Rico" (Erdman 1987). A numerical system of species identification was developed to correspond with species codes used in Erdman's publication. Fishermen usually landed fishes in the round (not eviscerated), except deepwater snapper and large grouper that they usually landed gilled and gutted. Lobster, oyster and octopus were also landed in the round, and conch weights included meat only. Land crab statistics were reported in number of dozens with each dozen assumed to produce 1 lb. of meat. Some landings were reported as one of four classes of fish (first, second, third and "trash" fish) reflecting their market value: "trash" fish are perceived to have little or no market value. Classification varied somewhat by region but the following descriptions were used to characterize each class broadly: first class fish included large snapper, grouper, grunt, trunkfish and hogfish; second class included small snapper and grouper, parrotfish, goatfish, and triggerfish; third class included smaller individuals of second class fish and large squirrelfish. The "trashfish" category included butterflyfish, angelfish, surgeonfish, small squirrelfish and small fishes of a large number of species (Matos-Caraballo and Sadovy 1990).

Catch per unit of effort (CPUE) was evaluated for landings data by calculation of total pounds per trip, making a subsample by month, using only those landings trip tickets that clearly indicated a single trip.

Landings data was entered in computer, using Microsoft FoxPro 2.6, checked against the original landing trip tickets, corrected and analyzed using Microsoft FoxPro 2.6 and Microsoft Excel. All data presented in this report are raw data. As in previous years (1988-97) a correction factor was used in calculations to correct for under-reporting. The correction factor was expressed as the percentage of fishermen that regularly cooperated with statistics divided by the total number of active fishermen in the Island of Puerto Rico. A total of 1,758 commercial fishermen were active during 1994 - 1997 (Matos-Caraballo 1996). The correction factor for 1998 and 1999 was 78 %, for 2000 was 57 % and for 2001 was 68 %. Correction factors before 1989 are discussed in Matos-Caraballo and Sadovy (1990; 1991) and Matos-Caraballo (1992; 1993; 1995; 2001).

Commercial Biostatistical Data

Biostatistical data of finfish and spiny lobster were collected by port agents. Each individual was identified by species to determine catch composition. Finfishes

were measured in fork length (FL) and spiny lobster in carapace length (CL), both in millimeters (mm), and weighed in grams. Data were recorded on data sheets form. The form was designed to facilitate entry and processing of effort data. Biostatistical data were entered in Trip Interview Program (TIP) developed by NMFS Southeast Fishery Science Center. Later, the data stored in TIP was converted to FoxPro and analyzed using Microsoft Excel. The data collected include date, name of fisherman, fishing area, depth, gear, species, length, weight and effort by gear type. When possible, sex and gonad stage were visually inspected

RESULTS

Commercial Landings Data

In Puerto Rico during 1998, it was estimated that a total of 4,427,467 pounds of fish and shellfish were landed, with a market value of $8,946,870 (using the correction factor of 78 %). During 1999, it was estimated that a total of 4,265,435 pounds of fish and shellfish were landed, with a market value of $8,795,880 (using the correction factor of 78 %). For 2000, it was estimated that a total of 5,756,130 pounds of fish and shellfish were landed, with a value of $11,793,159 (using the correction factor of 57 %). In 2001, it was estimated that a total of 5,233,859 pounds of fish and shellfish were landed, with a value of $10,800,657 (using the correction factor of 68 %). The correction factor of 78 % of total fishermen cooperating with the Program in 1998-99 is the highest since 1988 when 56 % of fishermen cooperated.

Reported data show that from January-December 1998, a total of 3,453,424 pounds were reported, in 1999 was a total of 3,327,039 pounds were reported, for 2000 a total of 3,280,994 pounds and for 2001 a total of 3,559,024 pounds (Table 1).

A total of 32,839 trip tickets were collected during 1998, 35,545 throughout 1999, 38,887 for 2000 and 41,949 for 2001. Landings were principally comprised by five species of shellfish and 45 groups of species or families of finfish, although a total of 155 finfish groups and/or species and 10 shellfish species were reported by fishermen.

A total of 13,620,481 pounds (6,178 metric tons) of fish and shellfish were reported in Puerto Rico during 1998-2001. The mentioned landings have a market value of approximately $27,407,302. The most important fish group, in terms of percentage of total pounds landed (fish and shellfish), for 1998-2001, were the deepwater snappers (mainly *Lutjanus vivanus* and *Etelis oculatus*) 9 %, yellowtail snapper (*Ocyurus chrysurus*) 7 %, lane snapper (*Lutjanus synagris*) 7 %, mackerel species (*Scomberomorus cavalla* and *Scomberomorus regalis*) 5 %, various species of tuna 5 %, various species of grunts mainly the white grunt (*Haemulon plumieri*) 4 %, dolphinfish (*Coryphaena hippurus*) 4 %, groupers, principally red hinds (*Epinephelus guttatus*), reported 4 %, parrotfishes 3 %, and trunkfishes 3 % (Table 1). The most important of the shellfish species were the spiny lobster (*Panulirus*

argus) 9 % of total reported landings, and the queen conch (*Strombus gigas*) 8 % (Table 1).

Table 1. Landings reported by species and coast in Puerto Rico during 1998 - 2001

	1998		1999		2000		2001	
SPECIES	POUNDS	*P/P	POUNDS	*P/P	POUNDS	*P/P	POUNDS	*P/P
FISH								
Tunas								
Blackfin tuna	450	1.28	982	1.05	3,274	1.10	25,286	1.08
Little tunny	21,076	0.96	18,310	0.95	17,176	1.03	20,323	1.09
Skipjack tuna	51,922	1.12	40,318	1.18	32,174	1.14	38,391	1.07
Yellowfin tuna	41,653	1.21	48,915	1.22	46,755	1.17	35,392	1.31
Tuna category	83,720	1.13	46,620	1.14	38,185	1.25	26,147	1.33
Ballyhoo	49,449	1.26	50,848	1.24	56,934	1.27	60,905	1.26
Grunts	115,613	1.51	118,255	1.52	118,344	1.48	156,641	1.43
Hogfish	49,843	2.10	46,519	2.10	58,419	2.17	66,843	2.25
Trunkfish	90,893	1.82	83,884	1.76	83,795	1.69	77,814	1.78
Dolphinfish	137,033	1.60	130,055	1.62	137,729	1.57	111,075	1.89
Squirrelfishes	18,998	1.29	14,696	1.35	16,038	1.27	18,313	1.23
Mullets	53,451	1.30	61,935	1.22	54,106	1.25	61,129	1.23
Jacks								
Bar jack	27,186	1.38	40,895	1.43	45,265	1.35	50,845	1.41
Horse-eye jack	6,121	1.45	5,106	1.42	7,568	1.58	6,907	1.40
Yellow jack	3,313	1.36	2,021	1.24	2,460	1.58	3,934	1.29
Jack Category	61,517	1.57	38,774	1.62	30,405	1.45	36,168	1.41
Parrotfishes	97,559	1.43	80,719	1.47	73,973	1.55	99,255	1.46
Groupers								
Coney	13,900	1.90	10,254	1.92	11,671	2.00	16,091	1.88
Red hind	54,974	2.08	65,912	2.05	61,239	2.09	69,098	2.16
Misty grouper	5,556	2.20	6,717	2.13	5,264	2.12	6,222	2.18
Nassau grouper	19,095	1.54	14,957	1.63	12,965	1.65	18,706	1.85
Yellowfin grouper	1,791	1.90	3,348	2.18	11,208	2.10	3,708	2.16
Grouper category	43,385	2.04	47,892	2.05	40,761	2.18	54,180	2.22
Mojarras	19,383	1.57	22,072	1.65	18,249	1.69	19,445	1.60
Snappers								
Lane snapper	220,886	1.97	196,483	2.05	211,517	2.04	186,225	2.12
Yellowtail snapper	252,016	2.02	279,373	2.12	363,508	1.93	326,998	2.14
Silk snapper	213,124	2.72	229,277	2.78	196,483	2.66	291,722	2.88
Mutton snapper	77,393	2.05	96,346	2.11	86,807	2.03	90,563	2.13
Queen snapper	46,099	2.85	66,682	2.84	62,866	2.76	107,871	2.86
Vermillion snapper	16,581	2.35	17,237	2.43	22,397	2.30	44,891	2.34
Wenchman	2,302	2.44	3,644	2.33	4,952	2.31	7,731	2.72
Snapper category	56,545	2.03	63,031	2.04	50,237	1.96	60,114	2.06
Triggerfishes	64,392	1.55	49,921	1.56	41,986	1.59	60,929	1.50
Barracudas	33,784	1.68	24,939	1.47	26,066	1.50	19,888	1.50
Porgies	26,545	1.57	34,577	1.52	29,563	1.52	37,031	1.51
Snooks	100	1.18	136	1.63	394	1.77	11,830	1.60
Tarpon	2,343	1.21	2,374	1.04	354	1.06	2,193	0.87
Goatfishes	15,009	1.65	26,203	1.67	20,703	1.95	22,475	1.95
Sardines	23,665	1.22	27,621	1.25	25,251	1.14	25,398	1.20
King Mackarels	106,407	1.84	127,697	1.92	124,496	1.70	101,572	1.94
Cero	71,403	1.84	63,924	1.99	53,789	1.90	84,711	1.92
Rays	16,161	0.98	3,149	0.84	10,201	0.97	3,637	1.07
Sharks	47,409	1.52	46,878	1.52	43,077	1.44	45,199	1.57
Wahoo	1,154	2.30	6,697	1.86	2,180	1.58	8,344	1.60
CLASSIFFIED								
First Class	137,856	1.50	103,248	1.77	85,684	1.79	96,539	1.98
Second Class	120,050	0.77	106,771	0.70	58,463	0.81	32,775	1.31
Third Class	65,703	1.14	33,090	1.18	49,562	1.17	46,656	1.01
Trash	86	1.09	475	1.29	568	1.46	515	1.52
Other fishes	143,640	0.29	115,461	0.28	98,079	0.47	83,572	1.80
Total Fishes	2,830,487	1.61	2,725,070	1.62	2,675,080	1.62	2,887,686	1.70
SHELLFISH								
Conch	260,990	2.22	213,739	2.25	261,702	2.23	328,467	2.44
Land crab	4,604	13.87	2,600	14.88	2,130	15.71	6,322	14.26
Lobster	296,369	5.24	326,914	5.27	258,154	5.05	285,018	2.53
Octopus	39,483	2.45	43,601	2.58	48,703	2.29	33,939	2.58
Marine crabs	2,478	2.94	2,513	2.41	2,211	2.09	3,351	2.50
Other shellfish	16,993	3.14	12,602	3.80	13,014	3.16	14,241	3.83
Total Shellfish	622,937	4.98	601,969	5.20	605,914	5.09	671,338	4.69
TOTAL	3,453,424	2.02	3,327,039	2.06	3,280,994	2.05	3,559,024	2.06

Matos-Caraballo (2001) observed that during 1993 - 1997, several fish and shellfish species that in the past were usually discarded by fishermen, have gained commercial importance. These species did not have market value years ago, now are easily sold at reasonable prices. During 1998 - 2001 this trend was observed. For example, Table 1 shows that the squirrelfish (e.g. *Holocentrus ascensionis* and *H. rufus*) was sold in 1997 at an average price of approximately $1.29 per pound. Shellfish species in the same situation are marine crabs, *Carpilius corallinus,* and *Mythrax spp* were sold at approximately $3.00/pound. On the other hand, species that have no market in Puerto Rico, *Acanthurus spp, Holocanthus ciliaris, Pomacanthus arcuatus*, and *P. paru* are fished in the municipality island of Vieques, to be sold in the market of Saint Croix, USVI.

The gear types (as defined in Matos-Caraballo and Torres-Rosado 1989), which accounted for the highest percentage of landings, by weight during 1998-2001, were lines (hand line, troll line, long line and rod and line together) taking 40 % of the total catch (Tables 2-5). Lines were followed by traps (fish trap and lobster trap) taking 21 % of the total reported catch (Tables 2-5). Traps were followed by nets (beach seine, gill net, cast net and trammel net) that accounted for 20 % of the total reported catch (Tables 2-5). Nets were followed by diving (skin and SCUBA), this gear class fished 19 % of the total reported catch (Tables 2-5).

During 1998 - 2001, prices varied markedly by municipality (Table 6). For example, in 1999, the lowest average price per pound for fish and shellfish was obtained on the north coast, in the municipality of Isabela at $1.18, and the highest average price was obtained in the south coast, in the municipality of Patillas with $3.17/pound in 2001 (Table 6). The most productive of the 42 municipalities during 1998-2001, was Cabo Rojo accounting for 18 % of the total landings, by weight (Table 6). The west coast, reported 34 % of the total weight, being the most productive, followed by the south, 32 %, the east, 21 % and the north, 13 % (Tables 6).

From a total of the trip tickets collected during 1998-2001, approximately 82 % clearly indicated that the catch referred to a single fishing trip (number of trips = 1). A subsample of these data by month was made. Fishing trips are generally of a half-day duration. The CPUE for landings was 54 pounds per trip (ppt) in 1998, 53 ppt in 1999, 71 ppt in 2000, and 68 ppt in 2001.

Table 2. Landings reported by species and by gear in Puerto Rico during 1998

SPECIES	BEACH SEINE (Pounds)	FISH TRAP (Pounds)	LOBSTER TRAP (Pounds)	GILL NET (Pounds)	BOTTOM LINE (Pounds)	TROLL LINE (Pounds)	LONG LINE (Pounds)	LAND CRAB TRAP (Pounds)	CAST NET (Pounds)	ROD AND LINE (Pounds)	SKIN DIVING (Pounds)	SCUBA DIVING (Pounds)	TRAMMEL NET (Pounds)	TOTAL (Pounds)
FISH														
Tunas														
Blackfin tuna	0	0	0	0	450	0	0	0	0	0	0	0	0	450
Little tunny	4,494	0	0	783	3,929	11,728	0	0	27	0	0	0	145	21,076
Skipjack tuna	4,723	0	0	1,092	8,186	37,880	21	0	0	0	0	0	0	51,922
Yellowfin tuna	443	0	816	59	6,370	33,955	0	0	0	0	0	0	0	41,653
Tuna category	7,466	0	0	2,466	20,295	53,356	70	0	0	0	0	0	0	83,720
Ballyhoo	1,330	1,554	3	43,450	2,335	457	126	0	159	0	0	0	35	49,449
Grunts	1,539	47,271	68	25,730	14,524	881	917	0	189	0	0	1,575	23,888	115,613
Hogfish	28	11,464	91	3,454	2,585	230	213	0	0	0	417	29,178	2,197	49,843
Trunkfish	195	56,898	3,010	6,192	3,093	221	1	0	226	0	77	6,126	9,852	90,893
Dolphinfish	0	0	0	1,340	32,049	103,511	0	0	0	0	0	0	133	137,033
Squirrelfishes	20	9,135	0	2,686	5,625	341	31	0	17	0	0	120	1,142	18,898
Mullets	957	2,166	67	46,225	2,256	99	44	0	783	0	25	48	782	53,451
Jacks														
Bar jack	3,373	1,674	0	8,286	10,590	1,774	245	0	25	0	359	371	471	27,166
Horse-eye jack	20	87	0	1,079	4,581	191	41	0	32	0	20	60	30	6,121
Yellow jack	0	288	0	308	2,414	41	0	0	0	0	70	194	0	3,313
Jack Category	6,405	1,683	0	10,231	37,882	486	3,391	0	256	0	69	330	804	61,517
Parrotfishes	253	24,701	0	15,725	0	0	35	0	95	0	0	15,289	41,491	97,589
Groupers														
Coney	3	4,897	0	703	6,123	54	253	0	17	0	129	958	763	13,900
Red hind	16	17,441	186	852	23,511	235	936	0	53	10	65	11,130	536	54,974
Misty grouper	0	324	0	66	4,241	83	714	0	0	0	0	130	0	5,558
Nassau grouper	0	3,617	16	210	14,173	112	76	0	6	0	66	806	9	19,085
Yellowfin grouper	0	198	0	115	831	0	36	0	0	0	0	653	0	1,791
Grouper category	5	8,316	0	1,478	23,332	194	781	0	0	0	36	9,025	214	43,386
Mojarras	1,662	1,030	0	14,987	1,219	46	98	0	999	0	0	112	63	19,383
Snappers														
Lane snapper	3,044	79,899	122	40,473	91,063	0	30,025	0	324	0	0	2,951	3,865	220,886
Yellowtail snapper	2,773	19,885	35	9,485	209,990	0	4,429	0	213	0	111	1,495	3,880	252,016
Silk snapper	0	47,981	0	0	165,051	0	0	0	92	0	0	0	0	213,124
Mutton snapper	1,310	18,887	214	7,827	40,728	0	1,890	0	167	0	4	4,890	2,519	77,363
Queen snapper	0	724	0	0	46,345	0	0	0	0	0	0	0	0	46,069
Vermilion snapper	0	4,102	0	0	12,454	0	0	0	46	0	0	0	0	16,581
Wenchman	0	135	0	418	1,749	0	0	0	0	0	0	0	0	2,302
Snapper category	1,169	10,442	3	8,800	20,714	0	389	0	42	0	0	10,876	4,331	56,545
Triggerfish	15,422	11,689	0	14,573	22,409	0	31	0	77	0	9	166	39	64,392
Barracudas	5,169	804	0	9,381	13,932	2,775	91	0	169	0	19	675	1,169	33,784
Porgies	167	11,090	60	9,407	4,038	66	218	0	58	0	0	450	991	28,545
Snooks	0	0	0	9	83	0	0	0	0	0	0	8	0	100
Tarpon	169	46	0	1,169	341	0	0	0	0	0	0	618	0	2,343
Goatfishes	18	11,861	25	1,108	1,073	0	0	0	25	0	0	49	755	15,009
Sardines	547	481	0	3,466	2,280	0	0	0	16,887	0	0	0	24	23,685
King Mackerels	2,891	0	0	14,456	57,671	32,315	202	0	0	0	359	528	66	108,407
Cero	866	0	0	9,546	28,134	31,832	224	0	0	177	130	309	171	71,403
Rays	0	0	0	2,074	172	65	60	0	0	0	0	130	13,869	16,161
Sharks	844	0	0	5,817	22,882	1,404	10,765	0	0	0	0	1,103	4,594	47,409
Wahoo	0	0	0	15	133	1,006	0	0	0	0	0	0	0	1,154
CLASSIFIED														
First Class	6	44,804	0	6,483	25,389	66	0	0	0	0	0	26,882	32,360	137,868
Second Class	987	46,524	0	10,894	5,710	12	13	0	0	0	0	429	55,801	120,050
Third Class	0	32,520	4	1,972	3,739	0	0	0	0	0	0	27,426	40	65,703
Trash	0	86	0	0	28	0	0	0	0	0	0	3	0	86
Other fishes	10,777	46,712	12	62,746	9,814	1,651	1,078	0	2,944	0	130	3,186	5,202	143,640
Total Fishes	79,193	662,846	4,724	406,894	984,972	316,308	66,662	0	23,511	187	2,074	162,021	211,366	2,830,487
SHELLFISH														
Conch	98	137	0	2,812	3,741	6,413	0	0	0	0	7,538	240,088	197	260,880
Land crab	0	0	0	0	0	0	0	4,604	0	0	0	0	0	4,604
Lobster	2,090	101,268	40,086	1,052	0	0	0	0	0	0	7,541	152,091	14,309	298,389
Octopus	94	1,475	272	184	0	0	0	0	0	0	20,909	16,706	249	39,488
Marine crabs	0	1,320	0	54	0	0	0	0	25	0	0	1,043	36	2,478
Other shellfish	2,098	1,201	86	920	0	0	0	0	218	0	0	12,447	83	16,993
Total Shellfish	4,278	105,398	40,444	5,022	3,741	6,413	0	4,604	243	0	35,990	422,345	14,888	622,937
TOTAL	83,471	668,244	45,168	411,916	988,713	322,721	66,662	4,604	23,754	187	37,064	584,366	226,254	3,453,424

Table 3. Landings reported by species and by gear in Puerto Rico during 1999

SPECIES	BEACH SEINE (Pounds)	FISH TRAP (Pounds)	LOBSTER TRAP (Pounds)	GILL NET (Pounds)	BOTTOM LINE (Pounds)	TROLL LINE (Pounds)	LONG LINE (Pounds)	LAND CRAB TRAP (Pounds)	CAST NET (Pounds)
FISH									
Tunas									
Blackfin tuna	0	0	0	500	78	404	0	0	0
Little tunny	4,151	0	0	327	1,774	12,058	0	0	0
Skipjack tuna	2,399	0	0	2,362	6,146	29,246	55	0	25
Yellowfin tuna	0	0	0	1,039	3,961	43,915	0	0	0
Tuna category	1,494	0	0	1,829	13,344	29,724	60	0	124
Ballyhoo	236	189	0	47,478	1,534	520	73	0	539
Grunts	3,611	50,025	15	34,590	14,567	314	790	0	5
Hogfish	0	10,758	0	1,863	2,152	121	30	0	0
Trunkfish	95	56,520	653	4,879	3,464	64	44	0	88
Dolphinfish	0	0	0	1,641	14,791	113,303	275	0	0
Squirrelfishes	39	7,005	0	1,942	5,272	108	107	0	25
Mullets	2,176	1,568	98	53,585	1,857	140	197	0	2,129
Jacks									
Bar jack	3,914	2,095	0	17,342	14,382	2,101	399	0	135
Horse-eye jack	15	91	0	919	3,902	109	36	0	17
Yellow jack	0	139	0	722	1,020	55	0	0	0
Jack Category	9,268	706	0	12,127	14,427	325	247	0	1,046
Parrotfishes	110	20,389	46	18,868	0	0	6	0	318
Groupers									
Coney	0	3,632	7	1,364	4,609	72	48	0	0
Red hind	30	12,745	26	1,326	30,939	66	289	0	48
Misty grouper	0	646	0	360	4,985	39	472	0	0
Nassau grouper	14	4,339	0	547	9,236	46	63	0	0
Yellowfin grouper	0	148	0	63	623	1	0	0	0
Grouper category	62	9,810	0	2,491	25,075	219	336	0	108
Mojarras	937	1,248	0	16,930	1,460	35	20	0	1,187
Snappers									
Lane snapper	3,133	71,484	0	32,005	51,931	0	33,953	0	1,509
Yellowtail snapper	4,117	22,711	5	14,170	227,069	0	6,761	0	127
Silk snapper	0	62,407	0	0	173,957	0	2,913	0	0
Mutton snapper	1,211	22,635	30	10,988	53,361	0	2,029	0	108
Queen snapper	0	1,371	0	0	54,918	0	10,393	0	0
Vermillion snapper	0	3,177	0	0	14,035	0	25	0	0
Wenchman	0	104	0	0	3,076	0	464	0	0
Snapper category	2,043	9,201	9	12,250	19,964	804	689	0	10
Triggerfishes	188	24,084	15	1,373	10,595	147	7	0	36
Barracudas	5,422	0	0	5,573	8,562	4,379	31	0	77
Porgies	1,244	12,841	0	13,761	5,445	69	72	0	0
Snooks	0	0	0	48	90	0	0	0	0
Tarpon	0	0	0	1,835	463	0	0	0	0
Goatfishes	0	11,784	0	11,041	3,035	86	12	0	75
Sardines	789	0	0	2,573	1,627	0	0	0	22,632
King Mackerels	1,897	0	0	12,771	61,168	49,138	1,293	0	164
Cero	1,604	0	0	15,273	25,783	16,595	1,173	0	679
Rays	91	0	0	421	587	0	0	0	0
Sharks	596	0	0	8,314	27,405	1,094	4,863	0	22
Wahoo	0	0	0	4,003	273	2,421	0	0	0
CLASSIFFIED									
First Class	1,703	34,250	55	5,892	15,005	292	0	0	0
Second Class	1,600	34,611	0	9,169	1,051	0	0	0	0
Third Class	117	21,288	0	210	4,590	29	0	0	0
Trash	0	295	0	150	30	0	0	0	0
Other fishes	8,303	31,525	47	56,689	9,963	3,865	846	0	766
Total Fishes	62,809	536,021	1,004	443,643	953,401	313,904	69,073	0	32,197
SHELLFISH									
Conch	0	0	0	0	0	0	0	0	0
Land crab	0	0	0	0	0	0	0	2,600	0
Lobster	456	130,003	30,207	2,767	0	0	0	0	191
Octopus	69	2,087	204	558	0	0	0	0	54
Marine crabs	0	1,584	19	74	0	0	0	0	95
Other shellfish	54	5,601	0	2,443	0	0	0	0	0
Total Shellfish	579	139,275	30,430	5,842	0	0	0	2,600	341
TOTAL	63,388	675,296	31,434	449,485	953,401	313,904	69,073	2,600	32,538

Table 4. Landings reported by species and by gear in Puerto Rico during 2000

SPECIES	BEACH SEINE (Pounds)	FISH TRAP (Pounds)	LOBSTER TRAP (Pounds)	GILL NET (Pounds)	BOTTOM LINE (Pounds)	TROLL LINE (Pounds)	LONG LINE (Pounds)	LAND CRAB TRAP (Pounds)	CAST NET (Pounds)
FISH									
Tunas									
Blackfin tuna	0	0	0	36	164	3,044	0	0	0
Little tunny	4,264	0	0	1,203	768	10,262	0	0	0
Skipjack tuna	1,207	0	10	2,183	4,328	24,446	0	0	0
Yellowfin tuna	0	0	0	1,145	1,682	43,309	0	0	0
Tuna category	2,843	0	0	648	7,607	27,056	0	0	0
Ballyhoo	3,558	0	15	49,750	1,044	1,227	20	0	312
Grunts	10,924	41,019	0	38,671	17,046	117	647	0	410
Hogfish	296	11,293	10	1,796	1,956	37	3	0	0
Trunkfish	1,516	55,395	491	5,502	3,404	136	143	0	8
Dolphinfish	0	0	0	1,304	13,373	120,003	2,436	0	0
Squirrelfishes	770	5,284	0	2,148	7,029	273	66	0	29
Mullets	3,072	640	77	45,999	2,290	165	118	0	1,387
Jacks									
Bar jack	3,429	2,014	0	22,201	14,315	1,430	423	0	205
Horse-eye jack	64	229	0	1,602	5,181	157	21	0	30
Yellow jack	51	360	0	567	1,100	0	40	0	20
Jack Category	3,391	720	6	14,119	11,094	317	166	0	100
Parrotfishes	185	19,278	0	20,971	154	7	0	0	12
Groupers									
Coney	0	3,741	0	1,511	5,824	233	25	0	0
Red hind	6	12,974	0	2,021	33,782	320	199	0	80
Misty grouper	0	560	0	163	2,891	0	1,177	0	27
Nassau grouper	0	2,311	16	499	9,062	243	80	0	6
Yellowfin grouper	0	9,775	0	144	373	0	28	0	0
Grouper category	602	7,156	0	1,935	19,036	370	1,005	0	111
Mojarras	885	1,468	27	12,166	1,012	91	540	0	1,643
Snappers									
Lane snapper	1,240	63,738	35	37,377	74,142	175	24,746	0	4,995
Yellowtail snapper	8,782	26,066	31	18,134	302,166	155	3,707	0	1,212
Silk snapper	0	52,206	0	560	125,350	0	20,367	0	0
Mutton snapper	380	21,364	27	15,219	39,722	0	2,652	0	174
Queen snapper	0	427	0	107	32,516	0	49,725	0	91
Vermillion snapper	10	5,331	0	720	15,499	0	837	0	0
Wenchman	24	62	0	1,159	3,461	0	246	0	0
Snapper category	139	7,831	10	14,450	19,932	46	458	0	50
Triggerfishes	334	19,803	16	1,614	8,816	236	85	0	13
Barracudas	2,578	445	0	11,988	6,323	4,299	10	0	22
Porgies	741	11,441	0	11,930	3,746	122	19	0	18
Snooks	140	0	0	85	15	126	0	0	10
Tarpon	0	0	0	311	25	18	0	0	0
Goatfishes	18	15,109	0	2,884	2,347	0	3	0	62
Sardines	776	173	0	1,505	1,272	0	2,277	0	19,018
King Mackerels	1,164	0	0	13,524	61,977	44,698	303	0	158
Cero	296	0	0	13,017	32,088	6,611	145	0	502
Rays	0	0	0	238	81	96	0	0	0
Sharks	121	0	0	4,933	18,726	1,392	8,970	0	0
Wahoo	0	0	0	0	576	1,584	0	0	0
CLASSIFFIED									
First Class	406	26,745	228	3,006	9,360	29	0	0	0
Second Class	4,497	22,802	0	4,662	1,878	0	0	0	0
Third Class	0	19,353	0	62	3,648	0	0	0	0
Trash	0	169	0	220	103	30	0	0	0
Other fishes	5,563	32,848	20	41,932	11,975	2,675	163	0	726
Total Fishes	64,070	500,144	1,019	428,141	940,058	295,539	121,850	0	31,431
SHELLFISH									
Conch	36	0	0	175	0	0	0	0	0
Land crab	0	0	0	0	0	0	0	2,130	0
Lobster	314	93,609	18,908	2,599	0	0	18	0	42
Octopus	3	1,421	13	837	0	0	0	0	93
Marine crabs	0	1,452	0	12	79	0	3	0	35
Other shellfish	480	3,004	44	4,212	1,410	145	0	0	1,037
Total Shellfish	833	99,686	18,965	7,835	1,489	145	21	2,130	1,207
TOTAL	64,903	599,830	19,984	435,976	941,545	295,684	121,871	2,130	32,638

Table 5. Landings reported by species and by gear in Puerto Rico during 2001

SPECIES	BEACH SEINE (Pounds)	FISH TRAP (Pounds)	LOBSTER TRAP (Pounds)	GILL NET (Pounds)	BOTTOM LINE (Pounds)	TROLL LINE (Pounds)	LONG LINE (Pounds)	LAND CRAB TRAP (Pounds)	CAST NET (Pounds)
FISH									
Tunas									
Blackfin tuna	405	0	0	816	2,905	20,455	705	0	0
Little tunny	5,205	0	0	2,224	4,346	8,461	67	0	0
Skipjack tuna	707	0	0	3,673	8,702	24,222	0	0	0
Yellowfin tuna	199	0	0	530	2,542	30,844	1,159	0	0
Tuna category	978	0	0	2,428	9,387	10,375	340	0	0
Ballyhoo	578	898	155	56,896	1,951	82	0	0	476
Grunts	16,573	57,936	205	40,607	21,026	2,191	414	0	89
Hogfish	436	14,106	49	2,400	3,702	134	0	0	118
Trunkfish	2,175	54,624	520	6,597	3,265	171	32	0	121
Dolphinfish	0	0	0	1,815	20,117	84,649	1,781	0	0
Squirrelfishes	1,498	7,362	25	2,868	5,664	427	15	5	136
Mullets	1,800	1,037	19	51,893	2,975	591	20	0	2,369
Jacks									
Bar jack	3,663	3,261	21	20,244	18,294	1,121	355	0	272
Horse-eye jack	51	650	0	1,090	4,044	319	10	0	30
Yellow jack	897	177	1	1,050	887	30	0	0	0
Jack Category	6,829	1,723	0	10,299	16,239	2,125	43	0	381
Parrotfishes	864	23,695	17	21,396	841	55	31	0	344
Groupers									
Coney	0	4,978	0	1,947	7,017	0	241	0	101
Red hind	0	15,244	0	2,759	38,795	0	530	0	177
Misty grouper	0	635	0	519	3,672	0	1,134	0	0
Nassau grouper	34	2,406	0	722	9,755	0	32	0	8
Yellowfin grouper	0	553	0	191	1,222	0	0	0	0
Grouper category	100	18,930	0	2,628	21,872	249	879	0	10
Mojarras	279	1,000	0	14,629	1,648	40	19	0	1,361
Snappers									
Lane snapper	4,480	58,336	336	32,503	66,659	571	17,482	0	148
Yellowtail snapper	12,858	23,371	175	15,700	265,728	354	2,577	0	162
Silk snapper	0	109,003	0	0	177,003	0	5,716	0	0
Mutton snapper	2,800	20,511	111	12,508	46,329	0	1,241	0	216
Queen snapper	0	2,724	0	0	94,581	0	10,366	0	0
Vermillion snapper	0	27,845	0	0	17,014	0	32	0	0
Wenchman	0	1,764	0	0	5,850	0	117	0	0
Snapper category	844	8,904	13	12,498	24,866	528	600	0	159
Triggerfishes	59	29,325	57	2,263	12,159	1,015	268	0	132
Barracudas	4,775	0	0	6,315	6,384	1,814	72	0	55
Porgies	519	13,100	8	17,134	4,319	382	67	0	47
Snooks	1,241	0	0	7,017	2,635	793	0	0	110
Tarpon	152	0	0	1,833	142	66	0	0	0
Goatfishes	0	16,932	0	3,803	1,422	0	12	0	0
Sardines	1,051	669	0	3,246	2,539	0	211	0	17,682
King Mackerels	526	0	0	14,520	53,628	28,044	248	0	134
Cero	548	0	0	10,023	39,773	30,415	293	0	23
Rays	255	0	0	490	1,085	0	0	0	0
Sharks	631	0	0	7,267	21,058	993	9,311	0	200
Wahoo	0	141	0	28	6,395	1,180	0	0	0
CLASSIFFIED									
First Class	80	45,353	151	427	14,475	102	15	0	0
Second Class	180	20,701	559	1,501	1,162	0	0	0	0
Third Class	533	28,402	0	221	7,811	0	0	0	0
Trash	0	124	0	28	130	27	0	0	0
Other fishes	5,773	20,896	28	45,306	7,923	1,019	37	0	566
Total Fishes	80,376	637,293	2,450	444,151	1,091,958	253,844	56,512	5	25,627
SHELLFISH									
Conch	0	0	0	203	0	0	0	0	0
Land crab	0	0	0	0	0	0	0	6,322	0
Lobster	281	102,003	32,198	1,480	0	0	0	0	317
Octopus	0	1,482	363	212	0	0	0	0	10
Marine crabs	15	1,903	15	157	0	0	0	0	10
Other shellfish	9	3,747	3	1,418	0	0	0	0	829
Total Shellfish	305	109,135	32,579	3,470	0	0	0	6,322	1,166
TOTAL	80,681	746,428	35,029	447,621	1,091,958	253,844	56,512	6,327	26,793

Table 6. Landings reported by municipality and by coast in Puerto Rico during 1998 - 2001

	1998		1999		2000		2001	
LOCATION	POUNDS	P/P*	POUNDS	P/P*	POUNDS	P/P*	POUNDS	P/P*
NORTH	436,026	1.84	420,522	1.82	342,113	1.91	589,893	2.14
Isabela	13,690	1.52	12,963	1.18	7,849	2.46	11,735	3.56
Quebradillas	0	0.00	0	0.00	0	0.00	0	0.00
Camuy	22,910	1.64	5,927	1.78	6,813	1.70	4,060	2.66
Hatillo	4,580	1.36	5,184	1.95	1,762	1.48	4,232	2.28
Arecibo	40,980	2.05	56,206	2.13	38,480	2.20	73,812	2.47
Barceloneta	37,260	2.23	19,198	2.13	21,858	1.88	36,736	2.26
Manatí	16,328	2.33	14,127	1.91	11,301	1.97	17,361	2.04
Vega Baja	35,898	2.90	28,412	2.15	35,899	2.37	68,169	2.41
Vega Alta	15,371	2.13	9,071	2.19	17,596	2.10	28,694	2.15
Dorado	13,864	2.04	15,794	2.75	13,578	2.24	28,069	2.70
Toa Baja	1,136	1.23	2,819	1.41	4,846	2.31	1,010	1.49
Cataño	42,650	2.12	46,419	2.24	21,097	2.18	23,769	2.34
San Juan	80,590	2.25	96,594	2.15	91,082	1.98	133,003	2.10
Carolina	28,135	1.78	32,799	1.60	27,054	1.83	56,785	1.73
Loíza	43,069	1.52	28,599	1.68	10,950	1.87	43,752	1.97
Río Grande	16,570	2.31	32,583	1.99	21,188	1.85	34,254	2.08
Luquillo	20,975	1.94	13,847	1.76	10,762	2.13	4,452	2.05
EAST	608,379	1.86	650,043	2.05	664,287	2.24	948,758	2.37
Fajardo	135,003	1.77	150,003	2.06	128,003	2.22	179,003	2.20
Ceiba	67,064	1.76	58,111	1.81	78,839	2.34	139,003	2.42
Naguabo	88,869	1.97	159,003	2.19	159,003	2.35	178,003	2.53
Humacao	63,415	2.14	99,565	2.46	101,003	2.67	111,003	2.71
Yabucoa	12,666	1.88	30,269	2.16	48,568	2.03	39,869	2.03
Maunabo	25,911	1.67	67,827	1.65	21,689	1.89	23,120	2.20
Culebra	451	1.71	28,977	2.06	24,179	2.17	21,754	2.39
Vieques	215,000	1.95	56,288	1.98	103,003	2.24	257,003	2.47
SOUTH	1,059,601	2.03	1,090,326	1.96	1,243,346	2.02	1,040,871	2.43
Patillas	38,876	2.55	32,863	2.51	48,081	2.51	47,939	3.17
Arroyo	42,353	1.83	43,845	1.74	41,700	1.90	56,950	2.15
Guayama	145,656	2.05	142,003	2.01	107,003	1.94	106,592	2.26
Salinas	91,035	2.13	79,622	2.14	95,842	2.10	83,597	2.40
Santa Isabel	52,611	2.31	53,647	2.34	62,297	2.32	54,992	2.77
Juana Díaz	163,003	1.84	135,003	1.99	135,003	2.01	143,003	2.60
Ponce	112,003	1.96	94,244	1.93	137,003	1.67	103,003	2.16
Peñuelas	53,129	2.43	53,608	2.16	68,427	3.09	69,042	3.26
Guayanilla	21,929	1.42	54,988	1.08	80,004	1.13	69,747	1.53
Guánica	124,003	2.01	157,003	1.83	247,003	1.75	107,003	2.42
Lajas	215,003	1.81	243,500	1.78	221,003	1.85	199,003	1.99
WEST	1,349,418	1.81	1,166,148	1.88	1,031,248	1.87	999,502	2.14
Cabo Rojo	755,003	2.02	629,003	2.18	545,003	2.16	491,062	2.27
Mayaguez	105,003	1.78	107,003	1.86	94,643	1.95	87,763	2.04
Añasco	69,316	2.47	34,524	2.29	45,625	2.14	44,847	2.68
Rincón	88,355	1.82	106,003	2.09	121,003	1.94	122,003	2.58
Aguada	93,738	1.51	79,812	1.41	79,971	1.61	96,824	1.71
Aguadilla	238,003	1.23	210,003	1.33	145,003	1.43	157,003	1.54
TOTAL	3,453,424	1.88	3,327,039	1.92	3,280,994	2.01	3,559,024	2.27

Commercial Biostatistical Data

A total of 53,027 individuals caught by commercial fishers were measured and weighed during 1998-2000. Sex determination of fishes in the field has been difficult due to the reluctance of fishermen to permit this activity, and the general limitation in available time for measuring samples, and difficulties in assessing any but the ripest individuals, for sex.

The species most frequently measured from 1998 - 2000 were: *Ocyurus chrysurus*, *Haemulon plumieri*,*Lutjanus synagris*, *Panulirus argus*, *Epinephelus fulvus*, *Epinephelus guttatus*, *Sparisoma chrysopterum*, *Lutjanus vivanus*, *Sparisoma viride* and *Scomberomorus cavalla*..

Figuerola et. al, (1998) indicated that *Ocyurus chrysurus* females reach Minimum Size of Sexual Maturation (MSSM) at around 248 mm FL and males at 224 mm FL. During 1998 - 2000, approximately 15 % of *O. chrysurus* individuals were taken below 224 mm FL.

Panulirus argus has been protected under federal and local government management plans, for approximately the last 18 years. These management plans prohibit the capture and/or possession of *P. argus* below 89 mm (3.5 inches) of carapace length. During 1998 - 2000, approximately 18 % of the total individuals sampled by FSP were taken below the minimum legal size (MLS).

Epinephelus guttatus is the most abundant grouper species reported in Puerto Rico. Sadovy et. al. (1994) studied *E guttatus* from 1987 - 1992, reporting that MSSM is 215 mm FL. *E. guttatus* taken below 215 mm FL, were approximately 3 % of the biostatistical samples during 1998 - 2000.

Figuerola (1991) reported that *Lutjanus vivanus* females reach MSSM at 410 mm FL. Biostatistics data of 1998 - 2000 show that approximately 97 % of total individuals of *L. vivanus* (males and females) were taken below the MMS of 410 mm.

DISCUSSION

Commercial Landings Data

The most reported groups by weight in the commercial fisheries landings for 1998 - 2001, showed that snappers, grunts, groupers, parrotfishes, mackerels, dolphinfish and trunkfishes. Reported commercial landings data reported have been around two millions pounds per year from 1987 - 94 (Matos-Caraballo in press). Since 1995, 96 and 97, an increase has been observed in the number of fishermen that cooperated with the FSP, resulting in 3.7, 3.6 and 3.8 millions pounds reported, respectively. Stability of this landings reports were consistent for 1998 - 2001. Approximately a total of 400 more commercial fishermen cooperated with FSP during 1997 than 1994. One possible reason to explain the increased landings reported might be due to an increase in the number of fishermen cooperated with the FSP during 1995 - 1997. This increase in participation probably occurred because the PRDNER and the Puerto Rico Department of Agriculture have provided

economical help to fishermen who cooperate on a regular basis to the FSP. Usually a certification from FSP is required. When we compare the landings reported in late 1970s and early 1980s (around 5 million-7 million pounds), with the reported landings of 1987 - 1997, an indication of overfishing is observed.

Another symptom of overfishing was observed in several species discarded by fishermen in the past that now have become commercial species (e.g. *Holocentrus ascensionis, H. rufus* and *Acanthurus spp.*). These species are now marketable due to the decrease in landings of preferred species, and an increase in the demand of more fresh fish products.

The fish market of Saint Croix USVI purchase the Vieques landings of *Acanthurus spp, Holocanthus ciliaris, Pomacanthus. arcuatus, P. paru* and many juvenile reef fish species. The mentioned species are subject to severe fishing pressure.

The municipality of Cabo Rojo and the west coast have continued to be the most productive municipality and coast respectively since 1972 (Weiler and Suárez-Caabro 1980, Collazo and Calderón 1988, Matos-Caraballo and Sadovy 1990 and 1999, Matos-Caraballo 1993, 1995, 1997). However, the west coast has shown a tendency to decrease the percentage of total landings reported from 52 % in 1983 to 37 % in 1997, and 34 % in 1998 - 2001. For years 2000 and 2001 the south coast reported more landings that west coast for the first time since 1972. Cabo Rojo shows the same tendency (Table 6). Biostatistical data of FSP indicate that the fishing resources in the west coast are overfished (Matos-Caraballo in press). The mentioned tendencies are evidence of the need of effective management and enforcement to preserve the fishing resources of Puerto Rico.

Pots continued to show a decreasing trend in their catch percentages since 1982 (Matos-Caraballo and Sadovy 1990 and 1991, Matos-Caraballo 1992, 1993, 1995; and 1997), when fish traps alone caught 71.2 % of the total pounds reported (Collazo and Calderón 1988) to 24 % during 1994 - 1997, and contnues decreasing to 21 % for the period of 1998 - 2001. On the other hand, an increasing trend was observed in the percentage of reported landings taken by all lines combined, when compared with 1982, in which the percentage was 12.4 % (Collazo and Calderón 1988) to 44 % during 1994 - 1997, 40 % for the period of 1998 - 2001. Nets have shown a similar trend. For example, the gill nets and trammel nets caught 2.7 % in 1982 (Collazo and Calderón 1988), while in 1998 - 2001 they caught 20 %. Young fishers were observed using SCUBA divers. They are very active, fishing 4-5 days per week and their main target are conch and lobsters. The diver gears reported 19 % of the landings during 1998 - 2001.

Average annual catch per unit effort (CPUE) in was estimated to be 63ppt - 80ppt during 1994 - 1997, for 1998 - 2001 was reported 53 - 71ppt. Collazo and Calderón (1988) mentioned that during 1979 - 1982, the CPUE for the vessels of 21-25 ft was 122.74 pounds/trip. It was observed that vessel over 30 feets length have almost disappeared from the Puerto Rico's commercial fishery. This is another evidence of the overfishing symptoms of Puerto Rico's fishery resources.

Commercial Biostatistical Data

The commercial biostatistical for *L. vivanus* data indicates that the Puerto Rico fishery resource is overfished. *P. argus* in Puerto Rico has a minimum legal size of 89 mm carapace length. During 1994 - 1997, a total of 36 % of *P. argus* sampled was caught below minimum legal size. However, for the period of 1998 - 2000, only 18 % of *P. argus* were caught before minimum legal size. This improvement occurred probably due to effective enforcement by the FMP and because this resource has a strong resilience to a high fishing pressure.

CONCLUSION

In 1979, reports of landings in Puerto Rico recorded 7,212,000 pounds of fish and shellfish. During the decade of the eighties, landings decreased consistently. During 1995 - 2001, reported landings ranged between 3.2 million and 3.8 million pounds of fish and shellfish. The vessels of >30 foot length have been diminishing. The Puerto Rico Fishery Census is in process and probably will result in a decrease of 500 commercial active fishers compared to the 1996 commercial fishery census. Landings information has shown that several fish and shellfish species that fishermen discarded in the past because they did not have market value are now easily sold. These species now have market value because of the decreased landings of the traditional valuable species. Another symptom of overfishing is evidenced in the CPUE data. During 1979 - 1982, average pounds per trip was 122.73 and in 2001, it had declined to 68 pounds per trip.

Another set of problems associated with the fishery resources is observed thru biostatistical data, which show that *L. vivanus* are consistently taken below the –MSSM. *P. argus* is protected by FMP that seems to be working, although this species is under heavy fishing pressure.

After the analysis of these facts, it is concluded that during 1998 - 2001, several fishery resources in Puerto Rico have continued to decline, despite an increase in the number of landings reported, due to an increase in the number of fishermen that cooperates with FSP. The information presented in this report urges the need for measures to protect the fishery resources of Puerto Rico, including the improvement of the enforcement of the existing fishing regulations and Fishery Management Plans.

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Caribbean Coastal Resources Co-management — Part 1

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ABSTRACT

Coastal resources co-management is a relatively recent development in the systems of natural resources governance in the English-speaking Caribbean. There is much interest in co-management among government agencies and non-governmental organisations, ranging from consulting with stakeholders to delegated and community-based management. Resource users are less familiar with the concept. The Coastal and Marine Management Program (CaMMP) of the Caribbean Conservation Association (CCA) is implementing a project on developing guidelines for successful coastal resources co-management in the Caribbean. It is part of the United Kingdom Department for International Development (DFID) Natural Resources Systems Programme (NRSP) for the Land-Water Interface. Cases of co-management initiatives in Barbados (sea urchins and Fisheries Advisory Committee), Belize (marine protected area and Fisheries Advisory Board), and Grenada (lobster and seine net fisheries) are being documented. Less detailed investigations are being done in other locations. The ecological and institutional analysis research framework, some preliminary findings and a few tentative conclusions are provided here as 'Part 1' in sharing project outputs. The project is expected to conclude in mid-2003, with further outputs to be reported at subsequent GCFI meetings.

KEY WORDS: Caribbean, coastal, co-management

Recursos Costeros del Caribe Co-gerencia de los Recursos: Parte 1

La co-gerencia costera de los recursos es un desarrollo relativamente reciente en los sistemas del gobierno de los recursos naturales en el Caribe de habla inglesa. Hay interés mucho en la co-gerencia entre las agencias de estatal, extendiéndose simplemente de consultar con los tenedores de apuestas al desarrollo completo de la gerencia comunidad-basada. El interés también está creciendo entre organizaciones no gubernamentales, pero los usuarios del recurso tienden para ser menos familiares con el concepto. El programa costero y marina de la gerencia (CaMMP) de la asociación del Caribe de la conservación (CCA) está poniendo un proyecto en ejecucio'n sobre las pautas que se convierten para la co-gerencia costera acertada de los recursos en el Caribe. Es parte del departamento BRITÁNICO para el programa de los sistemas internacional de los recursos naturales del desarrollo (DFID) (NRSP) para el interfaz del Tierra-Agua. Los casos de las iniciativas de la co-gerencia en Barbados (los pilluelos de mar y comité consultivo de las industrias

pesqueras), Belice (área protegida marina y tablero consultivo de las industrias pesqueras) y Grenada (las industrias pesqueras netas de la langosta y de la jábega) se están documentando. Menos investigaciones detalladas se están haciendo en otras localizaciones. El marco ecológico e institucional de la investigación del análisis, algunos resultados preliminares y algunas conclusiones tentativas se proporcionan aquí como > la parte 1 = en compartir salidas del proyecto. Se espera que el proyecto concluya en mid-2003, con > la parte 2 = ser divulgado en la reunión de GCFI de ese año.

PALABRAS CLAVES: Del Caribe, costero, co-gerencia

INTRODUCTION

The "Wider Caribbean" includes the northeast coast of South America, the Caribbean Sea, the Gulf of Mexico, and the south-eastern Atlantic coast of North America. The region is geographically complex with the highest density of separate states per unit area in the world (Chakalall et al. 1998). Across these states, as part of a global trend, recognition that resource users can play several valuable roles in coastal resource management has prompted increased efforts at their inclusion in governance (James and Fourniller 1993, Smith and Berkes 1993, Finlay 1996, McConney and Mahon 1998). Such initiatives are termed participatory, collaborative or cooperative management (usually shortened to co-management) and include community-based management. Definitions of co-management centre on the theme of sharing management responsibility and authority between government agents and stakeholders (McConney 1998, Brown and Pomeroy 1999, Pomeroy et al. 2001, Berkes et al. 2001).

DRIVING FORCES

Stakeholder involvement in marine protected area (MPA) management is now a standard guideline (Kelleher and Kenchington 1992, Salm et al. 2000). But there are many are "paper parks", with little active or effective management, in the Caribbean (Geohagen et al. 2001, Roberts et al. 2001). Because of this, much attention has turned to measuring management effectiveness (McField 2000). Governance and socio-economic indicators concern co-management.

The Code of Conduct for Responsible Fisheries seeks to ensure that fishers are integrated into coastal management. MPAs and other managed areas are locations for such integration and partnerships in governance. Coastal management in some places incorporates co-management at levels from research and monitoring (Smith 1994) to community decision-making in management (Berkes et al 2001, McField 2000).

Coastal resources are important to tourism, especially in small Caribbean islands with few other significant natural resources (CANARI 1999a, Clauzel 2001). Coastal conflicts include interactions between fisheries and tourism. Yet workers in

each labour force frequently find part-time employment in the other industry (Heyman and Graham 2000). Tourism has many impacts on reefs, mangroves, seagrass and beaches. Coastal settlements engaged in community-based tourism and eco-tourism may seek to co-manage these critical habitats that are threatened in many parts of the Caribbean (CCA 2001, Renard 1991).

The Coastal and Marine Management Program (CaMMP) of the Caribbean Conservation Association (CCA) is implementing a project on developing guidelines for successful coastal resources co-management in the Caribbean. The University of the West Indies and Marine Resources Assessment Group are partners. It is part of the UK Department for International Development (DFID) Natural Resources Systems Programme (NRSP) for the Land-Water Interface. Cases of co-management initiatives in Barbados (sea urchins and Fisheries Advisory Committee), Belize (marine protected area and Fisheries Advisory Board) and Grenada (lobster and seine net fisheries) are being researched. This paper, Part 1, introduces some interim findings from the project and refers to previous and continuing work by other researchers. Final results and conclusions will be presented at a future meeting of the Gulf and Caribbean Fisheries Institute.

CO-MANAGEMENT CONCEPTS AND METHODS

What co-management could or should be in theory or potential, and actually is in practice, has been extensively researched (e.g. Jentoft 1989, Kuperan and Abdullah 1994, Pomeroy and Berkes 1997). Co-management encompasses a range of institutional arrangements often depicted as a scale based on the relative balance of responsibility and authority between state and stakeholders. Studies of co-management in Africa (Normann et al 1998) and Asia (Pomeroy et al. 2001) have used the institutional analysis methodology developed by the International Centre for Living Aquatic Resources Management (ICLARM) and Institute for Fisheries Management and Coastal Community Development (IFM) (ICLARM and IFM 1998). The ICLARM/IFM conceptual framework and methodology was adopted for this research. It emphasises three main categories of co-management (Figure 1).

"Consultative co-management" is common in the Caribbean literature (Brown and Pomeroy 1999). Next is a level of joint action and decision-making. This is where several countries seem to be headed. The term "collaborative co-management" is preferred to "cooperative co-management" because it connotes stronger relationships of partnership, and "cooperative" may be confused with the formal organisations of the same name. "Delegated co-management" includes, but is not limited to, community-based management. Few countries in the Caribbean appear to be at the latter level, but it is not uncommon in other developing countries (Baird 2000). National co-management structures based on multi-stakeholder boards or committees are common in fisheries management in the English-speaking Caribbean (Jacobs 1998, McConney and Mahon 1998).

Government has the most control	*Consultative comanagement*	*Collaborative comanagement*	*Delegated comanagement*	*People have most control*
	Government interacts often buts makes all the decisions	Government and the stakeholders work closely and share decisions	Government lets formally organised users/stakeholders make decisions	

Figure 1. Categories of co-management

While these three categories illustrate a gradation from less to more civil society empowerment, they are not necessarily phases along a path towards community-based management. Each category is a suitable goal in its own right. Aiming at community-based management may not be appropriate. However, establishing successful co-management is seldom immediate, and progression through several categories of co-management is often apparent as institutional relationships are developed and mature. Like most participatory processes, this takes time and careful tending. Pomeroy (1998) recognises three phases of co-management and describes the sequence of steps within these in detail. A much-simplified version is in Figure 2.

Pre- implementation à	*Implementation à*	*Post- implementation*
Realise need for change Meet and discuss change Develop new management	Try out new management Educate people in new ways Adjust and decide what is best	Maintain best arrangements Resolve conflicts and enforce Accept as standard practice

Figure 2. Phases of co-management

Questions for research include asking: (1) What phases of co-management are cases in the Caribbean at? (2) To which category of co-management do they seem to be headed? (3) What can make progress and achievement sustainable?

This project should provide some answers to these questions by mid-2003, especially for the six detailed case studies. It will provide guidelines for successful coastal resource co-management in the Caribbean that take into account coastal

zone management and pro-poor issues. The sections below combine the results of a survey of CARICOM countries undertaken by CaMMP of the CCA in 2001, under its Coastal Resources Co-management Project (CORECOMP), with results from the present DFID-NRSP funded project.

CO-MANAGEMENT IN THE WIDER CARIBBEAN

Language contributes to complexity in the Wider Caribbean. English, Spanish, Dutch and French are spoken in addition to several creole languages. Language differences reflect and accompany a variety of economic, cultural, social and governance systems. The six case studies of the co-management guidelines project are confined to the English-speaking Caribbean, but the project also considers co-management in non-English speaking territories.

Recently there has been considerable networking and collaboration in co-management studies across the region and languages. The IUCN Working Group on Collaborative Management (CMWG) promotes such exchanges. Over 100 possible cases of coastal co-management (74) or indigenous managed areas (26) have been compiled based on published literature for Central America and the Caribbean (Hugh Govan pers. com.).

The Caribbean Natural Resources Institute (CANARI) prefers the term "participatory management" (CANARI 1999c). Coastal co-management is being tried at the Samana Bay Biosphere Reserve in the Dominican Republic and at La Parguera Fisheries Reserve in Puerto Rico (CANARI 1999b).

The Community Based Coastal Resources Management (CBCRM) Program of IDRC has published outcomes of its first phase of projects with case studies from Columbia, Costa Rica, Cuba, Honduras, Mexico and Nicaragua as non-English speaking countries (IDRC 2002). The project is in its second phase.

These are only a few of the several co-management research and pilot project initiatives in the Wider Caribbean. Communication amongst them continues to be a challenge, but this is slowly being overcome.

CO-MANAGEMENT IN SOME CARICOM COUNTRIES

Brown and Pomeroy (1999) examined fisheries co-management in several Caribbean Community (CARICOM) countries. Cases surveyed or studied to date under CORECOMP and the co-management guidelines project include:

Barbados

Sea Urchin Management — The fishery for the white sea urchin (*Tripneustes ventricosus* locally called "sea egg") has collapsed on several occasions. After multi-year closures to facilitate recovery, followed by declines mainly due to renewed overfishing, the government initiated co-management.

Fisheries Advisory Committee — Under its 1993 Fisheries Act the government of Barbados formed a multi-stakeholder Fisheries Advisory Committee in 1995. The FAC has struggled to define and meet its co-management mandate. Challenges include its lack of power and recognition.

Belize

MPAs — There are several examples of community-based MPA co-management and a national example of fisheries co-management. The guidelines project includes the Laughing Bird Caye National Park and Gladden Spit Marine Reserve. These two MPAs fall, respectively, under co-management agreements between the Forestry and Fisheries Departments and a community-based NGO. Other MPA co-management initiatives include Port of Honduras Marine Reserve, Sapodilla Cayes Marine Reserve; Caye Caulker; etc.

Fisheries Advisory Board — Belize has a Fisheries Advisory Board (FAB) that has been a powerful force in fisheries for over 30 years. It has not been well documented as an example of co-management, but is closely linked to strong government support for fishing cooperatives.

Dominica

Soufriere/Scotts Head Marine Reserve — A multi-stakeholder local area management authority (LAMA) set up under the fisheries legislation attempts to manage this scenic area on the south coast of the island that is heavily used by locals and visitors. Progress has been hampered by the impacts of hurricanes.

Guyana

Fisheries Advisory Committee — This multi-stakeholder consultative body is in its early stages, constrained by the low institutional capacity of the fisheries authority in a country beset by social and economic problems.

Grenada

Lobster fishery — At the rural town of Sauteurs government recently started a co-management project to encourage use of more responsible fishing gear for lobster harvest. The local fishing co-operative is also presently being revived.

Formalising beach seine traditional rules — The seine net fishery in Grenada is a case of an attempt by government to systematically document traditional fishing rules and customs in order to consider incorporating them into formal fisheries management plans and legislation. Traditional beach seine rules have also been documented in neighbouring countries.

Jamaica

Tourism Product Development Company (TPDCO) — This is an initiative to organise the fisheries aspects of tourism on the north coast especially. Emphasis has been on charter boat operations, particularly on registration and standards. The board includes fishermen's groups, hoteliers and government agencies.

Portland Bight Protected Area — Described as "a bold experiment", a local NGO, the Caribbean Coastal Area Management Foundation (C-CAM), has undertaken to introduce co-management to an area of land and sea totalling almost 19,000 hectares. The process has taken about seven years of preparation to get to the stage at which the State is apparently willing to share responsibility.

Negril Marine Park — The Negril Coral Reef Preservation Society (NCRPS) recently (October 2002) signed an instrument with the Natural Resources Conservation Authority (NRCA) delegating responsibility under the NRCA Act to the NCRPS for the conservation and management of the Negril Marine Park. The delegation is for a five-year term, renewable at the end if both parties agree. The National Environment and Planning Agency (NEPA) will monitor and review implementation of the delegation instrument on behalf of the NRCA.

St. Lucia

Soufriere Marine Management Area — The SMMA is the most thoroughly documented case of co-management in the eastern Caribbean. Early in 2001 it changed its legal character to become a, more autonomous, not-for-profit local company. Although seen widely as a model of success in terms of process, the people involved still see it as an experiment in progress with many challenges.

Canaries/Anse la Raye Marine Management Area — CAMMA was recently established, modelled upon the SMMA. It is at a very early stage of co-management.

Sea Urchin Management — Unlike Barbados, the management of sea urchins in St. Lucia follows the more classic community-based model. The fisheries authority has engaged the fishing industry in specific locations in monitoring and management of adjacent areas due to fisheries collapses and closures.

St. Vincent and the Grenadines

Tobago Cays Marine Park — Situated in the Grenadines islands off St. Vincent, this MPA under government control is seldom regarded as a co-management case, but is gradually moving towards greater stakeholder participation.

Surinam

Biggi Pan — This is an emerging case where fishers have set up a slipway in their fishing location and the fisheries authority is considering enlarging their authority to manage operations in the area by providing inputs to keep the waterways navigable. This may or may not fully evolve into co-management.

Trinidad and Tobago

Fisheries Monitoring and Advisory Committee — This is based on a 1997 agreement between government and stakeholders to promote sustainable management and optimal utilisation of the coastal fisheries of Trinidad and Tobago. The MAC provides a forum for stakeholders to meet, resolve conflict, and take action such as direct input into fisheries policy and decision-making.

Matura Bay sea turtle conservation — The northeast coast of Trinidad is an important leatherback turtle nesting area. The community-based Nature Seekers group has engaged in turtle conservation with the Wildlife Section of the Forestry Division that includes guided tours and other facets of ecotourism. Turtles are tagged and nests safeguarded. This is cited as a model for replication.

The above eighteen cases are only a few of the co-management exercises in CARICOM countries. Several are not documented, even in grey literature. In the above 18 cases, most (55%) were categorised as collaborative (Figure 3).

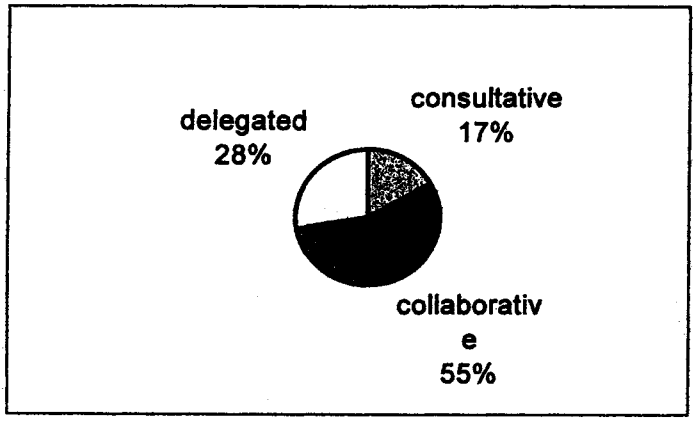

Figure 3. Categories of co-management in cases examined

In applying the framework of analysis to some of these cases the pattern shown in Table 1 emerges regarding the types and phases of these initiatives.

Most initiatives were multi-faceted, engaging in several activities as shown in

Figure 4. All concerned information exchange. All but pre-implementation cases reported engagement in management. Planning and enforcement were the next most common activities, followed closely by policy. However, there is a steady decline from research to interpretation that mimics the typical practise of less stakeholder involvement in the activities perceived as being technical/scientific.

Table 1. Analysis of co-management by phase and type

Type / Phase	Consultative co-management	Collaborative co-management	Delegated co-management
Pre- implementation	1	5	0
Implementation	1	3	2
Post- implementation	1	2	3

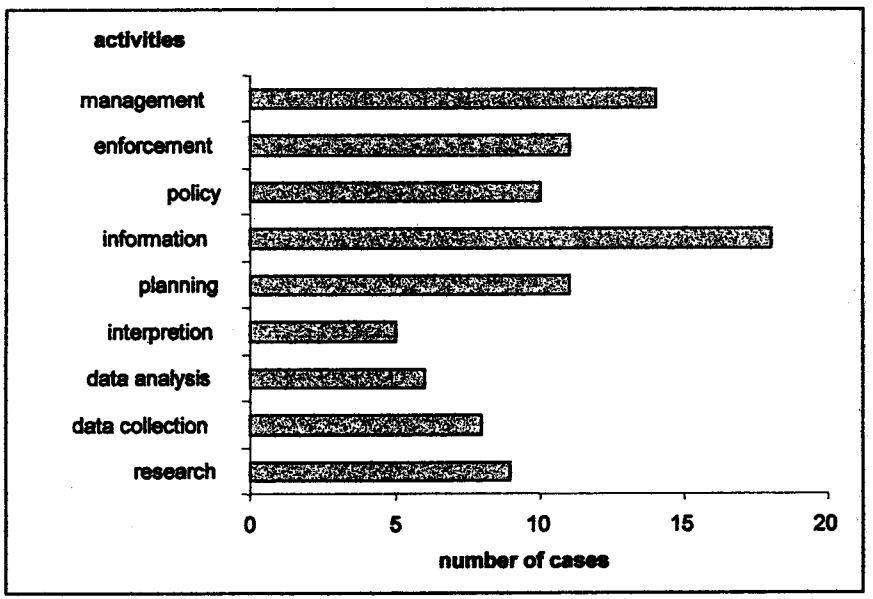

Figure 4. Activities undertaken in co-management in cases examined

Government agency satisfaction with the initiatives is illustrated in Figure 5. No respondent was either completely or not at all satisfied, leaving this almost even mid-range distribution. However, the proportion of less than satisfied officials is cause for concern, since high proportions need to be achieved for sustainability.

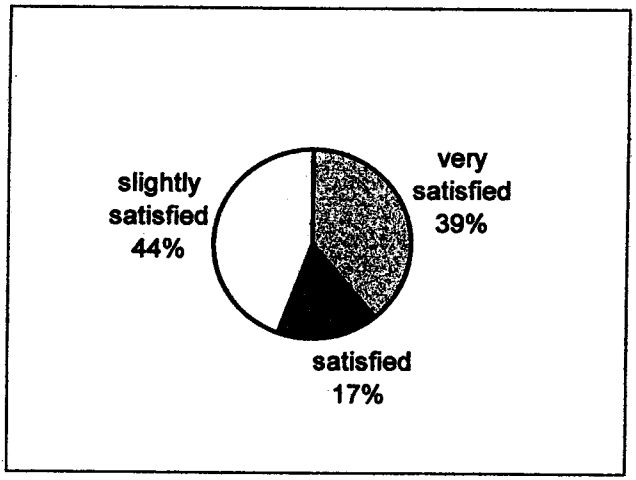

Figure 5. Government official satisfaction with co-management in cases

DISCUSSION

Much like African cases (Normann 1998), the Caribbean cases are mostly in pre-implementation or early implementation phases of co-management. A few such as the Soufriere Marine Management Area (Renard 2000) may be mature enough to be labelled post-implementation. A significant consequence of this is that comparing "before" and "after" conditions due to co-management interventions is less feasible in the Caribbean than other locations such as in Asia where much more work has been done (Pomeroy et al. 2001).

Although the term is used frequently, and is rapidly gaining popularity in government and NGO circles, the concepts of co-management are often not well known or defined, especially among resource users. In many of these initiatives, building the capacity of stakeholders to participate is a prerequisite for further progress and sustainability. Associated aspects of governance such as gender, poverty, alternative or complementary livelihoods and opportunities for the youth have only recently appeared on the agendas of governments in the region.

Integrated coastal management and fisheries management have transformed in recent times to give emphasis to the need for government and stakeholder involvement. Co-management is one facet of this trend towards inclusion. We can therefore expect to see additional co-management initiatives and chances to systematically document the factors that seem to facilitate sustainable success.

ACKNOWLEDGEMENT

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Harte Research Institute for Gulf of Mexico Studies: Initiatives in Marine Science Research

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ABSTRACT

The Harte Research Institute (HRI) for Gulf of Mexico Studies is a newly endowed and developing institute at Texas A&M University-Corpus Christi. Its mission is to support and advance the long-term sustainable use and conservation of the Gulf of Mexico. HRI will encourage a tri-national responsibility and approach to understanding the Gulf of Mexico ecosystem, including the United States, Mexico, and Cuba, and it will promote excellence and innovation in interdisciplinary scientific research, public policy initiatives, and education of the public. Cooperation and collaboration with Gulf and tri-national partners will be a hallmark of HRI activity. A $46 million endowment was given by Mr. Edward H. Harte, philanthropist and former publisher of the *Corpus Christi Caller-Times*, and the State of Texas provided an additional $18 million to build a facility to house HRI. To date, a 19-member Advisory Council has been formed, planning meetings have been held in Corpus Christi, Houston, Havana, and Veracruz, and building construction will start in spring 2003, with move-in slated for January 2005. Although wide-ranging activity and research are planned after HRI officially "opens," several early projects are already underway: Veracruz reef studies; biodiversity of the Gulf of Mexico; Gulf of Mexico GIS; and, "GulfBase," a Gulfwide research website.

KEY WORDS: Gulf of Mexico, research, tri-national

The Harte Research Institute para Estudios del Golfo de Mexico: Iniciativas en la Investigación de las Ciencias Marinas

El instituto de investigación de Harte (HRI) para el golfo de los estudios de México es un instituto nuevo y en desarrolloen el camo de la Universidad de Tejas A&M en Corpus Christi. . Su misión que emerge es animar y fomentar el uso sostenible a largo plazo y conservación del golfo de México. HRI animará una responsabilidad tri-nacional y se acercará a entender el golfo del ecosistema de México, incluyendo los Estados Unidos, el México, y la Cuba, y promoverá excelencia e innovación en la investigación científica interdisciplinaria, iniciativas del orden público, y la educación del público. La cooperación y la colaboración con el golfo y los socios tri-nacionales serán un sello de la actividad de HRI. De dotación $46 millones fue dada por Sr. Edward Harte, editor del the Corpus Christi Caller-Times y philanthropist, y el estado de Tejas proporcionó $15 millones adicional para

construir una facilidad para contener HRI. Hasta la fecha, se ha formado a un consejo consultivo 18-member, las reuniones de planeamiento se han celebrado en Corpus Christi, Houston, La Habana, y Veracruz, y los facilidades del edificio seran terminadas a finales de 2002 y se habilitara en enero de 2005. Aunque la vastas actividad e investigación se planean después de HRI oficialmente funcionando varias los proyectos ya están en curso: Estudios de los arrecifes de Veracruz; biodiversity del golfo de México; Golfo de México GIS; y, "GulfBase", un website para la investigación en todo el Gulfo.

PALABRAS CLAVES: Instituto de investigación de Harte, investigación científica interdisciplinaria

INTRODUCTION

Texas A&M University-Corpus Christi (TAMU-CC) became a part of the Texas A&M University System in 1989, but the founding as a university was in 1947 when the University of Corpus Christi, a small Baptist University, was formed on Ward Island immediately after WWII, and the closing of the U.S. Navy's Ward Island Radar Training Station. In 1957 the fledging university started its marine science program under the direction of Dr. Henry H. Hildebrand. After the campus was almost completely destroyed in 1970 by Hurricane Celia, the university was transferred from Baptist to state ownership into the University System of South Texas. Continuing as a small, primarily teaching institution in the 1970's, graduate degrees and research began to slowly take hold in the 1980's, especially with the formation of the Center for Coastal Studies and the Conrad Blucher Institute for Surveying and Science. Unfettered by typical, long-standing academic traditions and with an entrepreneurial spirit, TAMU-CC began inviting state and federal natural resource agencies to its campus to be co-located with academic programs. The great synergism developed by this model of operation, as well as the efficiency and effectiveness of the academic-government partnership, led the State of Texas to build a facility to house the state agencies and academic research centers together on campus. Presently, 7 state agencies, 3 university research centers, and several A&M System components are housed in this state Natural Resources Center building. Funding for a federal Natural Resources Center is currently being sought.

On 19 September 2000, Mr. Edward H. Harte donated $46 million to establish a new research institute at Texas A&M University-Corpus Christi (TAMU-CC) to focus on the Gulf of Mexico. Mr. Harte, philanthropist and former owner of the *Corpus Christi Caller-Times* newspaper, worked with Dr. Robert R. Furgason, President of TAMU-CC, to establish the endowment to include endowed research chairs, endowed graduate research assistantships and an endowed operating budget. Subsequently, during the fall of 2002, the Harte Support Foundation was established to manage the assets until the institute officially "opens its doors" in January 2005. The Foundation consists of three Trustees, Mr. Ed Harte, Mr. Jonathan M. Hornblower, and Mr. David L. Sinak. In the spring of 2001 during the Texas

Legislative Session, Dr. Furgason was able to obtain $15 million from the State of Texas to build a facility for the Harte Research Institute on the TAMU-CC campus. An additional $3 million was added to that amount from other state building funds to allow for the construction of four graduate instruction and research laboratories. These labs, along with eight offices, will allow collaboration between Harte research scientists and faculty and students within the Physical and Life Sciences Department in the College of Science and Technology. Other well-established entities at TAMU-CC whose strengths will be utilized or merged with HRI include: the Center for Coastal Studies, the Center for Water Supply Studies, the Conrad Blucher Institute for Surveying and Science, the Geographic Information Science research program, and the Texas Coastal Ocean Observation Network.

Mr. Ed Harte, who had been Chairman of the Board for the National Audubon Society during the 1970's, and again in the early 1990's, was inspired by the book *Sea Change* (Earle 1995) in deciding to endow and establish the research institute. After meetings and discussions between Mr. Harte, President Furgason, and Dr. Sylvia A. Earle, she agreed to become Program Coordinator and Chairman of the Advisory Council for the new institute during the summer of 2001. During that summer, and the following academic year, a highly distinguished Advisory Council of 19 members was established. Members represent academia, industry, and conservation, as well as all three countries surrounding the Gulf of Mexico, United States, Mexico, and Cuba (Table 1). Dr. John W. ("Wes") Tunnell, Jr. was appointed Associate Director in September 2001, and that fall the new institute was officially named the Harte Research Institute for Gulf of Mexico Studies.

INSTITUTE DEVELOPMENT

The Harte Research Institute (HRI) Advisory Council held four meetings during the 2001-2002 academic year, and plan to continue holding three or four meetings per year until the Institute is in full operation (Table 2). The December 2001 Advisory Council Meeting included a Workshop of research scientists from the U.S., Mexico, and Cuba (Figure 1). This workshop and the subsequent proceedings (Tunnell 2002) produced influential and substantial research information and focus for the HRI Advisory Council. Highlights of the Proceedings are shown in Table 3. Information from all Advisory Council meetings, as well as data gathered from other leading marine/oceanographic laboratories, institutes, and universities, have assisted in developing the vision and mission statement, as well as the goals and objectives of HRI.

Table 1. Advisory Council Members for Harte Research Institute for Gulf of Mexico Studies representing the United States, Mexico, and Cuba.

Name	Affiliation
Dr. Sylvia A. Earle, Chair	Explorer-in-Residence, *National Geographic Society*
Dr. Homero Aridjis	Journalist, *Mexico City*
Mr. William B. Baker	Environmental Manager, *Reliant Energy*
Mr. William Bradford	Former CEO, *Dresser/Halliburton*
Mr. Luke Corbett	CEO, *Kerr McGee*
Mr. Jean Michel Cousteau	*Ocean Futures Society*
Dr. Richard E. Ewing	Vice President for Research, *Texas A&M University*
Dr. Robert R. Furgason	President, *Texas A&M University-Corpus Christi*
Mr. Terry D. Garcia	Executive Vice President, *National Geographic Society*
Dr. David E. Guggenheim	Vice President, *Ocean Conservancy*
Mr. William Harte	*Harte Family*
Ms. Katharine Armstrong-Idsal	Chair, *Texas Parks and Wildlife Commission*
Sr. Alejandro Junco de la Vega	Publisher, *Monterrey*
Dr. Kumar Mahadevan	Executive Director, *Mote Marine Lab*
Sr. Guillermo Garcia Montero	Director, *National Aquarium of Cuba*
Mr. Patrick F. Noonan	Chairman, *The Conservation Fund*
Dr. John Ogden	Director, *Florida Institute of Oceanography*
Dr. Alberto Vazquez de la Cerda	Admiral, *Instituto Oceanografico, Secretaria de Marina, Mexico*
Dr. Don Walsh	Oceanographer and *Trieste* Pilot

Table 2. HRI Advisory Council Meeting dates and locations (as of Fall 2002).

	Location	Dates
1.	Corpus Christi, Texas, at TAMU-CC	15-17 October 2001
2.	Corpus Christi, Texas, at TAMU-CC - included Gulf of Mexico Workshop and Proceedings by scientists from U.S., Mexico, and Cuba	12-13 December 2001
3.	Houston, Texas	18 February 2002
4.	Havana, Cuba	29-30 April 2002
5.	Veracruz, Mexico	10-11 October 2002
6.	Corpus Christi Texas at TAMU-CC	planned (January 2003)
7.	*Washington, D.C.*	*planned (April 2003)*

Figure 1. Location of invited institutions/marine labs for Planning Workshop for Harte Research Institute for Gulf of Mexico Studies held at Texas A&M University-Corpus Christi, 12 - 13 December 2001.

Table 3. Synthesis of information and suggestions/recommendations for the new Harte Research Institute from HRI Gulf of Mexico Planning Workshop (Tunnell 2002).

i)	Hold an annual or biennial Gulf of Mexico Symposium,
ii)	Be international or "tri-national" in collaboration,
iii)	Communicate science to public,
iv)	Collate, integrate and synthesize Gulf of Mexico science,
v)	Foster collaboration between existing entities,
vi)	Consider policy,
vii)	Develop Gulf of Mexico (bilingual) website,
viii)	Develop ecosystem models (conceptual and dynamic),
ix)	Consider conservation biology and biodiversity research focus, and
x)	Consider all stakeholders

VISION AND MISSION STATEMENT

It is the vision of the Harte Research Institute for Gulf of Mexico Studies to be a research center of excellence providing international leadership in generating and disseminating knowledge about the Gulf of Mexico ecosystem and its critical role in the economies of the North American region.

The mission of the Harte Research Institute, an endowed research component of Texas A&M University-Corpus Christi, is to support and advance the long-term sustainable use and conservation of the Gulf of Mexico. This mission will be accomplished by:

i) Providing an environment to conduct meaningful and successful programs in research and education with highly qualified faculty, staff, and students,

ii) Promoting excellence and innovation in interdisciplinary scientific research, public policy initiatives, and education of the public concerning the Gulf of Mexico,

iii) Encouraging a tri-national responsibility and approach to understanding the Gulf of Mexico ecosystem, involving the United States, Mexico, and Cuba,

iv) Collaborating and cooperating with other organizations that are dedicated to addressing issues related to the Gulf of Mexico, in order to achieve common goals, and

v) Disseminating freely research results to the scientific community, management agencies, the general public, and policymakers, in order to foster the wise and appropriate use of the Gulf of Mexico.

GOALS AND OBJECTIVES

The goals and objectives of the Harte Research Institute developed to-date are:

i) To become a leading research institute and remain committed to high-quality, innovative research on the Gulf of Mexico,
ii) To lead in synthesizing, integrating, and communicating Gulf of Mexico research,
iii) To monitor and periodically publicize the "State of the Gulf," to uncover gaps in existing knowledge, and to create initiatives to fill those gaps,
iv) To cooperate with state and federal resource management agencies by providing scientifically based knowledge for sound policy and management of the Gulf of Mexico and surrounding region,
v) To establish partnerships and alliances with educational, governmental, non-governmental, and private sector organizations interested in long-term sustainable use and conservation of the Gulf of Mexico, and
vi) To develop strong public education and public policy programs, using a broad diversity of approaches, including:
   - ★ A bilingual Gulf of Mexico website of research institutes, research personnel, research projects, and other information about the Gulf of Mexico.
   - ★ A biennial Gulf of Mexico Symposium.
   - ★ Conferences on Gulf of Mexico issues, both scientific and policy, as needed at the Harte Research Institute building at Texas A&M University-Corpus Christi.
vii) To develop a Gulf-wide Geographic Information System.
viii) To foster tri-national cooperation and collaboration in science and management of the Gulf of Mexico.
ix) To study the conservation biology and biodiversity of the Gulf of Mexico.
x) To be a leader in exploration of the Gulf of Mexico.
xi) To study the Gulf of Mexico as a large marine ecosystem, influenced by the Caribbean Sea and surrounding watersheds, requiring monitoring, modeling, and management.

HARTE RESEARCH INSTITUTE BUILDING

The HRI building was designed by Richter Architects of Corpus Christi and WHR (Watkins, Hamilton, Ross) Architects of Houston during 2002. The three-story, 55,000 sq. ft. building with six wet labs, two dry labs, two seawater labs, a teaching lab, a GIS lab/suite, an education/outreach suite, a large conference room and many associated offices will be built on the northwest side of the TAMU-CC campus on Ward Island, which is located on the south side of Corpus Christi Bay in Nueces County, Texas (Figure 2). Construction will begin in spring 2003 and move-in is projected for January 2005.

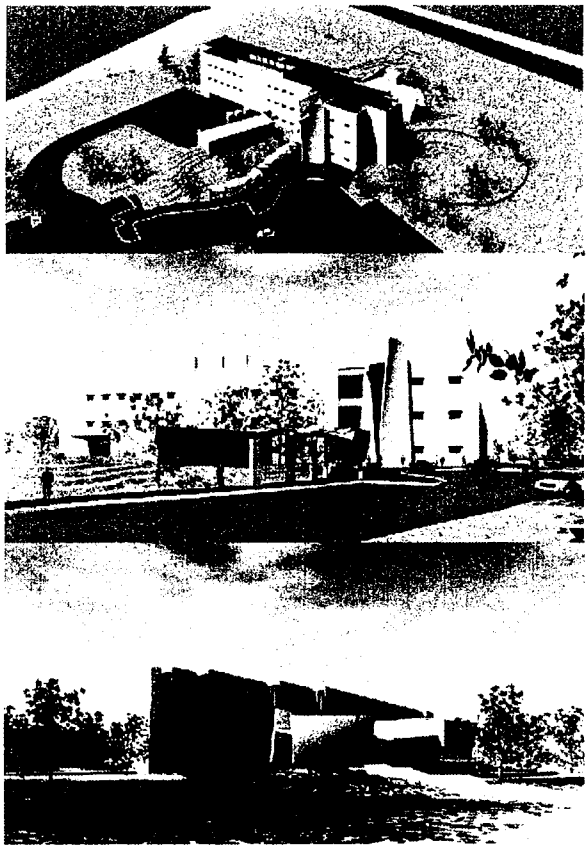

Figure 2. Architectural renderings of the newly designed Harte Research Institute at Texas A&M University-Corpus Christi.

EARLY ACCOMPLISHMENTS

During year-one of planning and development, in addition to the above-mentioned accomplishments, HRI:

i) Developed a significant and meaningful logo (Figure 3),
ii) Assisted in funding a book by Dr. Rezneat Darnell, Professor Emeritus in Oceanography, Texas A&M University, on the Gulf of Mexico,
iii) Developed and opened (15 October 2002) a new database website (GulfBase.org) on Gulf of Mexico research personnel, institutes, and projects, as well as other Gulf information and facts,
iv) Developed an HRI website to open in late 2002 about the new Institute,
v) Sponsored training on *Deep Worker* and *Deep Rover* mini- submersibles as part of the National Geographic Society's Sustainable Seas Expedition

program at the Offshore Technology Research Center at Texas A&M University in College Station, Texas,

vi) Sponsored a two-week collaborative research cruise, the "Veracruz Reefs Expedition", with HRI, National Geographic Society's Sustainable Seas Expeditions, and the Mexican Navy's Oceanographic Institute aboard their research vessel *Antares*; and

vii) Is hosting the first HRI Visiting Scholar-in-Residence, Dr. Ernesto Chávez, from Mexico.

Harte Research Institute
for Gulf of Mexico Studies

Figure 3. Logo for Harte Research Institute for Gulf of Mexico Studies.

PLANNED ACTIVITIES

In addition to the above accomplishments, the HRI will be:

i) Starting the Edward H. Harte Distinguished Lecture Series at TAMU-CC each fall and spring,

ii) Initiating a tri-national initiative to document the "Biodiversity of the Gulf of Mexico," ultimately producing a relational database and book,

iii) Co-sponsoring and conducting a research cruise to Cuba in 2003;

iv) Developing a Gulf of Mexico GIS, and

v) Holding a biennial "State of the Gulf" Conference.

SUMMARY

The Harte Research Institute for Gulf of Mexico Studies is a newly endowed and developing institute at Texas A&M University-Corpus Christi. This $46 million endowed Institute will be housed in an $18 million facility projected to open in January 2005, and it will focus on tri-national cooperative and collaborative work with U.S., Mexican, and Cuban entities interested in the long-term sustainable use and conservation of the Gulf of Mexico.

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The Importance of Emotional Intelligence to Fisheries Management

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ABSTRACT

There is a growing awareness that fisheries management is really about people management. It is about influencing the people who utilize and impact on the fisheries resources to behave in a particular way. It is also about utilizing the experiences of those people to inform and transform the fisheries management process, so that the goals of fisheries management may be reached in a more efficient and cost effective manner. As a result of this understanding, fisheries management is evolving into a discipline that is paying more attention to participatory management of fisheries resources by placing increasing emphasis on utilizing fisher's knowledge. It is no longer accepted that Government officials or scientists have all the answers. Other persons need to be involved if we are to find workable solutions to our problems. If the above premise is true, then it is time that fisheries managers move away from relying solely on their technical skills and pay more attention to improving their people skills. This paper explores a relatively new concept, that of "emotional intelligence" and demonstrates that by improving our abilities to relate to people (that is our emotional competencies) we can indeed become more effective fisheries managers.

KEY WORDS: Emotional intelligence, participatory fisheries management

La Importancia de la Inteligencia Emocional a la Gerencia de las Industrias Pesqueras

Hay una conciencia creciente de que la administratcion de la industria pesquera se trata realemente de una administration popular. Se trata de influenciar a las personas que utilizan los recursos pesqueros para comportarse de una manera particular. Se trata tambien de utilizar las experiencias de esas personas para informar y transformar la administración del proceso pesquero, de manera que puedan ser alcanzados los objectivos administrativos de las empresas pesqueras de una manera más eficiente y efectva. Como resultado de este entendimiento, la administratción de las empresas pesqueras está evolucionando hacia una disciplina que treste mayor atención a la administratción de forma participatoria de los recursos pesqueros haciendo mayor énfasis en la utilización del conocimiento de los pescadores. Ya no se acepta que los representantes del Gobierno o los científicos

tengan todas las respuestas. Necesitamos incluir a otras personas si nos disponemos a encontrar soluciones realmente manejables para nuestros problemas. Si la premisa antes mencionada es verdadera, entonces es hora que los administradortes de la empresa pesquera se alejen de la idea de confiar únicamente en sus conocimientos técnicos y presten mayor atención al mejoramiento de sus propias destrezas. Este informe explora un concepto relativamente Nuevo, el de la "inteligencia emocional" y demuestra que mejorando nuestras habilidades para relacionarnos con las personas (es decir, nuestra competencia emocional) podemos sin dudas convertirnos en más eficientes administradores de la industria pesquera.

PALABRAS CLAVES: Inteligencia emocional, la administratcion de la industria pesquera

INTRODUCTION

The Case for People Management

Who would argue about the need to manage fisheries resources? The myth that fisheries resources are inexhaustible has long since collapsed, as have many fish stocks that have been inappropriately managed. It is widely accepted that in the absence of management, the benefits that the fisheries produce will diminish. Even though some members of fish species survive, they will not be worth fishing for i.e. they would have become commercially extinct (Berkes et al, 2001). In extreme cases these species may even become biologically extinct.

While many Caribbean fisheries are organised and conducted in ways which will inevitably lead to overfishing (Haughton and Singh-Renton 2001), a future can still be envisaged whereby fisheries make a sustained contribution to food security, poverty alleviation, employment, foreign trade, foreign exchange earnings, cultural development, development of communities, recreation and tourism, and thus, to the livelihood and sustenance of the people of the region.

However, to attain this vision marine resources must be managed to provide society with optimal benefits without compromising the long-term health of fish stocks or marine ecosystems. The factors which constrain proper management include: irresponsible fishing practices; inadequate knowledge of fish stocks, the marine ecosystem and the social and economic conditions of the fishers; inadequate long-term policies; inadequate human and institutional capacity for research, planning and decision making; inadequate participation of resource users in planning and decision-making; inadequate monitoring, control and surveillance; inadequate post harvest handling, processing and marketing; inadequate port and other shore-based facilities; environmental degradation and pollution of the region's marine waters, and scarce financial resources.

If you think about it, most of the factors cited above are about people. They are not about fish. They are about influencing the way people think and behave in order to achieve specific goals associated with fisheries management. In fact, the goals of

fisheries management are not about fish either, they are about maintaining and enhancing the services and products that fisheries resources provide to humans, whether those services be ecological, aesthetic, psychological, etc.

In essence then, it might be reasonable to suggest that effective fisheries management is really a matter of how successfully people who participate in the fisheries sector collaborate with each other in order to achieve particular goals. If we accept the above, then it is fair to state that while it is important for persons involved in the management of fisheries resources to have technical skills, it is also important for them to have "people skills".

These concepts are not new ones, Charles (2001) recognised that it is difficult to place environmental factors as primary considerations in decision-making on the use of natural resources. The comments of several authors point to insights about the role of people and people management in the fisheries management. Consider the following contributions:

i) Haughton and Singh-Renton (2001), indicate that in order to achieve this goal it becomes necessary to improve awareness of fisheries issues and the capacity of resources users to work in partnership with government to jointly manage fisheries,
ii) Nelson (1995 cited in Haughton and Singh-Renton, 2001), states that "The central issue is that it is the people working in fisheries, their knowledge of the issues in fisheries and ability to build positive networks of stakeholders that are the real basis for achieving our developmental goals", and
iii) Delaney (2002) suggests that if we put the "spotlight on the human factor" we may find that we already have the tools required to better manage our fisheries resources.

FAO (1997), Bunce et. al. (2000) and others including the participants at the Symposium on Caribbean Marine Protected Areas: Practical Approaches to Achieve Economic and Conservation Goals, held during the 54th Annual Meeting of the Gulf and Caribbean Fisheries Institute (GCFI 2003), identified a number of gaps in management effectiveness. Among the measures suggested to fill these gaps were:

i) Train managers in communications skills;
ii) Understand stakeholders needs via improved stakeholder assessments;
iii) Require ... scientists to meet together with the community ... in order to understand their needs and share perspectives
iv) Overcome incorrect perceptions.

The above contributions point to the need to travel a management route that is not just grounded in "stark" science, but instead take a softer approach that considers the "people aspects". This often requires more than just a seemingly objective assessment of the situation. It brings to bear information that we know intuitively, but not as yet cognitively. It acknowledges that we sometimes have to use what is often referred to as a "gut feeling" about whether a situation is viable or

a particular stakeholder is trustworthy.

From another perspective, it is recognised that "people who will be affected by (our actions as managers) must be willing to place their faith, and possibly their livelihoods, on conclusions drawn by scientists" (Roberts and Hawkins 2000: parentheses ours).

In this paper we explore a concept called Emotional Intelligence (EI). We have chosen this concept because it is a scientific way of explaining something that we always knew, but had not before put words to. We want to encourage discussion on this topic because we feel that it is relevant. We also want to come closer to answering some of the questions that we have (Figure 1.). We ask you to join us on this journey, to carefully consider the information that we have presented, and to use it where it can be beneficial. We also ask you to continue to share your experiences in this area so that, over time, we can increase the collective wisdom that we have in this area and use these insights to generate an improved approach to fisheries management.

Perhaps people > biology

Perhaps people > rules

Maybe individuals > groups

Maybe Increased E I => decreased conflict

Maybe Decreased conflict => improved management

Perhaps Managing people > managing fish

Figure 1. Some considerations about the role of people in fisheries management

WHAT IS EMOTIONAL INTELLIGENCE?

Emotional Intelligence (EI) – the Definition

Emotional Intelligence is the ability to use feelings in order to interact smoothly with others and accomplish common goals (Goleman 1998). Stated another way, emotional intelligence is the ability to access, manage and make use of feelings. It means managing feelings so that they are expressed appropriately and effectively. There is a growing view that this ability may be far more important to ongoing success than intellectual knowledge or technical skill (Harris 2001). Goleman

(1998) suggests that with increasing job complexity, emotional intelligence becomes more important; he suggests that it may be four times more important than cognitive abilities in explaining different levels of performance (*ibid.*). Goleman (1998) also suggests that while technical ability may be a requirement to enter a particular field, it is emotional intelligence that may determine success. It is important to state that Emotional Intelligence is really nothing new, people have always been aware of the presence and importance of what we now refer to as EI. However, they may not previously have had the extensive vocabulary now associated with this discipline, and may have been limited to the use of words such as character and charisma.

The concept of EI is based on a long history of research and theory in psychology (Cherniss 2000), and has developed out of the advances made in neuroscience in the last century (Goleman 1995).

Emotional intelligence involves many competencies or abilities that may be either personal or social (Boyatzis 1994 cited in Boyatzis et al. 2000). An emotional competence is a learned capability based on emotional intelligence that results in outstanding performance (Goleman 1998). Our emotional competencies show how much of that potential we have is translated into on-the-job capabilities.

Personal competencies rest largely on self-awareness and include characteristics such as self-control, adaptability, trustworthiness, conscientiousness, creativity, and innovativeness. Social competencies involve awareness of others. They may include empathy, political awareness, the ability to understand others' emotions, and other talents or skills needed to influence, communicate, lead, develop others, manage conflict, promote teamwork, or catalyze change.

Emotional intelligence is observed when a person demonstrates the competencies that constitute self-awareness, self-management, social awareness and social skills at appropriate times and ways in sufficient frequency to be effective in the situation (Boyatzis et. al. 2000).

It is important to note that simply having a high level of emotional intelligence does not guarantee that a person will have learned the emotional competencies that matter for work, it only means that they have good potential to learn them Goleman's (1998). The fact that EI can be learned is important to remember, as it indicates that people have the potential to improve on their current capabilities and on their effectiveness in the "workplace".

Emotional Intelligence – the Application

So the above is a lot of "mumbo jumbo", good to hear about — but so what? How do we relate this to our daily reality and what is the relevance of this subject to fisheries management? Let's reflect on some of our collective experiences and see if there are any lessons that can be learned from them.

Have you ever been in a meeting/group with specific objectives (say consideration of a fisheries management plan), and gotten the feeling that the whole exercise was going nowhere? That while the persons in the room should (theoretically, at least) have the technical expertise and insights to solve the problems, other things were interfering with the group's ability to achieve its

purpose?

Have you ever been in a fisheries sector organization where you have felt stifled? Where you knew that you had the potential to contribute more, but somehow you were not being allowed?

What about a situation where a person who has excellent technical skills has been recruited, and you look forward to the promise of their contribution but are disappointed, because, in spite of their technical expertise their "attitude" and "approach" do not allow for their expertise to make the difference that it should?

To look at more positive scenarios, have you ever been struggling with a program or an assignment and a conversation with a colleague (possibly with less technical expertise than you have) has caused you to feel motivated, to try again where you would have given up, and to excel where you might have failed? How about those (hopefully not rare) occurrences when you walk into a working group and there is a synergy, a dynamic, that causes the group to reach it's full potential, and to achieve effortlessly what it would otherwise have struggled to do.

While most of us may have at least one of these types of experiences, we may not necessarily have been able to "put our finger" on the reasons why these situations occur. We would like to suggest that it is the human factor. As human beings, we need to be listened to, valued, empathized with, understood. We perform best in situations where we are comfortable, where our needs are met, where we are encouraged to excel, where we feel empowered.

Good fisheries management plans and programs are not always enough to ensure successful fisheries management. We need good people, good relationships and good organizations, to effect these plans. Often, "great" written plans are produced, but never implemented.

Technical expertise, insight, and wisdom together provide an important platform for change, but in order to actually achieve this change, people have to be involved. In fisheries management, for example, a wide array of persons from differing backgrounds (fishermen, fish processors, economists, politicians, fisheries scientist, lawyers) all have to be able to come to common understandings and, to agree on and achieve common goals.

In order for so many persons to work together to achieve so much, it is important for the individuals and groups involved to have certain emotional competencies. The persons must be competent as individuals (personal competence), but they must also have certain collective competencies (social competence). Goleman (1998) argues that it is the emotional competencies that often make the difference between success and failure. Competencies such as self-control, self-confidence, adaptability, innovation, ability to manage human diversity, ability to manage conflict, and ability to manage effective teams are important in any job, but even more important in complex jobs, such as the interdisciplinary jobs so common in fisheries management.

Since emotional competencies can be learned (Goleman 1998), by putting forth some effort, persons can improve their emotional competencies, thereby enhancing their ability to cope positively in the wide variety of work-related situations that they

might encounter. It is not necessary to discuss the entire range of emotional competencies here: this is done thoroughly by Goleman (1998). However, in the next few paragraphs, a few emotional competencies will be chosen and discussed within the context of fisheries management and the fisheries manager.

Emotional Intelligence and the Individual

Every individual has an impact (positive or negative) on the individuals around him or her. Sometimes it only takes one individual who is out of "sync" to destroy the work of the entire group. This impact is especially significant if the person is the group leader, or the person who is seen to have the most technical skills. It is therefore important to analyze the emotional competencies of the individual. One key competence is to know one's strengths and weaknesses and to be honest about them. In a discipline such as Fisheries Management, it is not possible for one person to have all the answers. If one has an accurate idea of one's strengths and weaknesses, it is easier to understand in what areas one can best contribute to the goals of fisheries management and where one needs to go for help. This can save the time energy and money that is lost if one consistently tackles and fails in tasks that one is not suited for.

Another important competence is that of self-confidence. Persons who are confident in their selves and their abilities, are more likely to achieve the goals of their organizations. Too many persons make the excuse that "I can't make any difference" or, "The Ministers of Government will do what they want anyway". Such thinking sabotages the creative thought process, as persons resign themselves to an outcome, rather than seeking a creative solution to the challenges that they face. Confidence and creativity are important in fisheries management. To some extent, every situation encountered is unique. The same situation occurring in two different countries may require different approaches. Cultural, social, political, and personality differences can often mean that a solution that works successfully in one place is likely to be a failure in another place. Innovative thinking therefore becomes an important criteria for success, those who are both innovative and confident are more likely to be able to achieve the goals of fisheries management.

Emotional Intelligence and Working Groups/teams

In the discipline of fisheries management, it is common to have working groups and teams of all types. Fisheries Advisory Committees and Councils, working groups to assess the biological status of fisheries resources, teams to address certain problems such as fish kills, are not only common, but necessary. The trans-boundary nature of many fisheries resources means that it is common for many of these working groups/teams to be regional or international. Members of these teams often come from different cultures, different social and economic backgrounds and different areas of technical expertise. Often, they have to function and make complex decisions against the backdrop of financial constraints, as well as constraints of time, information and restrictive mandate.

In these situations, certain social competencies are necessary. Good leadership is a must, or the group may be left floundering, or may lose a lot of time before it finds its way. However, within this setting, there is a need for other emotional competencies, such as the ability to work together as a team, the ability to understand each other and to communicate clearly, and the ability to manage conflict and to work together towards common goals. While this may seem obvious, far too often team facilitators/leaders may be chosen based on their technical skills alone, or their post, with very little reference to their people skills/competencies. This may have the potential to cause frustration and lack of trust and may lead to a team that under performs, or worse still is ineffective.

Emotional Intelligence and Fisheries Organizations

Most fisheries managers function within the context of a fisheries organization, whether it is a government organization or a fishers' organization. Often these organizations have excellent strategic management plans and fisheries management plans. Far too often these plans are either not implemented, or are implemented in a time frame that does not allow the organization to make efficient and effective use of its resources. It is not uncommon for these organizations to have persons who are individually excellent in their fields, but fail to translate this into organizational excellence. Often there are several persons who have the potential to contribute significantly to the organization, but few who actually do. In some cases thousands of dollars have been invested in training persons, but this training seems to have little effect on individual and organizational effectiveness.

These examples may point to shortcomings in the emotional intelligence of the organization. Within most organizations it is the technical and reporting relationships that are emphasized (organizational structure). Recruitment is often based on technical competencies alone. We suggest that fisheries organizations should pay more attention to the people side of things. Persons should be recruited based not only on their technical competencies, but on the other emotional competencies needed for doing the job. Training should be determined on an individual basis and should seek to build on the emotional competencies necessary for fulfilling the role that the person plays in the organization. There should be commitment to the development of persons in the organization i.e. recognizing and meeting their development needs. There should be a focus on building collaborative and cooperative relationships within the organization and with organizations and persons to whom the organization provides services. Lines of communication should be open, and persons within the organization should be responsive to giving and receiving feedback. Feedback should not be seen as a personal attack, but as a means of helping the organization to move forward.

Flexibility and willingness to change should be hallmarks of the organization, so that the organization does not become obsolete, but can continue to respond effectively to the needs of those they serve. Fisheries organizations should be learning organizations – making appropriate use of new information and insights, as well as learning from experience. Each member of the organization should

understand the goals of their organization and they role that they play in the organization. Commitment to organizational goals can be built by ensuring that these are aligned with personal goals.

By repositioning the human being in the process of fisheries management, fisheries organizations may need to have a human resource manager on staff, who can help to ensure that: lines of communication remain open; persons have the opportunity to air their frustrations and have them addressed; and, collaborative relationships and goodwill are maintained and/or strengthened. It may also be necessary to consider having public relations officers, or some other mechanism of ensuring that feedback from the sector (the customers) is obtained in a timely and efficient manner, and that customer needs are met. Time spent empathizing with and understanding the needs of colleagues and co-workers should not be seen as time wasted away from work at the desk, but as an opportunity to built empathy, trust and improved collaborative relationships.

We are not suggesting that emotional intelligence take the place of technical knowledge and approach within organizations with responsibility for fisheries management, but that emotional intelligence be evaluated for the potential that it has to contribute to successful fisheries management, and that the concepts learned from a study of emotional intelligence be used where appropriate to enhance the outcome of our fisheries management efforts.

Emotional Intelligence and the Resource Users

At least two areas need to be considered in this section: 1) The interaction between fisheries organizations and the resource user 2) The interactions among resource users.

Fisheries organizations (in particular government organizations) often play a lead role in what happens in the fisheries sector. Often an approach is taken where the Government organization behaves as if it knows everything, and it expects everyone to do what it says without discussion. Often the organization does not even take the time to properly explain the rationale behind the decisions that it takes. There is still a widespread feeling among resource users that government officers sit in their offices and make decisions without a thorough understanding of realities. That is, the resource users' experience and wisdom does not seem to count for much. Another telling comment is that people who do research with the fisheries sector often come to them for information, but they never know what happens to the information. Given this, it is not surprising that some persons appear reluctant to comply with regulations and to give certain information.

We are suggesting, that there is more room for developing common understandings between resource manager and resource user. There is also room for commitment building, negotiation, empathy and discussion. Fisheries organizations must be willing to respond to the needs and experiences of those that they serve. This must not only happen at the formal level, but must become a part of how individuals experience their interactions with other individuals. We are not necessarily suggesting that government organizations move away from their

decisions regarding particular issues, but rather that they spend more time listen and understanding, rather than directing. The success of the Soufriere Marine Management Area in St. Lucia (Figure 2) is indicative of the efficacy of such an approach.

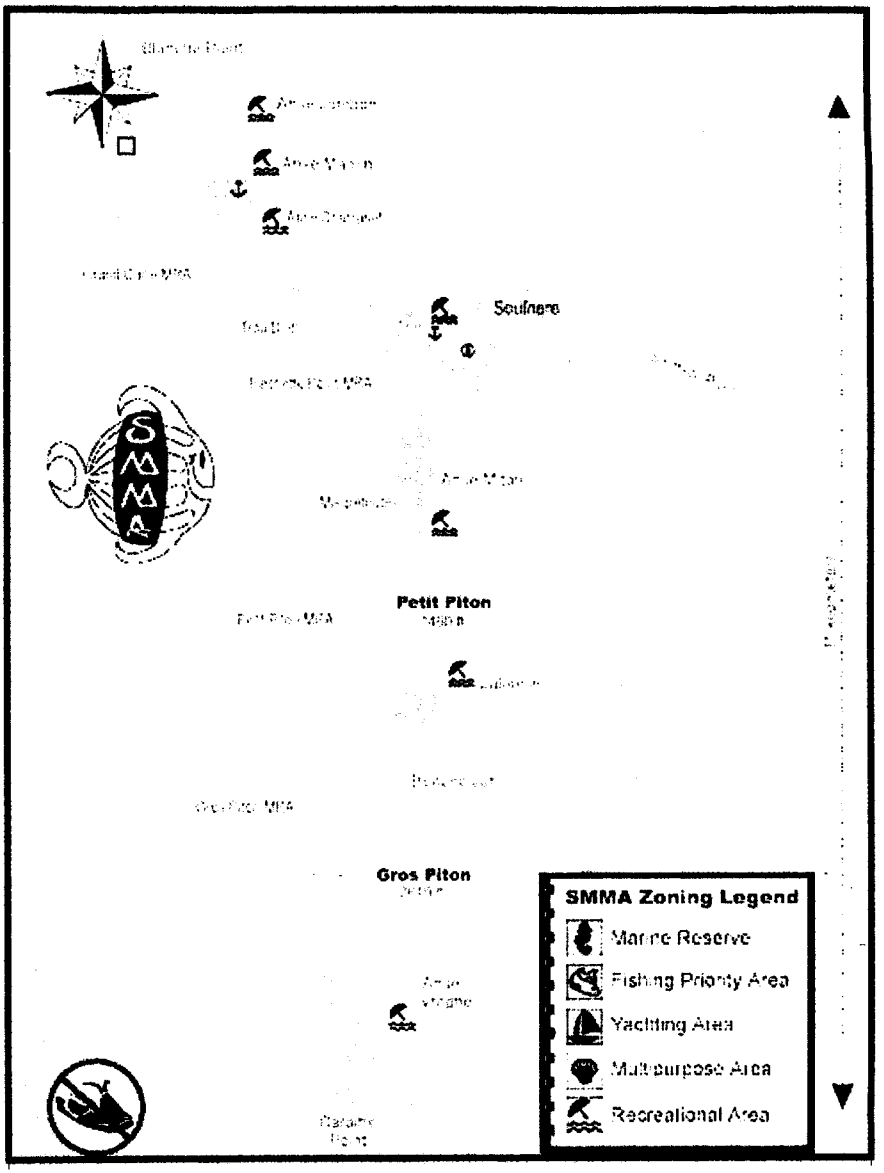

Figure 2. Soufriere Marine Management Area in Saint Lucia: fishers' knowledge and perspectives contributed in large measure to its sustainability.

Very few fisheries can be adequately managed without some level of collaboration between the resource manager and the resource user. McConney (2000, see also Berkes et al. 2001) identifies a spectrum of possibilities for power-sharing in fisheries, ranging from full community control to full government management. Within the Caribbean the trend is towards a more participatory form of management. Collaboration in these cases, has to be based on principles of transparency and accountability (Berkes et al. 2001). "As the conventional way of managing fisheries is gradually replaced by a new, more holistic and people-oriented way, there needs to be an emphasis on process. What makes the new management feasible is not a new formula that replaces the old, but putting into effect a new process of doing things" (*ibid.*). This new process, since it involves almost a "people first" orientation, must utilise an understanding of how people think and how we as managers can relate to them in a way that is supportive of our attempts to (invariably) change their behaviour. We must share with them a sort of "gut" appreciation for the things that drive them. As Carney (1998) put it: "we should listen to those with whom we are working and learn from them about their own objectives, their own understanding of what it means to be in and escape from poverty". To ensure that this takes place managers and resource users alike would be better served if they deal with each other based on accurate interpretations of emotions.

Emotional intelligence also has implications for how resource users relate to each other. In order to properly contribute to the process of fisheries management, resource users also need to come together to share information and clarify perspectives. Whether this occurs in the form of temporary interest groups, or as more well developed organizations, the same principles will apply. Group or organizations would benefit from the development of emotional competencies, as this will enable persons to interact and share diverse perspectives, with minimum conflict, bad feeling and frustration.

SUMMARY

If we could choose three things that we would want persons to implement after reading this paper they would be summarised as follows:

i) People first.
ii) Please may I listen to/empathise with you.
iii) Let me help you listen to/ empathise with me.

CONCLUSIONS

In conclusion, we are not suggesting a cure-all for the maladies experienced in fisheries management. What we are offering is food for thought, and essentially an alternative approach. What we want to convey is that this approach can and does work. The evidence and explanations for emotional intelligence are based on scientific fact. An understanding of EI or the development of EI competencies,

allows us to add another set of tools to our tool kit. Like any other tool, use it where it helps and where it is most effectively applied.

ACKNOWLEDGEMENTS

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Mediation-fostered Equality? An Examination of Environmental Negotiations from a Power/process Perspective

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ABSTRACT

This paper seeks to separate in theory and practice, structural and functional characteristics of various environmental mediation approaches. These approaches can be grouped into two basic model types that I call *outcome-driven* and *process-oriented.* I argue that if mediation is outcome-driven rather than process-oriented, factors associated with power disparity will negatively influence the achievement of equal footing in the process. Two cases of environmental negotiations featuring mediation processes are examined from a power/ process perspective, demonstrating difficulties that can arise from the reality that some stakeholders are 'more equal' than others. The formats of negotiation are explored to contrast and compare strategies employed, and suggestions are made as to the relevance of outcome-driven and process-oriented mediation approaches to varying types of conflicts.

KEY WORDS: Environmental negotiation, mediation, conflict resolution, natural resources management

Igualdad Conducido por Mediación? Un Análisis de Negociaciones Medio Ambientalistas

Dentro del contexto del manejo del medio ambiente, el termino "mediación" ha sido aplicado a muchas estrategias de intervención que intentan resolver las disputas de los partidos. Esta investigación repasa los estudios sobre la mediación y diferencia entre las estrategias que pueden promo ver un balance los partidos y las que no pueden. Dos perspectives basicas de mediación están identificadas:

i) Las orientadas a resultados y
ii) Orientadas al proceso.

Para ilustrar la aplicación de estas perspectivas, tres casos de negociaciones ambientales se discuten desde una perspectiva de poder/proceso. Estos casos demuestran las dificultades que surgen de la realidad de que algunos partidos son "mas equitativos" que otros. Las formatos de negociación son explorados para contrastar y comparar las esrategias de mediación aplicadas, y se han hecho sugerencias con respecto a la relevancia que tienen las perspectivas *orientadas a los reultados* y *a las orientadas a procesos* en las varios tipos de conflictos.

PALABRAS CLAVES: Mediación, estrategias de intervención, negociaciones ambientales

ON ENVIRONMENTAL MEDIATION

Mediation might be described as the process that seeks to foster equal footing for stakeholders. It is a process that recognizes the power disparities that place the investments of interested parties at risk. While the term 'mediation' is sometimes used interchangeably with 'negotiation', there is a significant difference. Negotiations can occur between two parties, but mediation essentially provides for the insertion of an intermediary between disputing parties. Mediations can take many forms – from large and complex tribunals to much simpler facilitated discussions; from formalized mediation procedures, to informal mediation processes. Of importance here, are the differences found in mediation practices. These differences stem from varied approaches to power disparities that occur in and result from social transactions.

There are any number of external characteristics that inform mediation, from culture, history, language, politics and law, to more interpersonal criteria based on individual personality, power, and status of both mediator and disputants. These characteristics, informing individual worldviews, can be loosely grouped into two descriptive areas: *nature* and *scope*. Cultural characteristics, family and community traditions, history, values, ethics and beliefs, language and semantics are examples of attributes that fall into the descriptive area of *nature*. The role of each mediation participant, the type of mediation (i.e. negotiating, integrative, collaborative, consensus building), the duration of the mediation process, number of participants, complexity of issues and legality are some attributes that describe *scope*. The nature and scope of the interaction within the triad of mediator and disputants inform the mediation process.

Although mediation is often thought synonymous with notions of achieving equal footing between unevenly advantaged stakeholders, there is disagreement as to whether equal footing is a necessary requirement of conflict resolution (Moore 1996). Many authors see an advantage to the dynamics of mediation where imbalance promotes shifts from positions to interests. The interest-based 'Best Alternative To Negotiated Agreement' (BATNA) approach (Fisher and Ury 1981) suggests that shifts in outcome perceptions can transform adversarial negotiations to collaborative efforts. Glasbergen (1995) views this transformation process as an interactive 'controlled change' producing what Gray (1989) conceptualizes as an evolving negotiated order. These shifts in perception are inherently related to outcome possibilities and the relative cultural capital (or power) associated with achieving them. The notion of transitioning from adversarial to collaborative negotiations maintains the framework of winners and losers, but shifts the focus onto 'win-win' outcomes.

Others wishing to move away from the adversarial perspective promote the efficacy of balance in stakeholder groups (Innes and Neumann 1994), and see the benefit of a dialogue approach or "a conversation among peers" (Issacs 1999) which assumes equal footing. Also focusing on equal footing is the Susskind, Levy and Thomas-Larmer (2000) mutual gains approach where professional negotiators are hired for the express purpose of overcoming stakeholder disparity. Where

negotiators and disputants have the common goal of collaboration, the concept of equal footing can be actualized. But as Touval and Zartman (1985) point out, disputants can also use professional negotiators in political maneuvering. Mediator bias and clout can augment the power disparity that will exacerbate the zero sum game.

The role played by the mediator, as well as the nature and scope of the mediation process are critically important to whether adversarial or collaborative methods are adopted in the mediation process. Moore (1996) specifies three types of mediators:

i) *Social Network Mediators* — who have an established trust relationship with the disputants;

ii) *Independent Mediators* — who are chosen on the basis of their neutrality to the disputants; and lastly,

ii) *Authoritative Mediators* — who are sought precisely because of their ability to settle a dispute through influence, authority and/or a vested interest bias.

Touval and Zartman, (1985) provide parallel descriptions of mediator roles: *communicator, formulator, manipulator.* There is some difficulty in presenting the mediation process in such concise packaging, precisely because it is a process – a changing and sometimes less than neat dynamic. We can however, explore some broad approaches to conflict resolution within the applied context of mediation.

Fisher and Ury (1981) distinguish between two strategies that define the relative perspectives of the disputants, as well as contribute to the nature and scope of the mediation process, namely, *position-based* or *interest-based.* Position-based strategies often feature obvious displays of power. The status of a lawyer as a 'heavy hitter' can be translated into power capital, useful in gaining negotiative advantage. Experts can be used in this manner as well, and those participants able to produce 'expert' evidence position themselves more strongly in an arena where a zero sum game is being played. With the position-based strategy, both sides have the expectation of winning, and both sides compete for a power advantage, sometimes by building their own power capital (legitimacy, credibility, and legal stance), and/or by undermining the power capital of the opponent. Because a *position* reflects perceptions of its utility for accomplishing benefit or gain, individual investment into the position will similarly relate to cost-benefit. Thus, a functional and inflexible relationship exists between individual investment and position – either the investment pays off, or it does not.

Interest-based strategies focus on the affective investment participants have in a variety of interests related to issues of contention. Here, co-operation is enhanced and there is an expectation on both sides of compromise. Overt displays of power provide little tactical advantage, so power is expressed in subtler currencies. For instance, one party might provide information that affects the other party's interests, thereby *educating* the other party. This tactic is often used by natural resources agencies in negotiating with stakeholder groups. Another is a tactic offered by Fisher and Ury, in which one party 'attacks the problem' while offering recognition

and support to the other party. This creates a dissonance in the other party, encouraging them to move away from the problem toward the comfort of solution. Thus, one party has precipitated a cognitive shift in the other party affecting their interests and resolve.

Figure 1 illustrates some characteristics generally associated with the two strategies, but it in no way infers exclusivity of characteristics between the two. In fact, Fisher and Ury specifically show the linkage in their description of 'hard and soft' positional bargaining. Their 'principled negotiation' model extracts characteristics of hard and soft negotiations useful in 'changing the game' to a hybrid focused on interests and solutions.

Position-based		Interest-based
win/lose outcomes	------	consensus outcomes
overt display of power	------	display of power subdued
functional investment	------	affective investment
expectation of win	------	expectation of compromise
expectation of expediency	------	expectation of time investment
inflexible	------	flexible
various levels of autonomy	------	higher levels of autonomy

Figure 1. Some characteristics of position-based and interest-based strategies. Broken lines represent the continuum of degree along which these characteristics occur.

Fisher and Ury promote an interest-based strategy as the preferred strategy as it opens up more options for negotiation. But while disputants appear (or are led) to adopt one strategy over another, the nature and scope of the process cannot usually be so distinctly categorized as being one strategy or another. The mediation process might travel back and forth from position-based to interest-based negotiations, or start out as a win-lose situation and be modified by a skilled mediator and willing/able disputants, into an interest-based process.

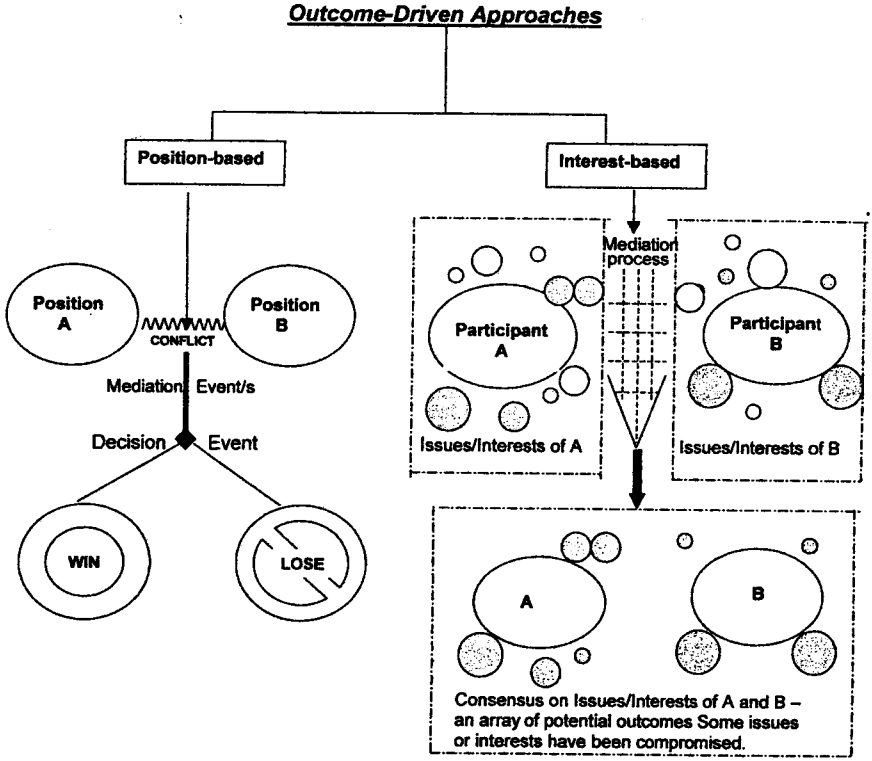
Thinking within a comparative framework of interest-based and position-based strategies is useful in conceptualizing the multifarious nature and scope of mediation processes, and the often complex interplay within and between them. The use of one strategy over another by participants can be a descriptor of the relative types of investment that various stakeholders might represent in a given mediation. Strategy preference can indicate the various levels of autonomy in decision-making that mediation participants have or perceive themselves to have. As well, strategy preference can reveal expectations (i.e. of their role in the process, of outcome, of time expenditure), and relative individual expectation levels held by participants. In

a position-based strategy, there is a focus on the outcome, and so we can say that the mediation is *outcome-driven.* Here, the strategy is to incorporate displays of power to drive the adversarial process to victory for one side and loss for the other.

Interest-based strategies are less clear. Even when an interest-based strategy is used in conjunction with consensus building methods, the focus may be *outcome-driven*, and not always overtly so. The focus on interests in the 'principled negotiations' method, is "...explicitly designed to produce wise outcomes efficiently and amicably" (Ibid.:10). Environmental negotiations incorporating mediation tactics provide some good examples in the use of overt and covert power strategies, many of which also use the semantics of interest-based consensus. Susskind, Levy and Thomas-Larmer (2000) examine a series of negotiated agreement and mediation cases which employ various power strategies and BATNA's to orchestrate interest-based agreements. In a similar vein, Innes, Gruber, Neuman and Thompson (1994) see BATNA as the first step in consensus building – a cost/benefit analysis of interests to determine compromise.

The deliberation of and shifting to 'best alternative to negotiated agreement' (BATNA) immediately recognizes the forfeiture of something substantive, and seeks a consensual settlement that allows stakeholders to adjust the boundaries within which they will maximize benefit and minimize cost in a situation. But while reaching consensual agreement, it is not correct to suggest that participants' eyes are not on 'best and worst case' outcomes. As in the use of BATNA, it is from these that the area between is negotiated. From this adjustment, outcome possibilities are expanded to reflect interests and ensuing deliberations will progressively narrow the area in which negotiation occurs until agreement is reached (see Figure 2). In achieving consensus based on interests, parties have avoided a zero sum confrontation. This has obvious advantages in disputes between stakeholders with on-going and/or localized relationships, in disputes with multiple stakeholders, or in court-mandated mediations where potential losses could be substantial. In many situations then, *outcome-driven* mediation, whether position-based or interest-based, provides satisfactory settlement. In others, however, it is less than satisfactory, resulting perhaps in deferred confrontations, increasingly convoluted issues, definitional uncertainties, and untenable agreements to name only a few possibilities[1].

Aside from some apparent difficulties with post-mediation realizations by stakeholders of having lost something in compromise, or outcomes of agreement that are either untenable in their idealism or so shallow as to be meaningless, there are situations in which an *outcome-driven* approach is deeply disquieting and less than appropriate in finding long term solution. Touval and Zartman (1985) provide case studies on U.S. peacemaking mediations, several years in the process and only nominally successful. In the cases studied, the US (acting as mediator) sought to induce, compel or persuade foreign parties of longstanding religious and political conflict to translate these into interests and negotiate a peaceful middle ground.



Outcome-driven approaches include position-based strategy and interest-based strategy. Position-based strategy: simple representation – two positions; mediation interface; zero Sum outcome. Interest-based strategy: A has multiple interests as does B. Relative import of interests/issues indicated by size of sphere. Relative attachment (heavy investment) of interest/issue indicated by proximity to A or B. Interests that are negotiated into consensual outcome are shaded. Interests that are compromised are represented by empty sphere. This is done through the mediation process. In order to 'win' on some issues, others have to be compromised. The outcome is what A&B can consensually negotiate.

Figure 2. Outcome-driven approach to position-based and interest-based strategies.

Some obvious questions arise. Can tradition, culture, and religious belief be reduced to negotiable interests? Burton (1990, 1996) and Moore (1996) suggest they cannot.

In related area, Frédérick (in Deudney and Matthew 1999) [2] discusses environmental security issues and conflicts on a global scale, noting that even when consensus has been reached through a mediation body or program (such as the Food and Agricultural Organization of the United Nations [FAO], United Nations Environmental Program [UNEP], or the Organization of Economic Cooperation and Development [OECD]), the agreements reached cannot be enforced because the mediating organizations or programs have no legal teeth to compel compliance. Certainly, one purpose of mediation is to facilitate negotiation of agreements. Where agreements are recognized by law, and where there is legitimated authority to compel compliance, the legitimated authority or authorized agent will subsequently act as police. But here again, questions arise. Should organizations founded on the notion of international cooperation (such as FAO, UNEP or OECD) be thinking of broadening their role so as to be able to enforce agreements between nations? Frédérick acknowledges that nations are primarily concerned with their own economic and environmental security.

> "*...(I)t is through the prism of their own national security and hence their own national interest, that states will analyze the impact of global environmental problems along with state behavior apt to upgrade the situation or further harm it*" (Ibid.:96).

Is it realistic to think that "beefed up" mandates toward "real powers of intervention" will accomplish anything save further conflict?

These examples point to a fundamental difficulty in the mediation process, particularly although not exclusively those associated with global participants – that of the pervasiveness of essentialist thinking. This is perhaps because mediation models offered by authorities or negotiators often make only superficial attempts at accounting for and comprehending the multifarious nature and depth of meaning attached to 'issues' by diverse stakeholders. In other words, mediations involving diverse identity groups (i.e. race, class, ethnicity, culture, language, politics, nationality, religion, tradition) often mistakenly engage in *translating* these characteristics and associated attributes (i.e. identity definitions, norms, needs, interests) by using 'mainstream' standards and definitions foreign to the actual groups in conflict. This is done on behalf and purportedly 'in the best interests' of the conflicting groups. More reasonably, it is to facilitate the application of the mediation model and the participation of the negotiators along ideological lines that inform those 'guiding' the process toward specific resolution outcomes. Meanwhile, the recognition of basic human needs common to groups in conflict and on which durable resolution might be built, escapes the process.

Fisher (1997), moving away from the 'how to' efficiencies of *Getting to the Yes* (1981), notes in this more recent work the importance of the distinction made by

Burton [3] between " 'deep-rooted conflict'...not based on negotiable interests and positions, but on underlying needs that cannot be compromised" and " 'disputes' about tangible, negotiable interests...". Differences of principle, ethic, nationalism, religion, and cultural meaning are examples of 'deep-rooted conflict'. Fisher suggests that these 'deep-rooted' conflicts can be accommodated by an innovative mediation technique called *integrative conflict resolution.*

> *"Thus ICR...can potentially provide some integration between the often conflicting major strategies of peace through strength and peace through cooperation. This potential is because ICR accepts the importance of power in influencing relationships, appeals to standards of fairness and justice as espoused by international law and world order models, and assumes that a firm and cooperative approach to conflict management will lead to satisfactory outcomes for all parties."* (Fisher 1997)

Not unlike Glasbergen's (1995) 'network management' scheme, ICR emphasizes the process of working through conflicts using a variety of methods. Yet, there is still the focus on 'satisfactory outcomes' from a 'firm and cooperative approach' that is somewhat troubling. Fisher describes ICR as having a secondary role to that of more "substantive negotiations". ICR is "de-escalatory" – useful in diffusing emotional displays in preparation for more subtle power strategies. Fisher's perspective on what is substantive does not appear to entirely grasp the point Burton makes. 'Deep-rooted' conflicts are deeply substantive.

Resolution of some environmental conflicts will require the establishment of collaborative trust and the security of building toward an array of equally met needs – substantive needs. Is it possible for collaborative trust to be equally exchanged if stakeholders are not or do not perceive themselves to be on equal footing? Not likely. Disparate conditions between stakeholders (in access to resources, political associations, level of investment, size of organization, coherency of claims – in other words, their relative power assets) filter into and influence the process despite an interest-based orientation. ICR as Fisher describes it, is not meant to equalize power – it is meant to diffuse the emotions of those who perceive themselves compromised. Burton (1996), however, claims that "(e)motional reactions must be expected and respected, but not avoided." The concept of integration is a good one, and Fisher notes its potential in a preventative role "...in a less chaotic future world". I would suggest however, that it is only through a process of integration focused on common human needs and away from power differentials that a less chaotic future world might be possible.

With increasing attention in public policy toward social justice and access issues, there is an accompanying focus on 'the process' – oftentimes as a hurdle to negotiate in order to get on with the business at hand of meeting administrative and legislative mandates. In some quarters, the mediation process is viewed opportunistically as a power game (Glasbergen 1995, Fisher and Ury 1981, Fisher 1997). Viewed as a means to an end, process is constrained to a conceptually legalistic, structurally fixed

format. In many mediation situations, this is entirely sufficient. But in 'deep-rooted' conflicts involving societal needs that cannot be compromised, attempts by mediation to coerce or influence outcomes, or to 'go through the motions' may be far more damaging in the long run. "Indeed, it may well be that conflicts are protracted unnecessarily just because inalienable values are translated into interests merely to fit into the traditional processes of bargaining and negotiation" (Burton 1987).

To view process exclusively as a means negates the phenomenon of process being a means and an end to itself. Process as an end infers a product – something additive and innovative. Thomas' (1994) 'power process perspective' addresses the additive nature of innovation as both the process and product (means and end) of an interactive dynamic between technological and social worlds. Following after Granovetter's (1985) idea of the 'embeddedness' of transactional behaviors in the social realm, Thomas emphasizes the 'mediating role of history, structure, and power relations', but moves beyond 'embeddedness' by alluding to the influence of change itself as additive and unpredictable. Similarly Bolan, in Bryson and Einsweiler (1991), recognizes the emergence of something new and additive. In differentiating between instrumental rationality (utility) and substantive rationality (normative), he suggests there is a third form, 'adaptive rationality', that mediates between instrumental and substantive rationalities. Adaptive rationality has a 'synthesizing' nature that "...adds the dimensions of creating new meanings and new thrusts of achievement through a communicative process that concentrates on understanding the existential interstices of shared power..." (142). It is in the recognition of a pathway between instrumental and substantive rationalities that the mediation process has the potential to synthesize a new knowledge grounded on shared experience and power.

If mediation is to make permanent progress toward resolving long-standing, deep and sometimes violent conflicts, then we must refocus our endeavors on the larger and deeper issues toward the kind of integration that *learns through the process,* and away from the short-term efficacy of outcome-driven models in mediated interventions. In conflicts over deeper issues, more than a temporary fix or a cursory effort at 'process' is required. In the process phenomenon, the dynamic of interaction is an end valuable in its own experience and creation, for it is through the shared experience of the process that we grasp the full import of our interdependence and learn from it. It is not the case of 'getting into each others' mindset' but rather the recognition of basic societal needs universally held. It is this recognition that effectively empowers parties in conflict to move beyond interests and work together toward durable solutions by providing for their own and others' needs. Differences in religion, culture, ideology, tradition, and nationalism viewed as integral to traditionally defined conflict, and problematic to outcome-driven styles of mediation, are accepted and respected as components of learning in what I call the *process-oriented* approach model.

In the *process-oriented* model, the additive potential of this integrative dynamic is nurtured. As depicted in Figure 3, the focus of mediation is on the shared learning

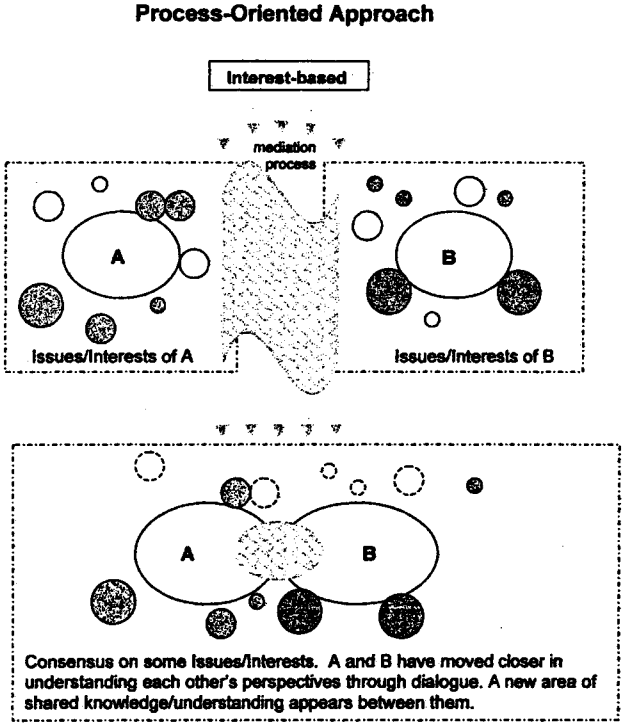
experience and the creation of new meanings and the development of understanding that transcends differences. In this model, outcome is secondary to the process and because of this, specific outcomes cannot influence the process. The power factor inherent to outcome-driven strategies, does not vanish in the process-oriented model. Rather, the effect of power disparity is neutralized by making this irrelevant to the process. The role of the mediator is critical in ensuring that coercive power is diffused, and a place of safe harbor is built so that 'deep-rooted' issues can be revealed in *dialogue*. With coercive power neutralized, participants may enter into the process of dialogue on equal footing. Through dialogue, the practice of listening, respecting, comprehending, expressing and collaborating facilitate equal empowerment of each participant. Isaacs describes dialogue as "...a conversation among peers" (1999). He notes that an emergent worldview promoting dialogue balances the languages of power (action and efficiency), affect (belief and feeling), and meaning (the spirit of truth). Without a balance of these, he says, there are corrupt, tyrannical and over-emotive consequences. Isaacs suggests that developing the capacity for dialogue is necessary for overcoming profound worldview differences.

In situations of 'deep rooted' conflict, it is not sufficient to pay lip service to the semantics of dialogue while maintaining the structural constraints of traditional top down 'driven' communications. It is unacceptable to speak of interests when needs are the root of the problem. To make progress toward resolution, mediations must be clearly intentioned and responsibly constructed by common need-oriented goals. The motivation of the mediation must be understood and accepted by all participants and all must be collaborators in the process orientation.

In the following sections, I examine mediation strategies used in specific cases to identify, contrast and compare *outcome-driven* and *process-oriented* approaches.

SELECTED CASES OF ENVIRONMENTAL MEDIATIONS

To underscore the often subtle differences in mediation approaches and the significance of these differences to what we understand mediation to be, I have selected two cases that illustrate *outcome-driven* and *process-oriented* approaches respectively. The case studies selected represent very different mediation scenarios. The first is an example of the regional interactions between various resource users, the agency regulating and managing the resource, and a management council that perhaps by default, functionally mediates between the two. In the second case, mediations take on global proportions with transnational and transcultural constituents, a formal United Nations mediation process and an NGO acting as informal mediator within an entirely separate mediation process. While these mediation scenarios vary in nature and scope, they share one significant common thread – both cases involve 'deep-rooted' conflicts. In only one case however, will coercive power be treated as an impediment and neutralized. In this case, the facilitator fosters a dialogue that enables 'less equal' stakeholders to participate equally in finding resolution to conflict issues.



Process-oriented approach applied to interest-based strategy. A has multiple interests as does B. The significance of interests is indicated by size and the investment/attachment to interest is indicated by proximity to A or B. Some interests met through consensus in an outcome-driven approach may become less important to the process as a whole. Conversely, other interests may now take on new meaning within the process. These are represented by broken circles. The focus of the mediation is on what can be learned through the process of dialogue. A and B are encouraged to engage in dialogue, thus building trust and developing a better understanding of each other's needs. There is less of a focus on specific interests/issues. Consensus may develop more slowly, but broader agreement (i.e. on issues that might otherwise be compromised) may be reached. The additive character of this approach is the knowledge/understanding learned through the dialogue process represented by the colored space conjoining A & B.

Figure 3. Process-oriented approach to interest-based strategy.

Case 1 – Gulf of Mexico Fisheries Council Meeting[4]

The Magnusson Act gives Regional Fishery Councils 'authority' over designated marine regions. But while the Councils are mandated to prepare fishery management plans for their authorized regions, they are limited to what essentially amounts to making recommendations that flow through the management agency to the Secretary. When the management agency (NMFS – National Marine Fisheries Service) plans regulation changes within the fisheries, the agency is required to give public Notice and entertain the recommendations of the fishery council. One of the roles of the Gulf Council (GC) then, is to provide a public forum to give "...all interested persons the opportunity to be heard..."(Magnusson Act [amend. 10/96] www.nmfs.noaa.gov). While the Gulf Council is not mandated to act in a formal capacity of mediator between NMFS and various stakeholders, its role has evolved into one that includes information gathering, hearing stakeholder concerns, considering concerns and conflicting information, making recommendations based on equity, and acting as facilitator for conflicts to be resolved.

The Council's regional authority as a 'watchdog' entity of fishery resources has evolved into the Council acting in a buffering role between contentious stakeholders and a management agency with firm ideas and direct access to the Secretary. Figure 4 is a simplified relational representation of the Gulf Council, NMFS and fisheries resource stakeholders.

Typically the meetings have several 'closed' sessions regarding items on the agenda prior to the meetings for public testimony. Resource users are notified by NMFS of upcoming council meetings and the agenda items. Matters not on the agenda are not open for discussion. A democratic format is used with members of the public registering before the meeting to voice their representations before the configured council meeting. The meeting has a formal courtroom configuration (Figure 5).

On May 12, 1999, 'fishermen',[5] business representatives, government officials, lawyers and other concerned citizens gathered in Austin, TX, for a Gulf of Mexico Fishery Management Council meeting. This meeting was one of a series scheduled around the Gulf – the same agenda, but different locales to increase public access.

"Someday science is going to catch up with reality". This phrase (and similar words) offered by fishers is heard several times during the meeting. One by one, they approach the podium to give testimony before the tribunal. Many of the exchanges are rapid, amidst paper shuffling, discrete consultations between the two tiers of 'official representatives', clerks speaking discretely into recording devices. One of the debates is on the timing of opening the season for commercial fishery:

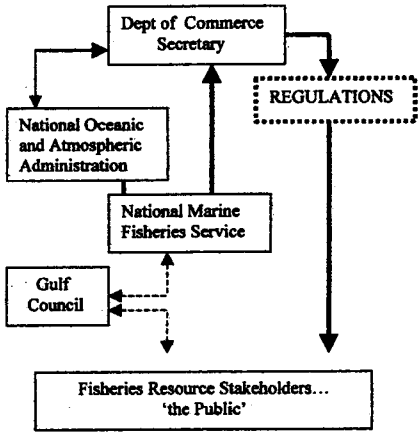


Figure 4. Simple Relational Chart of fishery stakeholders and management entities

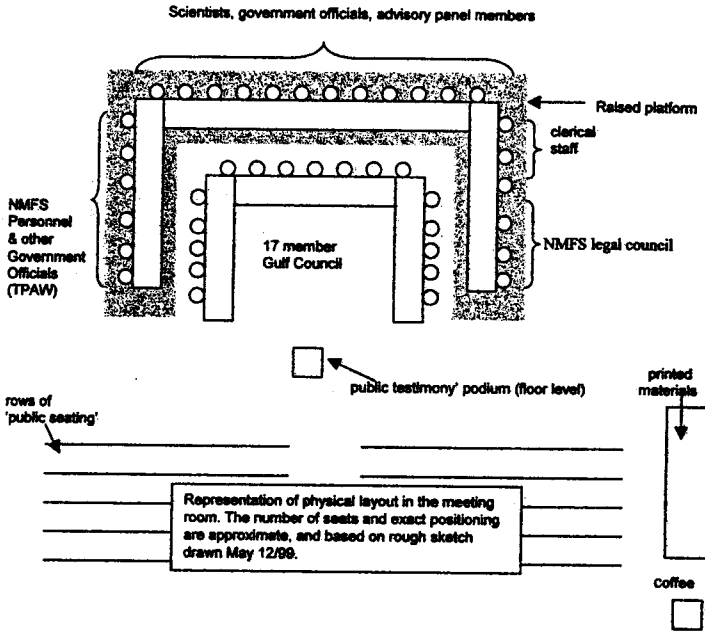


Figure 5. Physical format of Gulf Council meeting May 12/99 in Austin, Texas

Kimmer (NMFS): Fishery has been very co-operative "If they weren't, they wouldn't have been able to be so easily closed. Its inappropriate to open on National Holiday" (MLK Day)

GC member: "Haul happens so fast monitoring's impossible. Weren't even any boardings last year - they (fish and wildlife agents) couldn't find the boats."

Agency official (NMFS): Suggests 'leave the dock' time specification for monitoring.

GC member: Says this is unfair because LA (Louisiana) docks inland. LA fishermen would lose hours in the derby.

From floor: "Why not open MLK Day?" and "Irrelevant when you leave the dock – citations can only occur if gilled fish are found on the boat" (*people from the floor shouting at once, disorder erupts...several seconds pass then a voice over the din...)*

Kimmer (NMFS): Throws leave the dock time question at Gibson (FL fisherman) who Kimmer calls "an expert" ... *(quieting in the room)*

Gibson (FL): "Differences in equipment mean different reasons for going out. We must make access fair field of play. We'll (*fishers*) play by rules...whatever they are."

Kimmer (NMFS): Motions for commercial opening day after MLK Day. (*GC passes motion*) Commends GC on their voting. (*loud muttering, questions, confusion on the floor – there has been no clarification on opening time, leave the dock, or monitoring issues)*

Moderator: (*bringing room to order*) "I'm just the guy who's lost in the middle of the road, waiting to be found, looking for some stability within the fisheries."

The physical structure of the meeting is specifically designed to create a power hierarchy, with the Gulf Council (GC) members at floor level inside a raised platform where government 'officials' from NMFS, Texas Parks and Wildlife, and an armory of scientific experts and lawyers sit. Removed to the 'public gallery', the citizens (for whom 'process' is staged) are excluded from activities in the inner sanctum. The use of a microphone system means that only 'public' communications will be heard, yet the presence of covert communications will be seen. Court-like and adversarial, the 'negotiations' bring win/lose contentiousness. But of greater interest from a power/process perspective, are the subtle ways in which power is deployed and communicated, and what changes result from this.

The debate on when to open the commercial fishery has direct impact on the control that NMFS perceives they will be able to exert on this sector. They are particularly vocal in this exchange. GC members, in an honest attempt to represent concerns relevant to issues at hand, unwittingly provide a smokescreen to the maneuverings of the NMFS official who holds 'monitoring' up as a critical consideration of setting a specific 'leave the dock time'. Arguments from stakeholders are rampant, and in the midst Kimmer (NMFS) isolates and blindsides Gibson (a commercial fisherman from Florida). Gibson does not know the direction

Kimmer is taking and offers a diplomatic hedge. Having silenced fisher and GC opposition by using Gibson as a foil, Kimmer makes his motion and it is approved. There is general confusion regarding the meaning of the motion. This is borne out by the din in the room and the closing remark of the moderator. The rationale of NMFS's motion is not revealed at the meeting, nor are the details clarified. This adds to the perception of secrecy and the significance of the motion.

Power is at once product and means of production as it is gained and lost in trade and sacrifice between and within stakeholder groups. In these exchanges, the exertion of power by NMFS (through the GC) is recognized in the actions of those stakeholders who *react* to their perceived disempowerment. The proposition that the GC holds no power is evidenced in the minimal participation of the council in the debate and the lack of reaction directed toward the council by both NMFS and the fishermen. Only once does NMFS subtle control seem overwhelmed, and it appears that the disorder is deliberately calculated, as is its diffusion.

Perhaps because of its inability to exert power over both NMFS and resource stakeholders, the Gulf Council has filled the roles of educator, facilitator, negotiator, and buffer. In areas of contentiousness between NMFS and multiple fishery stakeholder groups, the Gulf Council through public forums, assessment panels, and regulatory recommendations, has attempted to act as an intermediary. But what appears to be a lack of authoritative legitimization renders many of these functions impotent.

While there is an attempt at the notion of public debate and general agreement (at least legalistically) on the consideration of stakeholder interests, the process is unmistakably *outcome-driven.* Final decisions on fishery matters are often perceived as arbitrary; always they are authoritarian. At best, it appears that the Gulf Council meetings provide opportunities for the appearance of political participation, access to advisory panels and stakeholder venting.

Case 2 — The Neptune Group and UNCLOS III (The Third United Nations Law of the Sea Conference), 1973 - 1982 [6]

In 1967, a proposal was put before the United Nations by Dr. David Pardo, UN Ambassador from Malta, that the seabed and ocean floor be declared the 'common heritage of mankind' and further, that an international, independent agency be established to "...assume jurisdiction over this area 'as trustee for all countries', and control all activities therein" (Glassner 1990). The General Assembly immediately set up a task force to work on the 'peaceful uses of the seabed and ocean floor'. The work of this committee became the foundation of the Third United Nations Conference on the Law of the Sea (UNCLOS III) convened in 1973 and ending with the signing of the UNCLOS III Treaty in 1982. The treaty established a more precise and extensive delineation of territorial waters than its precedent, and through this agreement the foundation was laid from which closely linked issues regarding the marine environment, the conservation of 'living resources', seabed mining and national security were negotiated.

The achievements of UNCLOS III were largely supported by the tenacious work of the Neptune Group, which emerged as a response to the political conundrum that engulfed Law of the Sea deliberations. The Neptune Group was an amalgamation of several NGOs (non-government organizations) spearheaded primarily by members of the Ocean Education Project (OEP), the United Methodist Law of the Sea Project (UMLSP), and the United States Committee for the Oceans – all from the U.S. The individual resources of the NGOs were scarce, but their worldwide network of secular and non-secular organizations synergized into an impressive effort (see Figure 6).

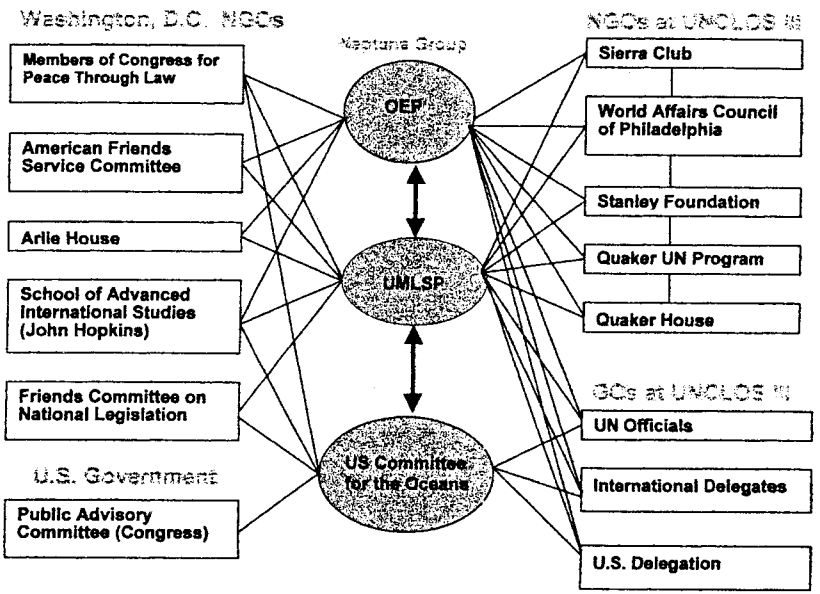


Figure 6. A relational representation of the Neptune Group network.

Initially, the Neptune Group had aspirations of influencing delegates to UNCLOS III in the direction of equitable international distribution of revenues gained from deep sea and continental shelf extraction. Similar myopic approaches however, had alienated some other environmental NGOs from UN delegates and officials. Neptune learned instead to listen intently to the needs expressed by delegates (Levering and Levering 1999) and to flexibly play multiple roles as needed.[7] The group established a reputation for credibility, and as 'honest brokers' provided accurate, useful information in settings of *recognized neutrality.* [8]

The following quotes from delegates provide evidence of the enabling effects of not an equalization of power, but rather the setting aside of it in favor of a kind of 'safe harbor':

> *(Neptune Group's) strongest suit was in bringing together delegates and people with real concerns to exchange views and be frank without having to commit to anyone...to take off coats and talk like human beings. - [Bernardo Zuleta (U.N. Official),* (Ibid.:151-152)]

> *The Neptune Group provided a neutral setting and it was very useful... It was possible for many Third World delegates to see the U.S. negotiating team solve problems with them rather than imposing preconceived ideas [emphasis mine] because of Neptune's help.-* [John Temple Swing (U.S. Delegate), (Ibid.: 152)]

> *NGOs were helpful in facilitating dialogue between the United States and key G77 negotiators on critical issues, or in getting it going again when it seemed to be deadlocked.-* [Markus G. Schmidt (1989), (Ibid.:150)]

In contrast, some participants, primarily from the U.S., considered the involvement of the Neptune Group to be a nuisance – perhaps even an impediment to the negotiation process:

> *(Some colleagues in the U.S. State Department) "were annoyed by the NGOs" and [...]some officials "felt the Leverings (of the Neptune Group) were overly naïve about the motives of Third World countries." - [Otho Eskin (State Department),* (Ibid.: 152)]

> *I thought the brainstorming sessions (arranged by Neptune) were more helpful at the time than I did in retrospect. They gave more immediacy to the issues than they deserved. The more people who talked [at the seminars], the more they gave the sense that it would work.- [George Aldrich (U.S. Negotiator),* (Ibid.:150)]

The comments above provide a contrast on perspectives from delegates who at least broadly share the same interests (those of the United States). The comments of Eskin and Aldrich (distrust, superiority, and adjusted recall) reflect the inability to break away from the focus on *outcome-driven* approaches used in the formal negotiations under the auspices of United Nations intervention and facilitation. Swing's comment is sensitive to international perceptions of the motives and power strategies exercised by U.S. and appreciative of the opportunity to transcend issues of nationalist power to deliberate on issues of more substantive global content. Swing is able to focus his rationale on what he can learn and what others can learn through the *process.*

It would be inaccurate to suggest that all roles and activities of the Neptune Group were *process-oriented.* They were not. Stateside, members of the Neptune Group lobbied hard for specific legislation; very much an outcome-driven endeavor. It would also be inaccurate to hold the formal negotiations of UNCLOS III up as process-oriented. There is nothing in the literature to suggest that the formal negotiations were anything but outcome-driven. It is because the Group found itself in a position where need dictated a very specialized non-partisan role, that a unique niche emerged – one outside the formal negotiation process but interconnected with the actors. Only in this niche (while attending the many sessions of the Conference) did the Neptune Group specifically avoid an outcome-driven approach with its inherent power displays. Here the roles of honest broker, educator, communicator, facilitator, were roles of service – nurtured with careful neutrality.

SUMMARY

This paper has presented the separate theoretical underpinnings of interest-based and position-based strategies in mediation. An examination of these strategies has illustrated a fundamental difficulty in some mediation situations in which the motivation is *outcome-driven.* There are many situations in which an *outcome-driven* approach is entirely satisfactory. In 'deep-rooted' conflicts where issues are non-negotiable however, an *outcome-driven* approach is unsatisfactory. More troubling is the potential for further injury when attempts are made to translate deeply-rooted needs into negotiable interests. It is not enough to develop interest-based mediation models that pay lip service to participant equality when power disparities are present and exercised. Although appealingly efficient over the short term, they are ineffective in fostering the long-term understandings necessary in lasting resolutions. A *process-oriented* approach proves far more effective and durable in the long term, particularly although not exclusively in mediations associated with global environmental and resource conflicts.

The cases presented have been useful in demonstrating the outcome-driven and process-oriented theoretical models discussed in this paper. Case 1 illustrated the confusion and frustration generated by an *outcome-driven* public process whose legislated intent is to provide public access and equality to stakeholders, but where

the latent intent and practice is social control and maintenance of an authoritarian status quo. Case 2 exemplified a *process-oriented* approach that emerged as a direct result of recognition by a mediating organization that an *outcome-driven* approach would not work. An entirely separate mediation process developed out of the inadequacy of the formal *outcome-driven* negotiations. The success of the *process-oriented* approach in diffusing power displays and providing a 'safe' zone for dialogue, garnered legitimacy for the mediating organization and is evidence of the appropriateness of this approach for 'deep-rooted' global conflicts.

In many domestic and in international stakeholder conflicts, an *outcome-driven* approach will continue to be the expeditious and entirely satisfactory way of dispatching resolution. In areas of long-standing and 'deep-rooted' conflicts however, a *process-oriented* mediation approach is urgently needed. Its application on situations of stakeholder conflict, where 'outcomes' have deep and abiding consequences on lives and livelihoods, would appear far more desirable than the situations of contentiousness that are maintained by present methods of stakeholder conflict resolution. Granted, it is costly in time and effort. But much of the time investment would be reduced if participants were brought together as early as possible after conflictive areas were identified and *before* these stakeholders became entrenched in positions that may have little to do with the conflict at hand. Intuitively, the appropriateness for *process-oriented* mediations as a preventative measure is clear. This of course would necessitate some vigilance in government agencies and other organizations to spot *potential areas of deep conflict* resulting from imminent environmental and/or policy changes. On a global scale, the appropriateness for *process-oriented* mediations in accomplishing an on-going dialogue between nations is reasonably the better effort toward participatory and cooperative resolution to issues.

The complexities of transnational and transcultural conflicts will continue to be problematic. The gravity of irreconcilable conflict compels academicians and professionals to understand and make understood, the ramifications of continuing to use mediation practices that exacerbate the 'deep-rooted' conflicts they are intended to resolve. We must ensure that mediation approaches that *can* foster equal footing and those that *cannot* are clearly distinguished in theory and in practice. It is incumbent upon those working in the area of mediation to understand the situational context in which a mediation approach is to be applied, clarify the theoretical content of the mediation approach, and then align intent and practice.

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FOOTNOTES

[1] See a reply by Stulberg (1981) to Susskind (1981) on ethical and logistical uncertainties of pareto optimal outcomes via consensus, in Bacow and Wheeler (1984: 248-251); Moore (1996) refers to BATNA as 'negative settlement range' (277), see also cross-cultural difficulties in setting BATNA's (279); Neuman (2000) on limitations of consensus.

[2] See also Bacow and Wheeler (1984) on negotiations entrenched in convoluted procedural machinations and used as smokescreens for non-compliance/accountability; Mansbridge (1990:22) on common interest and

conflict "...we need deliberative processes as well as adversary ones".

[3] Fisher cites Burton (1965, 1968, 1972, 1979, 1984, 1987, 1990a). See also *Conflict Resolution: its language and processes* (Burton, 1996).

[4] The material for this case study is taken from observation notes (May 12/99) from the Gulf Council meeting in Austin. TX. and from thesis research (Norris-Raynbird, 2000) cited in reference section.

[5] The use of this term is due to the resource users self-naming, and includes male and female commercial fishers, recreational fishers, charter and party boat operators. See Norris-Raynbird (2000) for semantic details on charter and party boat operators in the Gulf of Mexico.

[6] Materials for this case study taken from: Levering and Levering (1999); Glassner (1990); Buck (1998). For full citation see reference section.

[7] The Neptune Group donned many roles in supporting the negotiation of a Treaty over the years. The activities of members when Stateside were often political as they advocated on behalf or against specific issues and legislation. More specifically, the nationalist agenda rampant in the U.S. in the 70's, was of grave concern to the viability of a treaty and members rallied to subdue the effects of nationalism in favor of a worldview ethic and practice. During the many UNCLOS III sessions, however, the Neptune Group adopted a political neutrality, providing educational and public relations services, facilitating meetings and social gatherings for worldwide delegates, providing accurate communications for the media and arranging for independent scientists and experts to interface with delegates.

[8] The recognition of neutrality is evidenced in the perceptions of delegates responding to the *actions and articulations* of members of the Neptune Group. In Levering and Levering (1999), Bleicher (1990) notes the "universalist point of view" taken by the Neptune Group, and Richardson (1990) describes the Neptune Group as having "...reflected a point of view that was aware of the U.S. interests and which wished to avoid undercutting those interests, but...was also sympathetic and fair-minded to the Third World point of view". Glassner (1990) notes that the co-operative activities of Neptune Group helped delegates in achieving a 'fair and practical' treaty. Political neutrality is crucial to cooperative environmental and resource regimes as noted by Buck (1998) in reference to SCAR (Scientific Community on Antarctic Research). But it is more than presenting politically neutral rhetoric. Buck (following Weberian theory) suggests that the appearance of neutrality may be more important than its reality. In the short term, the *appearance* of neutrality may have the same or similar effects. Appearances, however, are difficult to sustain over time and

under political pressure. Deudney argues (in Deudney and Matthew (1999:214) that its not enough to 'talk the talk': "Nationalist sentiment and the war system have a long-established logic and staying power that are likely to defy any rhetorically conjured redirection toward benign ends". The credibility and legitimacy of the Neptune group was earned by 'walking the walk' of neutrality during UNCLOS III conventions. Maintaining organizational legitimacy means *both* 'talking the talk' and 'walking the walk', see Scott (1995).

The Effects of Seafood Import Tariffs on Market Demand for Nassau Grouper in the Turks and Caicos Islands

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ABSTRACT

This study examines the market demand for reef fishes from the artisanal inshore fishery in the Turks and Caicos Islands (TCI). The rapid growth of tourism in the TCI has dramatically increased the demand for seafood but, as yet, the reef fish fishery is relatively undeveloped. Large carnivorous reef fish such as Nassau grouper, *Epinephelus striatus*, are particularly vulnerable to overfishing because of their biology and their popularity in restaurants. The local fishing sector is protected by tariffs up to 40 % on imported seafood products: theoretically, this should increase demand for local fishes as it makes imported products comparatively more expensive. This study uses a paired comparison conjoint survey of TCI restaurants to assess the effects of changes in the import tariff rate on market demand for fresh domestic and frozen imported grouper, and potential substitute products. I find that the import tariff significantly increases demand for local Nassau grouper and, hence, could place increasing fishing pressure on these vulnerable reef fish. The policy implications and alternatives for Nassau grouper conservation are briefly examined.

KEY WORDS: Nassau grouper; tariffs; seafood demand; conjoint analysis

Los Efectos de las Tarifas de Importación de los Mariscos y la Demanda en el Mercado del Mero de Nassau en Islas de Turcos y las Islas de Caicos

Este estudio examina la demanda del mercado para los pescados de arrecife capturados por la pesquería costera artesanal en las islas de los turcos y las islas de Caicos (TCI). El crecimiento rápido del turismo en el TCI ha aumentado dramáticamente la demanda para los mariscos pero, hasta ahora, la pesquería de los peces de arrecife es relativamente subdesarrollada. Los pescados carnívoros grandes del arrecife tales como el mero de Nassau, *Epinephelus striatus*, son particularmente vulnerables a la sobre pesca debido a su biología y su popularidad en restaurantes. El sector local de la pesca es protegido por tarifas hasta 40 % en productos importados de los mariscos: teóricamente, esto debe aumentar la demanda para los pescados locales mientras que hace productos importados comparativamente más costosos. Este estudio utiliza una encuesta sobre conjunta apareada la comparación de los restaurantes de TCI para determinar los efectos de cambios en la tarifa de la tarifa de importación en la demanda del mercado para el mero importado doméstico y congelado fresco, y productos substitutos potenciales. Yo encontré que las tarifas

de importación ponen aumentan la demanda del mero local y por lo tanto, podrían aumentar la presión de pesca en estos pescados de arrecife tan vulnerables. Las implicaciones y las alternativas sobre el manejo y para la conservación del mero de Nassau son examinadas brevemente.

PALABRAS CLAVES: Mero de Nassau; tarifas; demanda de los mariscos; análisis conjunto

INTRODUCTION

Rapid growth of tourism in the Turks and Caicos Islands (TCI) has dramatically increased the demand for seafood but, as yet, the reef fish fishery is relatively undeveloped. This situation is changing, however, as increasing numbers of fishers from South Caicos, the center of the commercial lobster and queen conch fisheries, are increasingly willing to make the 60-km trip across the Caicos Bank to sell reef fishes to restaurants and hotels. Fishers receive prices around US $3.25 per kg for grouper and snapper species from the South Caicos processing plants, which are primarily set up for handling export-oriented queen conch and spiny lobster landings (author's personal observation). On the resort island of Providenciales, on the other hand, fishers receive up to $15.00 per kg for the same fish.

Imported seafood products in the TCI are subject to tariffs of up to 40 %. This policy generates revenue for government and should, theoretically, increase income in the artisanal fishing sector (the *de facto* social safety net for rural TCI 'Belongers'). An import tariff makes local reef fish more competitive relative to expensive imported products. While an import tariff causes some economic welfare losses (deadweight losses), local governments gain tariff revenue and fishers producer surplus (PS) increases as a result of the tariff. Hence, local actors capture increased resource rents at the expense of consumers – largely foreign tourists in the TCI – and there are economic incentives for both government and fishers to support the maintenance or expansion of import tariffs.

Figure 1 illustrates the general effects of a seafood import tariff. In the absence of trade, the domestic supply (S^0) and demand (D^0) curves would determine a market-clearing equilibrium at their intersection. When international supply is not subject to tariffs, the supply curve is kinked, forming supply S^1 at the world market price p^1. Total consumption is q^{t1}, of which q^{d1} is supplied domestically and the balance ($q^{t1} - q^{d1}$) imported. Total economic welfare under free trade is consumer surplus (CS), area *acd*, plus producer surplus (PS), area *def*. When an import tariff is imposed, raising the price of imports to p^2, the supply curve is given by S^2. Total consumption falls to q^{t2}, of which q^{d2} is supplied domestically and the balance imported. PS increases by area *dfgh* (dark gray), government captures tariff revenues, area *bghi* (medium gray), and CS falls to area *abh*. Deadweight losses under the import tariff are the two lightly shaded triangles, areas *bci* plus *fgh*.

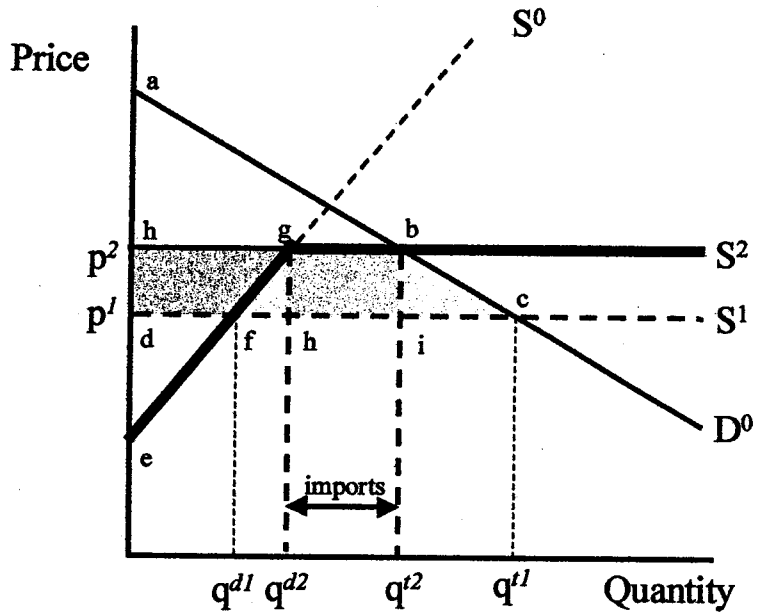

Figure 1. Welfare impacts of an import tariff

Whether the import tariff contributes to reef fish depletion depends on three factors. What is the market demand response to the tariff (i.e., the slope of, and shifts in, the demand curve)? What is the responsiveness of artisanal fishers to price signals in the local marketplace (i.e., the slope of the supply curve)? Finally, how inherently vulnerable are the target stocks (i.e., does the supply curve bend backwards, leading to the Gordon-Schaefer open access equilibrium)? This research addresses the first question and assesses whether the seafood import tariff increases domestic market demand for Nassau grouper, *Epinephelus striatus*, a vulnerable reef fish (Sadovy 1994, Coleman et al. 2000) that also holds considerable value for the dive tourism industry (Rudd and Tupper 2002).

METHODS

A two-part survey was developed for restaurant managers and buyers in the TCI. In the first section, respondents were presented with open-ended questions regarding what seafood products they used, whether their buying decisions were influenced by the import tariff, and their general observations on trends in the availability of local fishes. This research focused on the 'tourist' restaurants of Providenciales and Grand Turk, but the qualitative survey was also used to interview a number of 'native' restaurants catering to TCI "Belongers".

In the second part, a paired comparison conjoint survey was used to assess the marginal trade-offs that restaurant buyers make regarding key product attributes for

reef fishes and potential substitute products. Paired comparisons of this type are designed to elicit maximum information about subtle preference trade-offs and have long been used in market research (Green and Srinivasan 1978). The survey was administered in person by trained student researchers during April 2000. Respondents were assured that all information collected would remain confidential.

Each seafood product is composed of a bundle of attributes that provide value for restaurant buyers (i.e., contribute to profitability) but that vary in level between two profiles. After a pilot survey of selected restaurant owners and managers, experimental design was finalized. Key attributes and levels that were included in the final survey instrument included: product form (fresh or frozen); product source (local or imported); product type (grouper - Serranidae, snapper - Lutjanidae, mahi or dolphin fish – *Coryphaena hippurus*, and wahoo – *Acanthocybium solandri*); and purchase price (US $5.00, 6.00, 7.00, 7.20, 8.00, 8.40, 9.60 or 11.20 per lb). Price is one of the relevant product attributes, allowing the assessment of marginal pricing trade-off's for other product attributes. It should be noted that almost all local grouper landed in the TCI and sold to restaurants is Nassau grouper. Some other grouper species (e.g., tiger grouper, *Mycteroperca tigris*) are occasionally consumed, but *Ciguatera* toxicity limits sales of other groupers in restaurants.

Paired comparison conjoint surveys are cognitively challenging. The design space for paired comparison questions rises exponentially with the number of attributes and levels considered. This survey used two attributes with two levels, one with four levels, and one with eight levels, yielding a potential design space of $4^2 2^4 8^2 = 16{,}384$ possible paired comparisons. The experimental design challenge was to select a limited number of questions from the design space in such a way that useful information about attribute trade-off's is maximized. This was done using the Sawtooth Software Conjoint Value Analysis (CVA) software (Sawtooth Software 1996).

A nearly orthogonal and balanced experimental design consisting of 20 survey questions was constructed by choosing the design with the highest D-efficiency from a pool of 500 candidate surveys. The final survey instrument had $D = 0.932$ (where a score of 1.0 is fully orthogonal and balanced). Each of the twenty survey questions (e.g., Figure 2) asked respondents to express their preferences for one profile relative to another using a rating scale.

The results were collated and analyzed using the CVA software. An ordinary least square (OLS) dummy variable regression was conducted for each survey respondent. The regression coefficients, known in the marketing literature as part-worth's (the marginal valuations of choice variables), were then available for use in market simulations. See Rudd (2003) for a more detailed explanation of the CVA paired comparison analysis and simulation.

The CVA market simulation module was used to model the market share for various hypothetical seafood products. In these simulations, total utility for each alternative product was calculated based on the part-worth's for each individual survey respondent. Each respondent was assumed to choose the seafood product with the highest overall utility in the simulation. The individual choices were

aggregated to determine market share (% of respondents choosing the option) for each seafood product.

Category	Option A	Option B
Product form	Frozen	Fresh
Type of Seafood	Mahi mahi	Grouper
Purchase Price (US$/lb)	$9.60	$8.00
Source of Seafood	Imported	Local Fishery

1	2	3	4	5	6	7	8	9
A is much better		A is somewhat better		A & B are about equal	B is somewhat better		B is much better	
Please circle a number from 1 to 9 that reflects your rating								

Figure 2. A paired comparison question rating two seafood products

The simulations included six potentially competitive seafood products and used average prices reported in the qualitative survey:

i) Imported frozen grouper at US $5.20 per lb;
ii) Local fresh grouper at $5.75 per lb;
iii) Local fresh snapper at $6.54 per lb;
iv) Imported frozen snapper at $6.88 per lb;
v) Local fresh mahi at $7.60 per lb; and
vi) Local fresh wahoo at $8.00 per lb.

Market shares were calculated for two simulations in which the price of either frozen imported or local fresh grouper fluctuated. Other prices and products were held constant across simulations.

The first simulation, which varied the price of imported frozen grouper, simulates the effects of a change in the TCI seafood import tariff. The second simulation, which varied the price of local fresh grouper, simulates the effects of a change in local seafood prices (e.g., due to local depletion or by policies that make fishing more expensive). Two-tailed paired *t*-tests (using Bonferroni adjustment, total α-level of 0.05) were used to test the hypotheses that the market shares of the survey respondents for different products were significantly different (e.g., was market

share for imported frozen grouper at $5 per lb different from that of local fresh grouper at $6 per lb?).

RESULTS

Of 25 restaurants surveyed, 24 completed the qualitative surveys and 20 completed full conjoint surveys. These restaurants likely account for > 90% of TCI tourist restaurant consumption and approximately 50% of total TCI seafood consumption.

General Market Observations

Approximately 3,200 kg of fish were consumed weekly during the study period; grouper (725 kg) was the single most popular seafood. This implies the annual consumption of grouper is about 85 t (52 * [725 kg / 0.90] / 0.5), of which approximately 50 t (60 %) is landed locally. Weekly consumption of other types of seafood was 650 kg spiny lobster, 550 kg queen conch, 440 kg snapper, 400 kg mahi, 125 kg wahoo, and 265 kg of other products (primarily salmon, tilapia and tuna).

Most local grouper consumed was Nassau grouper. Imported grouper consisted primarily of frozen filets imported from Southeast Asia or Central America via Florida. Most mahi and all wahoo was landed by local sport fishing charter boats and sold directly to local restaurants.

The product mix in native restaurants was much different than in tourist restaurants. The native restaurants tended to use many more species of local fish interchangeably – several restaurants differentiated their purchases only as small or large fish. Native restaurant sales volume was variable, but was very high in some cases (e.g., one 'small' native restaurant used as much fish in one week as a large all-inclusive resort with over 1,000 guests).

Several restaurant buyers commented on the declining availability of reef fish in the Providenciales area. Buyers in Providenciales also noted that inconsistent quality and delivery from local fishers was the main reason that they purchased imported seafood, despite the import tariffs. Most buyers indicated that the import tariff did have an impact on their purchase decisions and that a reduction of the tariff, from 40 % to 20 % on finfish, would alter their purchasing behavior.

A cluster analysis characterizing market niches for the 20 restaurants that completed the full survey was conducted using Datadesk (Velleman 1997). Four distinct clusters were identified: seven restaurants for which price was the most important factor (price sensitive 'casual dining' operations); two restaurants for which product form (fresh) was the dominant factor; four restaurants that placed equal importance on product form, type, price and source; and seven restaurants that put a low priority on source and that shared a characteristic of high entrée price ('white tablecloth' restaurants that source quality product from wherever they can find it).

Conjoint Survey and Simulation Results

Regressions were conducted for 20 individual respondents and part-worth's were calculated for use in simulations. R^2 for high (> 0.88) for all respondents, indicating internal consistency in decision making.

In Simulation 1, the price of frozen imported grouper was varied, simulating the effect of changes in the seafood import tariff. Market shares for various seafood products in the face of varying imported grouper prices are shown in Table 1. Frozen imported grouper might be available from U.S. wholesalers for as low as $3.15 per lb, so $4.00 per lb may already represent an import tariff in the 25 % range. As the price of the imported grouper rises to $5.00 per lb, market share for that product falls from 30 % to 15 %. As price rises to $6.00 per lb, market share falls further to 5 %, and frozen imported grouper is priced totally out of the market at $8.00 per lb.

Table 1. Market share for seafood products when tariff on frozen imported grouper varies

		Market Share (%) for Six Seafood Products					
		Fresh local grouper	Frozen imported grjouper	Fresh local snapper	Frozen imported snapper	Fresh local mahi	Fresh local wahoo
Price of frozen imported grouper (US$/lb)	$4.00	40	30	10	0	10	10
	$5.00	45	15	20	0	10	10
	$6.00	50	5	20	5	10	10
	$7.00	50	5	20	5	10	10
	$8.00	50	0	20	10	10	10

As frozen imported grouper market share falls from 30% to 0%, three other products gain market share equally: fresh local grouper, fresh local snapper, and frozen imported snapper. The average price of frozen imported grouper during the survey period (April 2000) was $5.20 per lb. Reducing the price of imported product from the $5.00 range, by reducing the import tariff, would lead to reduced market demand for local grouper and snapper, potentially reducing fishing pressure on local stocks.

Simulation 2 models the effects of changes in the price of local fresh grouper. This could happen if fishing pressure started to deplete local stocks, driving up prices. It could also happen if the costs of fishing changed, or if the value of grouper for the dive industry were taken into account, correcting for market distortions resulting from fishing externalities. Table 2 shows the market shares for various seafood products when the price of fresh local grouper varies.

Table 2. Market Share for Seafood Products When Fresh Local Grouper Price Varies

		Market Share (%) for Six Seafood Products					
		Fresh local grouper	Frozen imported grouper	Fresh local snapper	Frozen imported snapper	Fresh local mahi	Fresh local wahoo
Price of frozen imported grouper (US$/lb)	$5.00	70	5	20	0	0	5
	$6.00	45	15	20	0	10	10
	$7.00	15	30	35	0	10	10
	$8.00	0	30	40	0	20	10

Table 2 demonstrates that there is a more complex reaction in the market to changes in the price of fresh local grouper. Buyers are very price sensitive, with market share falling from 70% at $5.00 per lb to 0% at $8.00 per lb. All other fresh local products – snapper, mahi, and wahoo – gain market share as the price of fresh local grouper rises. Market share for frozen imported grouper also rises.

Two-tailed paired *t*-tests were used to test the equivalence of market shares (i.e., restaurant buyer indifference between two products) for different seafood products under different pricing conditions. For instance, the null hypothesis that market shares were equal for frozen imported grouper at $5.00 per lb ($S_0$)and fresh local snapper at $6.54 per lb ($S_1$) could not be rejected (Table 3 – fail to reject H_0 at total $\alpha = 0.05$, $p > 0.05$). Conversely, market share equivalence for frozen imported grouper at $6.00 per lb ($S_0$) and fresh local grouper at $5.75 per lb ($S_1$) was rejected ($p = 0.004$) (i.e., cheaper fresh local grouper was significantly preferred).

Table 3 summarizes tests for frozen imported grouper, which has a statistically indistinguishable market share from that for fresh local snapper at all frozen imported grouper prices from $5.00 and $8.00 per lb and fresh local grouper at a frozen imported grouper price of $5.00 only. As frozen imported grouper price falls well below $5.00 we should expect to see restaurant buyers increasingly prefer the import product, perhaps to the extent that the equivalence of market share with fresh local grouper could again be rejected (i.e., when frozen imports are at $6.00, fresh local grouper is significantly preferred by buyers, when imports are at $5.00, buyers are indifferent, and when imports fall under $4.00, buyers may significantly prefer the imported product).

Table 3. Tests of equality of profile market share004s for frozen imported grouper (S_0) and other products (S_1). Two-tailed paired *t*-test *p* -values are for total α = 0.05, individual α = 0.001.

		Market Share Test (H_0:$S_0 = S_1$) *p*-value				
		Fresh local grouper ($5.75/lb)	Fresh local snapper ($6.46/lb)	Frozen imported snapper ($6.88/lb)	Fresh local Mahi ($8.00/lb)	Fresh local wahoo ($8.00/lb)
Price of frozen imported grouper (US$/lb)	$5.00	0.082	0.171	0.001	0.031	0.031
	$6.00	0.004	0.110	0.004	0.017	0.017
	$7.00	0.004	0.110	0.004	0.017	0.017
	$8.00	0.004	0.110	0.017	0.017	0.017

Similarly, Table 4 shows the two-tailed paired *t*-test results when fresh local grouper (S_0) at various prices of is compared with other seafood products at current prices. The patterns are more complex than in the previous case. For example, restaurant buyers exhibit indifference between fresh local grouper at $7.00 per lb and fresh local mahi at $8.00 per lb ($p = 0.666$). However, the equivalence of market shares is rejected when the price of fresh local grouper falls to $6.00 per lb ($p = 0.031$, indicating that the cheaper grouper is significantly preferred) or rises to $8.00 per lb ($p = 0.042$, indicating that the mahi is now significantly preferred to more expensive grouper).

Table 4. Tests of equality of profile market shares for fresh local grouper (S_0) and other products (S_1). Two-tailed paired *t*-test *p*-values are for total α = 0.05, individual α = 0.001.

		Market Share Test (H_0:$S_0 = S_1$) *p*-value				
		Frozen imported grouper ($5.25/lb)	Fresh local snapper ($6.54/lb)	Frozen imported snapper ($6.88/lb)	Fresh local mahi ($8.00/lb)	Fresh local wahoo ($8.00/lb)
Price of frozen imported grouper (US$/lb)	$5.00	0.000	0.014	0.000	0.000	0.000
	$6.00	0.083	0.171	0.001	0.031	0.031
	$7.00	0.330	0.214	0.083	0.666	0.666
	$8.00	0.010	0.002	0.000	0.042	0.163

Table 4 demonstrates that fresh local grouper is a substitute for each of the other five products. At a low price of $5.00 per lb, it is significantly preferred to all other seafood products. At intermediate price levels, market shares are not

significantly different for fresh local grouper and other products. When the price of fresh local grouper rises to $8.00 per lb, all products except fresh local wahoo are preferred to expensive grouper. By contrast, frozen imported grouper can only be viewed as a substitute for fresh local snapper and grouper.

DISCUSSION

A variety of market niches exist in the TCI restaurant sector. Preferences for seafood products varies substantially, but total annual seafood consumption in the TCI probably is in the 325- to 425-tonne range, assuming that consumption in restaurants during the study period (April) is average, our sample accounted for 90 % of tourist restaurant purchases, and that tourist restaurants account for about 50 % of total seafood consumption in the TCI.

Characteristics of Market Demand

Frozen imported grouper and fresh local grouper are substitute products. In Simulation 1, a 50 % change in the import price (from $4.00 to $6.00 per lb) induced a 10 % increase in market share for both fresh local grouper and snapper. Frozen grouper is generally viewed as a low-quality product; changes in prices had no impact on high-end local products (mahi and wahoo), and the main impact of frozen imported grouper on fresh local grouper market share occurred at prices less than the current import price ($5.20 per lb).

Market demand for fresh local grouper is very price sensitive. A 60% increase in price, from $5.00 to $8.00 per lb, resulted in market share falling from 70 % to 0%. The biggest market share gainer was frozen imported grouper (+ 30 %), but fresh local snapper and mahi also increased 20 % in market share as fresh local grouper price rose over this range. Fresh local grouper is viewed as a high-quality product and can substitute for high-end mahi and wahoo.

The results of both simulations imply that market demand for fresh local Nassau grouper in the TCI is quite elastic (i.e., the demand curve is relatively flat), and that the curve will shift up or down based on the price of substitute imported grouper, which is partially determined by the import tariff.

Characteristics of Market Supply

What are the next steps that need to be taken in an analysis of Nassau grouper management options in the TCI? The second step is to assess the response of local fishers to changes in market price signals. If fishers were profit maximizers, we would expect to see increased effort allocated to reef fish capture as demand rises. Fisher behavior and motivations in tropical artisanal fisheries are likely more complex, however, and factors such as risk preferences, alternative fishing opportunities, and revenue goals (rather than profit) may come into play. Many Nassau grouper caught on the South Caicos fishing grounds, for example, are taken by lobster divers who opportunistically spear fish (Tupper and Rudd 2002). Few data are available from fisher logbooks regarding the allocation of effort between

different fishing activities, fishing locations or landing volumes. Further work on the supply-side of the market is clearly required.

Policy Implications

Further complications arise in economic analyses of reef fish management options. First, large reef fish such as Nassau grouper provide non-extractive economic value for the dive tourism industry (Williams and Polunin 2000, Rudd and Tupper 2002) as well as being popular in restaurants. This makes policy decisions based on economic maximization criterion difficult because of nonmarket valuation challenges. This may also lead to conflicts between policy actors with different goals. For instance, the finance division of government may have a goal of revenue generation (in the TCI, there are no income, property or business taxes – substantial government revenue is raised by license fees and import tariffs) while other departments might have goals of efficient resource utilization, promotion of tourism, or conservation. Fishers and the dive tourism operators may also have conflicts over reef fish utilization.

Secondly, the biology and ecology of many reef fishes, including Nassau grouper, make them extremely vulnerable to overfishing (Coleman et al. 2000). They will have the classic backward-bending supply curves of the Gordon-Schaefer model that, in the absence of effective property rights, lead to an open access equilibrium where average, not marginal, cost just equals demand (i.e., total rent dissipation).

When an import tariff is imposed, consumer surplus falls. When harvest levels are relatively low, the tariff may increase producer surplus as local fishers increase production and get higher prices (recall Figure 1). Government gains tariff revenue. Once harvests rise above MSY, however, further increases in fisher revenue can be completely offset by rising costs. Strong incentives may still exist, however, for government to maintain or increase import tariffs if they are having difficulties meeting revenue generation goals. Thus, at low levels of fishing, goals of increasing fisher income and generating government revenue may coincide, but this will not necessarily remain the case as tariffs rise.

Nassau grouper stocks in the TCI are still in relatively healthy condition. In fact, densities in the TCI are the highest observed in the Caribbean region (Tupper 2002, Tupper and Rudd 2002). However, given the particular vulnerability of grouper to even low levels of fishing (Sadovy 1994, Coleman et al. 2000) and their value to the dive tourism industry (Rudd and Tupper 2002), it would seem prudent to implement pro-active policies that effectively protect this valuable resource as well as meeting other social and government revenue generation goals.

The optimal policy mix must account for species ecology, fisher behavior, government revenue generation, and market demand in both the restaurant and dive tourism sectors. Setting a total allowable catch (TAC) for Nassau grouper may be unfeasible because of problems monitoring catch. Similarly, minimum size limits are likely of limited usefulness because of monitoring difficulties and because Nassau grouper are sequential hermaphrodites (see Coleman et al. 2000) (i.e., harvesting only larger fish could still impair reproductive capacity).

Marine protected areas (MPAs) have been advocated for groupers (e.g., Coleman et al. 2000). Tupper (2002) and Tupper and Rudd (2002) have not found Nassau grouper to be more abundant within a small MPA near South Caicos, however. This is likely due to the relatively small size of the MPA relative to the comparatively large home range of Nassau grouper (the MPA had significant positive effects on the size, abundance, and biomass of smaller, more sedentary hogfish, *Lachnolaimus maximus*). Full protection of essential Nassau grouper habitat and spawning migration corridors on the very narrow fringe of the Caicos Bank would impose economic hardship on local fishers who depend on those areas for commercial species (spiny lobster) and subsistence fishing. Enforcement, again, would be problematic, and a large MPA could degenerate into another 'paper park'.

An alternative option may be a commercial trade ban (i.e., no purchase of, or trade in, Nassau grouper by restaurants, but no restrictions on subsistence fishing). This policy could have a number of pragmatic advantages (Rudd, 2003): local fishers would maintain access to fishing grounds for lobster and reef fishes other than Nassau grouper; government would maintains tariff revenues (a trade ban may even increase imports of substitute frozen grouper, increasing overall revenue); enforcement efforts could focus on shore-based restaurant buyers, reducing more expensive fisheries field enforcement costs; and Nassau grouper conservation would continue to provide valuable non-extractive economic value for the dive tourism industry.

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Aproximación a la Valoración Socioeconómica de un Arrecife en el Caribe Mexicano: El Caso del Garrafón

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RESUMEN

El Parque del "Garrafón" en la costa occidental de Isla Mujeres, Quintana Roo, tiene una extensión de 260 m, y ha representado durante años uno de los principales atractivos de la isla, donde la población económicamente activa se dedica al turismo, comercio y pesca. Durante 50 años, ha sido utilizado sin control ni vigilancia por buzos amateurs, buzos libres y turismo de playa en general, quienes junto con el efecto ocasionado por huracanes y tormentas tropicales, han originado una degradación total, quedando como un bajo rocoso. Sin embargo, es un área reconocida a nivel mundial y sigue siendo visitada. A pesar de los altibajos en el flujo de visitantes, el promedio anual es de 250 visitantes/día. Esta comunicación muestra como el valor económico del ecosistema proporcionado por el flujo de servicios y bienes (capital natural de un stock) y por el flujo de biomasa o servicios (ingreso natural), puede llegar más allá del estado de salud del ecosistema, su biodiversidad, su capacidad de asimilación de desechos, protección a fenómenos meteorológicos o la biomasa que de él se extraiga, elementos comúnmente usados para las valoraciones de los ecosistemas arrecifales y cuyo resultado es siempre muy subjetivo. Por concepto de entradas, se generaron durante 1997 ingresos del orden de 1 575,721.00 US dls, y por el de otros servicios relacionados 175, 536 US dls. La derrama económica a la isla vía empleos generados en esta actividad es superior a los 4 millones de pesos anuales. Considerando los ingresos directos ocasionada por la visita al parque, el valor bruto del m^2 de arrecife es de 398 US Dls. anuales. El valor real es mucho mayor, ya que no se consideraron los valores indirectos como puede ser su valor como estructura física que brinda refugio a especies de interés comercial y que impide la erosión de playa.

PALABRAS CLAVES: Valoraciones de los ecosistemas arrecifales, parque del "Garrafón"

Approach to the Socioeconomic Assessment of a Reef in the Mexican Caribbean: The Garrafón Case

The Garrafón Park in the western coast of Isla Mujeres, Quintana Roo, extends 260 meters, and it has represented during years one of the main attractions of the island, where the economy is dependent upon tourism, trade, and fishing. During 50 years, it has been used without control nor surveillance by scuba amateurs, snorkeling, and beach tourism. Together with the effect caused by hurricanes and tropical storms, the benthos has degraded to a shallow rocky floor. However, it

remains a popular tourist area with an annual average is of 250 visitors per day. This paper describes the economic value of the ecosystem provided by the flow of services and goods (natural capital of a stock) and for the flow of biomass or services (natural income). Human activity can impact ecosystem health and biodiversity, exceeds its waste assimilation capacity, protection to meteorological phenomenons, extraction of biomass, elements commonly used for the reef ecosystem assessment and whose results are always very subjective. For concept of entrances, they were generated during 1997 revenues of the order of 1,575,721.00 US dls, and for that of other related services 175,536 US dls. The economic benefit to the island, primarily through employment generated in this activity, exceeds 4 million pesos annually. Considering the direct revenues generated through tourism, the gross value of the reef m^2 is of US$ 398 annually. The actual value of the ecosystem is much greater when indirect values, such as physical structure that offers refuge to species of commercial interest and beach protection are factored.

KEY WORDS: Economic value, coral reef ecosystems, "Garrafon" park

INTRODUCCIÓN

Los recursos naturales suministran beneficios a la humanidad, a través de bienes y servicios definidos. Su disminución o pérdida generan deterioro ambiental, desaparición de especies y disminución de la calidad de vida (E. Otaiza 1994). La degradación de recursos ambientales constituye un problema económico porque trae consigo la desaparición de valores importantes, a veces de forma irreversible. Sin embargo como los bienes y servicios que proporciona un ecosistema no se encuentran almacenados en los mercados comerciales o no son adecuadamente valorados en términos comparables con los servicios y manufacturas de capital, tienen un bajo peso específico en las decisiones políticas (Costanza 1997)

Cuando un recurso ambiental pura y simplemente existe y nos proporciona bienes y servicios sin costo alguno, lo único que expresa el valor de los bienes y servicios que aporta es nuestra disposición a pagar por ellos, independientemente de si realmente pagamos algo o no (Barbier 1998). Para la valoración de los recursos naturales, en general se reconocen dos diferentes bases filosóficas, la aproximación antropocéntrica (o utilitaria) y la aproximación biocéntrica (o intrínseca). Estas dos aproximaciones no son mutuamente excluyentes, pero asignan diferentes valores a un mismo recurso en circunstancias similares (Peck 1999).

Los usos y beneficios de los recursos naturales pueden ser separados en tres categorías:

i) Uso directo, el cual incluye turismo y cosecha de un recurso natural o un bien.
ii) Uso indirecto, donde los beneficios generalmente son obtenidos a través del soporte y protección que otorga a otras actividades económicas, a menudo es referido como funciones naturales o servicios ambientales.
iii) No-uso, se estima como valor de existencia de acuerdo con el cual puede

ser excluido de cualquier uso humano común.

La valoración económica de los servicios ecológicos y la biodiversidad de ecosistemas importantes tales como los arrecifes de coral, representa ciertos riesgos. El acto de determinar valores para recursos naturales y sus servicios ecológicos correspondientes, que en su gran mayoría no tienen precio de mercado, puede llevar fácilmente a una sub-estimación de los valores mínimos reales. Sin embargo la valoración económica permite medir y comparar los distintos beneficios de los recursos naturales y así servir como un instrumento eficaz de facilitación y mejoramiento del uso racional, del manejo y la gestión (Barbier 1998).

Los arrecifes de coral son valorados por muchas razones. Ellos proporcionan alimentos, ingresos por turismo, protección a las costas y sus habitantes, nuevos medicamentos para algunas enfermedades que presentan resistencia a las drogas convencionales, etc.

En el contexto socio-económico, el turismo es un sector clave en la economía de muchos países Caribeños con arrecifes coralinos, incluido el nuestro, frecuentemente proporciona alrededor del 50% de su producto interno bruto y generalmente está en rápida expansión, en 1990 el turismo Caribeño generó 8,900 millones de dólares y dio empleo a más de 350,000 personas. En particular para el Caribe mexicano, Cancún y la Riviera Maya, reciben anualmente alrededor de 2 millones de turistas; se estima que existen 42,000 cuartos de hotel y que para el año 2010 se habrán construido un total de 150,000 (WWF 2000). Bajo esta perspectiva, en el presente documento se valora un pequeño arrecife de coral que se encuentra en Isla Mujeres en el caribe mexicano, y que ha presentado un uso intensivo desde hace mas de 50 años.

MATERIAL Y MÉTODOS

Isla Mujeres es una isla en la parte norte de la Península de Yucatán que tiene una longitud de 7 km por 1 km en su parte más ancha, el municipio representa el 2.16 % del total del territorio estatal y ocupa por su extensión el 7° lugar en el Estado (Gob. de Q. Roo 2002), la Figura 1 muestra la posición y coordenadas del sitio.

Para la evaluación del arrecife, se usaron datos de censos realizados por la administración del PMN en 1997 que consiste en: Número de visitantes, ingresos por entradas, Consumo de energía (gas, electricidad, teléfono), Consumo de alimentos y bebidas, Gastos de nómina, costo total de insumos todos los valores están dados en UD Dls. Los datos de costo por mantenimiento fueron calculados, sobre la base del costo/m^2 año, proporcionado por el Colegio de Arquitectos A.C. en Quintana Roo.

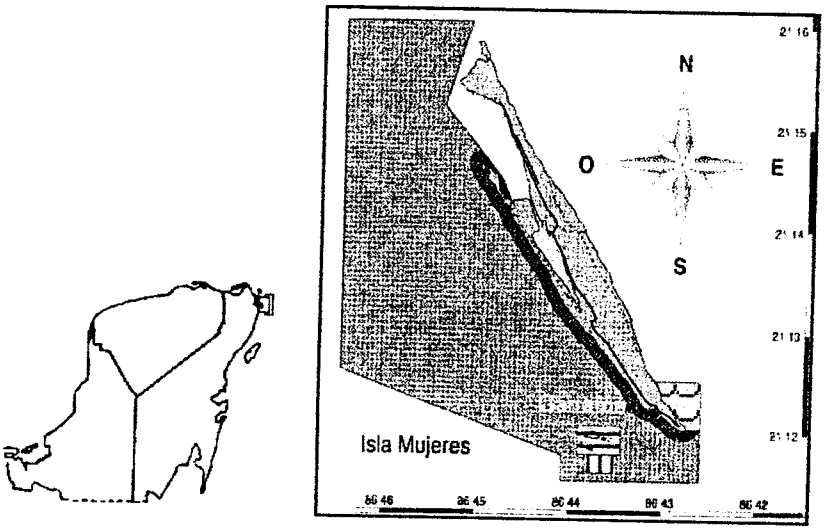

Figura 1. Área de estudio

El método empleado para el análisis fue el valor por uso directo (Recreativo). El valor del m^2 / año de arrecife se calculó de la siguiente manera:

$$Vm^2 A = \frac{Ingresos\ netos}{Superficie}\ año$$

Donde:

Ingresos Netos = Ingreso Total - Costo Total

Ingreso Total = Ingreso Entradas + Ingresos Servicios

Costo Total = Costos fijos + Costos variables

RESULTADOS

Los visitantes al parque el Garrafón, llegan por dos vías, terrestre y marítima; los resultados de las encuestas muestran que la mayor afluencia se da por vía marítima con un total de 78,200 personas (Tabla 1), la mayor afluencia se da en el mes de julio para ambas vías (Figura 2). La Tabla 2. Muestra los ingresos y costos totales por cada rubro utilizado en la valoración, el costo más alto se tiene en la energía, y el menor en los servicios.

Los valores obtenidos están dados en US dólares por m^2 de arrecife

IT = $ 2,311,576
CT = $733,500
IN = IT - CT

IN = 2,311,576 - 733,500 = 1,578,067

$$Vm^2A = \frac{1578067}{4500} = 350.68\ USDls/m^2$$

Tabla 1. Número de visitantes e ingresos por entradas al Parque el Garrafón.

VISITANTES VIA TERRESTRE			VISITANTES VIA MARITIMA		
Año 1997	No. Personas	Ingresos (US DL)	Año 1997	No. Personas	Ingresos (US DL)
Enero	6,239	93,585	Enero	4,242	33,936
Febrero	5,297	79,455	Febrero	4,110	32,880
Marzo	7,488	112,320	Marzo	6,318	50,544
Abril	4,497	67,455	Abril	6,157	49,256
Mayo	4,225	63,825	Mayo	7,614	60,912
Junio	3,521	52,815	Junio	9,825	78,816
Julio	7,986	119,790	Julio	12,316	98,528
Agosto	9,403	141,045	Agosto	10,539	84,312
Septiembre	3,147	47,205	Septiembre	4,369	34,952
Octubre	3,344	50,160	Octubre	4,170	33,360
Noviembre	3,359	50,385	Noviembre	3,786	30,288
Diciembre	4,791	71,865	Diciembre	4,754	38,032
TOTAL	63297	949,905	TOTAL	78,200	625,816

Tabla 2. Ingresos y costos totales por rubros generales en el parque del Garrafón

Concepto	Ingreso Anual	Costos
Entradas	1,575,721.00	260000
Servicios	175,527.00	32500
Alimentos y bebidas	560,328.00	130000
Mantenimiento		36000
Energía		275000
Total	2311576	733500

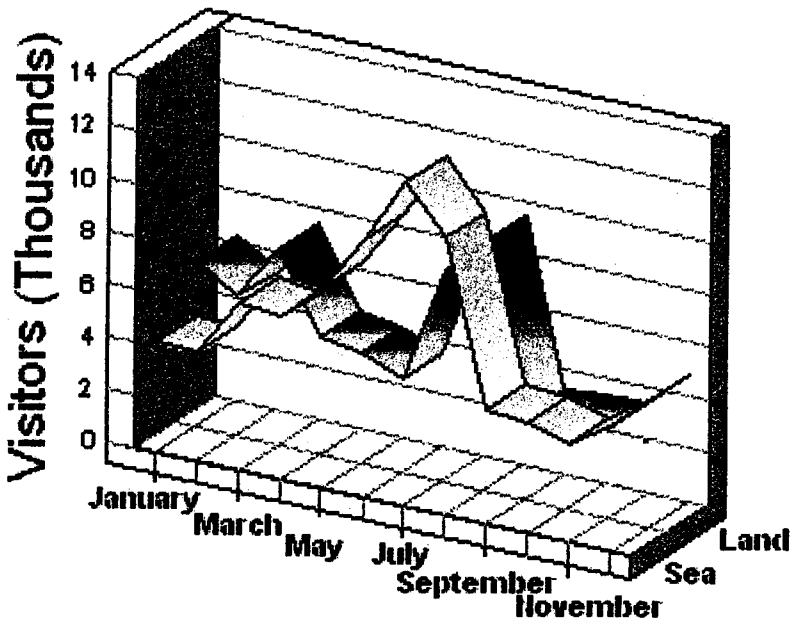

Figura 2. Entrada de los visitantes al parque de Garrafón por vía marina y terrestre durante 1997

DISCUSIÓN

La valoración por medio del costo - viaje parece ser el método más apropiado para medir el valor de la demanda de un recurso natural, ya que los usuarios incurren en una serie de gastos para acceder al recurso y teóricamente su valor se refleja en la suma de todos los gastos más el costo de oportunidad; sin embargo, la contabilización del costo de oportunidad por parte de los usuarios en ocasiones resulta difícil. Inicialmente se considero la posibilidad de usar este método para la valoración del Garrafón; sin embargo al revisar las bases de los supuestos y la información se concluyó que no cumplía el principal de los supuestos que le da sustento al método, ya que los usuarios llegan al parque como un destino secundario o terciario, es decir el visitante no viaja por acudir al parque, si no que viaja por visitar Cancún y/o la Riviera Maya. Por lo tanto al aplicar el método de costo-viaje se estaría en realidad valorando Cancún, la Riviera Maya o en el mejor de los casos Isla Mujeres.

La información con la que se contó, permitio la utilización del método de valoración directa dado que es posible asumir que el valor de un bien o servicio lo da la disposición que se tenga a pagar por éste, menos lo que cuesta

proveerlo y que el simple hecho de pagar por el uso recreativo, se le puede asumir como la disposición al pago que hay por parte de los usuarios, consecuentemente se realizó el análisis costo - beneficio, en el que se consideraron todos los ingresos asociados al uso recreativo del arrecife y los gastos que genera. Este método tiene la limitante principal que no son contabilizadas las funciones ecológicas de los valores de no uso y los valores indirectos; sin embargo, debe de quedar claro que al hacer una valoración de uso directo se obtiene el valor más bajo, pues en éste hay gran parte de gastos que no han sido considerados.

La mayor captación directa de ingresos se tiene por las entradas por vía terrestre no obstante que la mayor cantidad de personas entran por vía marítima, esto ocurre por que el costo del ingreso por vía terrestre es mas caro (Figura 2 y 3). Asimismo se presentaron dos picos a través del año que corresponden a las vacaciones de primavera y verano. El mayor flujo se da en verano, lo cual se debe a que en primavera el turismo que llega es de estudiantes y las preferencias no son exactamente por los atractivos de tipo familiar, mientras que en verano al ser el turismo más de tipo familiar el lugar se ve ampliamente favorecido. En la valoración se tomo en cuenta el ingreso económico captado por otros servicios estos son el del estacionamiento, renta de casilleros y venta de alimentos y bebidas partiendo del supuesto que estos no se captarían si el visitante no acudiera a hacer uso recreativo del arrecife.

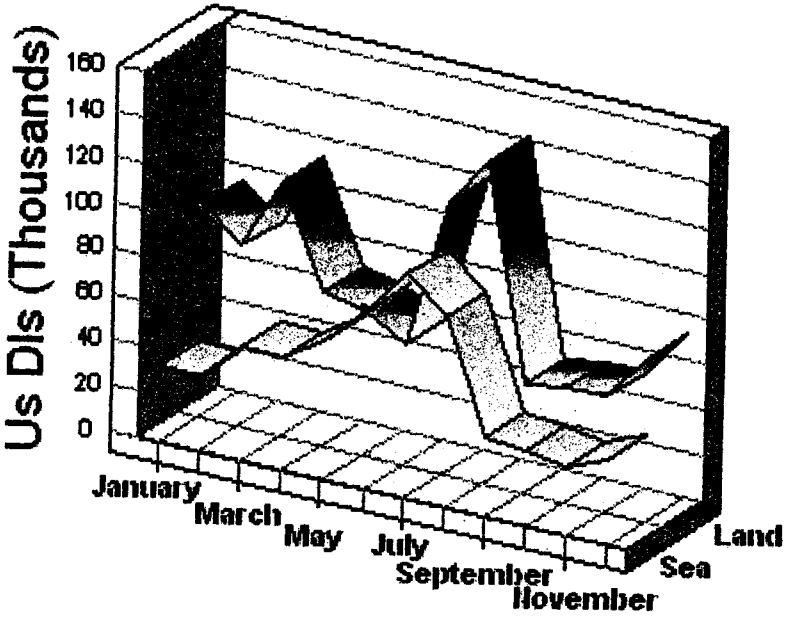

Figura 3. Ganancias generadas por concepto de las entradas por vía marina y terrestre al parque de Garrafón durante 1997

El valor final calculado para el m^2 de zona arrecifal es de 358.68 US dólar /año que es en términos generales casi diez mil veces superior al calculado en 1997 por Costanza et al. (1997) (375 US dl ha /año), esto a simple vista parece totalmente desproporcionado. Sin embargo debemos tomar en cuenta que el valor se da sobretodo por la disposición que el usuario tenga de pagar, tomando en cuenta su uso recreativo. Es prudente aclarar que Costanza et al. (op. cit.) valoran en su totalidad los arrecifes de coral del mundo y si consideramos que la gran mayoría de la superficie arrecifal valorada tiene valores, de no uso e indirectos, al promediar el valor de ha arrecife /año, conjuntamente con los arrecifes con usos recreativos, estos últimos terminan siendo subvaluados.

Sin duda los arrecifes más conservados y de gran belleza escénica, con una alta biodiversidad tienen un gran valor *per se*. Sin embargo, tal como menciona Costanza et al. (1997) "los bienes y servicios que proporciona un ecosistema no son adecuadamente cuantificados en términos comparables con los servicios y manufacturas de capital". Lo anterior hace notorias las graves fallas de mercado que existen, en donde un arrecife impactado puede llegar a ser diez mil veces más valioso que un arrecife funcional, en términos ecológicos.

El Garrafón es un pequeño arrecife de borde no mayor a 4,500m^2, se encuentra altamente impactado por las actividades recreativas que durante aproximadamente 50 se han hecho en el sin control ni vigilancia y que aunado al efecto ocasionado por los huracanes Gilberto, Roxana, Opal, etc. comunes en el área, han provocado que este sitio tenga un estado de conservación tal, que es hoy en día sólo un bajo rocoso. Sin embargo y aunque pareciera ser contradictorio este lugar se constituye en un considerable capital natural, que proporciona un flujo de servicios a manera de "Ingreso Natural". El ingreso natural que se tiene por concepto de recreación, hace de este sitio uno de los lugares más valiosos del mundo.

Este lugar es un sitio de alto valor económico, no por su producción de biomasa o por la relación que pueda tener en términos indirectos al generar refugio para organismos de interés económico o por que el germoplasma que contiene sea importante para su conservación; es valioso en función de su ubicación en uno de los lugares con mayor flujo turístico a escala mundial y en su propia característica como destino secundario de visita.

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La Pesca Deportivo-Recreativa en Quintana Roo, Mêxico

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RESUMEN

En Quintana Roo la pesca deportivo recreativa del tipo ligera de liberación, conocida también como "Fly Fishing", se considera una importante actividad por la derrama económica que genera en los distintos sectores de la población. Se lleva a cabo con moscas artificiales y con embarcaciones menores de 18 pies de eslora y motores de 30 a 40 HP.

Las especies objetivo que son capturadas en este tipo de pesca son principalmente: sábalo, robalo, palometa y macabí, ejemplares que habitan en aguas someras, de poca profundidad y baja salinidad.

Este tipo de pesca tiene la característica general de promover y fomentar la liberación de las especies que son capturadas, concientizando a la población deportiva a proteger las especies de escama de las lagunas y aguas interiores con se cuenta.

El estado de Quintana Roo posee aproximadamente 900 km de litoral y 373,097 has de lagunas costeras y continentales, esteros y bahías en los que se practica este importante deporte, teniendo su mayor representación en la parte norte y centro de la entidad, principalmente en los municipios de Lázaro Cárdenas, Isla Mujeres, Benito Juárez, Cozumel y Solidaridad, incluyéndose las Areas Naturales Protegidas de Yum Balam, Parque Nacional Isla Contoy, Parque Marino Arrecifes de Cozumel y la Reserva de la Biosfera de Sian Ka´an. En el municipio de Otón P. Blanco se encuentra en proceso de promoción en el Parque Nacional Arrecifes de Xcalak.

En el sector social pesquero este deporte es considerado como una alternativa de ingresos en la economía de los pescadores, dentro de las atribuciones de la SAGARPA se ha promovido la creación de 13 organizaciones con la figura jurídica de sociedades Cooperativas de Servicios Turísticos, para promover la diversificación de las actividades de captura por la prestación de servicios turísticos y de pesca deportiva, con la finalidad de fomentar el arraigo de los pescadores en sus comunidades y para evitar que sean desplazados de la actividad por personal foráneo, provenientes de otros estados.

PALABRAS CLAVES: Pesca deportivo recreativa, Quintana Roo

Sport and Recreational Fishing in Quintana Roo

In Quintana Roo the recreational sport fishing of the slight type, well known as Fly Fishing, is an important activity due to the economic impact that it generates in the different sectors of the population. This activity is carried out with artificial flies and in shallow draft vessels of 18 feet of length and motors of 30 to 40 HP.

The species targeted by these activity are mainly: tarpon, sábalo, snook, robalo,

permit, palometa and ladyfish, macabí, and other species that live in shallow depth and low salinity waters.

This type of fishing has the general characteristic to promote and to foment the liberation of the species that are captured, and as a consequence the sport fishermen protect the finfish from the lagoons and interior waters.

The state of Quintana Roo has approximately 900 km of the coastline and 373.097 hectares of coastal and continental lagoons, estuarine and bays in which this important sport practiced. The areas of greater participation are in the North and center of the state, mainly in Lázaro Cárdenas, Isla Mujeres, Benito Juárez, Cozumel y Solidaridad counties including the natural protected areas of Yum Balam, The National Park Isla Contoy, The Marine Park Arrecifes de Cozumel and the Reserve de la Biosfera de Sian Ka´an. In Otón P. Blanco County we are in the process of establishing the National Park Arrecifes de Xcalak.

In the social sector fishing east deports is considered like an alternative of income in the economy of the fishermen. The SAGARPA has promoted the creation of 13 organizations with the legal frame of Cooperative societies of Tourist Services, with the objective of promoting the diversification of these activities by the benefit of tourist services and sport fishing. The main purpose is to involve local fishermen in its communities in order to avoid that they are displaced of the activity by foreign personnel, originating of other states.

PALABRAS CLAVES: Pesca deportivo recreativa, Quintana Roo Pesca deportiva y recreativa, Quintana Roo

INTRODUCCIÓN

El Estado de Quintana Roo cuenta con aproximadamente 900 kilómetros de litoral, comparte 40 con el Golfo de México y 860 con el Mar Caribe; posee 21,000 kilómetros cuadrados de plataforma continental, 87,300 hectáreas de Bahías, Esteros y Lagunas y 84,000 hectáreas de cuerpos de agua en la parte continental.

Debido al gran potencial de recursos pesqueros existente dentro de los litorales con que cuenta el Estado, las 4 bahías, (de la ascensión, Espíritu Santo, Isla Mujeres y Chetumal) las 3 primeras con aguas transparentes típicas del Caribe, por lo tanto Quintana Roo es considerado un lugar privilegiado para la práctica de esta importante actividad pesquera, clasificada como estratégica y de contribución a la generación de divisas para el país, estimándose para el Estado una derrama económica global hacia los distintos sectores de la población en 15 millones de dólares cada año.

En el sector social de Quintana Roo, este actividad es considerada como una alternativa en la economía de los pescadores, se ha promovido la creación de 13 organizaciones con la figura jurídica de sociedades cooperativas prestadoras de servicios de pesca deportiva y turísticos, para promover la diversificación de las actividades de captura por la prestación de servicios, con la finalidad de fomentar el arraigo de los pescadores en sus comunidades, contribuyendo en sus ingresos y

diversificando sus oportunidades de empleo en sus lugares de origen.

Es una actividad que se practica con fines de esparcimiento y que vincula al ser humano con la naturaleza, principalmente con el mar y sus recursos, es importante resaltar la promoción de la liberación de las especies capturadas, se lleva a cabo en las modalidades de Pesca de altura y Ligera o de liberación.

La Pesca de altura, se efectúa con embarcaciones tipo yate, en aguas marinas y a grandes profundidades, se realiza en una franja de 50 millas contadas a partir de la línea de base desde la cual se mide el mar territorial, en las modalidades de Troleo y fondo, las especies objetivo son: el Marlin azul, Marlin blanco, Pez vela, Dorado, Wahoo, Sierra, Atún y Barracuda entre otras. Se realiza casi a todo lo largo de la costa norte y centro de la entidad, en las zonas turísticas como son: Cancún, Isla Mujeres, Cozumel y Solidaridad, lugares donde tiene su mayor desarrollo esta actividad, requiriendo promoción, capacitación e infraestructura la zona sur del estado y parte del municipio de Lázaro Cárdenas en la zona norte.

Cada año nos visitan alrededor de 250 yates de pesca deportiva, principalmente durante marzo-junio y Noviembre-Diciembre, mismos que demandan un promedio de 100 piezas de escribano por yate por salida.

EL ESCRIBANO

Es considerado un recurso potencialmente aprovechable para la realización y el desarrollo de la pesca deportiva de altura, un factor importante, ya que es una especie que contribuye de manera efectiva para realizar la pesca de los picudos, se cuenta con grandes cantidades del recurso, garantizando con esto una actividad más productiva y segura.

Es un pez migratorio que durante su ciclo de vida se mueve del Golfo de México a Brasil y Argentina, es altamente cotizado, por ser utilizado como una excelente carnada para la captura de los peces de pico y para abastecer de carnada a las marinas y prestadores de servicios de la pesca deportivo-recreativa que practican este tipo de pesca, es codiciado por los pescadores deportivos, principalmente los extranjeros que nos visitan.

La pesca ligera con mosca, mejor conocida como (Fly Fishing) se realiza en lagunas costeras, esteros y bahías, se lleva a cabo con moscas (señuelos) artificiales y con embarcaciones menores de hasta 18 pies de eslora con motores fuera de borda de 30 a 40 H.p. y se capturan especies como el Sábalo, Palometa, Robalo y Macabí, ejemplares que habitan en aguas someras, de poca profundidad y baja salinidad. Este tipo de pesca tiene la característica general de promover y fomentar la pesca deportiva de liberación y concientizar a la población deportiva a proteger las especies de escama de las lagunas y aguas interiores con que se cuenta.

Este tipo de pesca a diferencia de otras técnicas, exige un mayor esfuerzo y dedicación, no solo de práctica constante, sino también de estudio teórico y práctico, demanda equipos y accesorios especiales que requieren de esmerada atención y cuidado. Exige que el pescador posea un mínimo de habilidad y conocimientos para dominar las técnicas de lanzamiento, realizar sus nudos en la forma correcta y para

elaborar las moscas o carnadas artificiales que al final de cuentas es el objeto más valioso, ya que a través de esta se logra la captura.

La pesca con mosca es una alternativa positiva del "*Capturar y Soltar*", pues permite aplicar de manera más eficiente las técnicas desarrolladas para ese fin, practicar la pesca deportiva responsable.

Recientemente la pesca ligera o de liberación, ha cobrado mayor auge y desarrollo en las áreas naturales protegidas como la Reserva de la Biosfera de Sian Ka´an, que abarca los municipios de solidaridad, Felipe Carrillo Puerto, Yumbalam, en el municipio de Lázaro Cárdenas, específicamente en la Laguna Yalahau o Conil, en las lagunas de Plata y Montecristo en Cozumel, Parque Nacional de Isla Contoy y Laguna Chacmuchuc en Isla Mujeres.

ACCIONES DE CAPACITACIÓN Y ASESORÍA EN ORGANIZACIÓN

Con la finalidad de satisfacer las demandas y requerimientos del sector social pesquero que incursiona y se constituye día con día en Sociedades Cooperativas prestadoras de servicios de pesca deportiva y turística como una alternativa de ingresos, se ha apoyado la constitución de las Sociedades Cooperativas: Lancheros de la Bahía en Punta Herrero, Municipio de Felipe Carrillo Puerto, Bahía Blanca en Xcalak y Canal de Zaragoza en Mahahual, Municipio de Othón Pompeyo Blanco, Por la Justicia Social y Chacmuch en Isla Mujeres, Aluxes de Pino Suárez y Arrecifes del Caribe en Tulum, Municipio de Solidaridad, cabe mencionar que no se cuenta con los recursos necesarios para proporcionar la capacitación que se requiere en este sector, para procurar que cada vez se obtenga una mejor calidad y excelencia en los servicios que se presten. Evitando con esto que los pescadores se vean desplazados de la actividad por personal proveniente de otros estados.

La Asesoría Técnica y Capacitación para la integración de oportunidades de conservación y liberación mediante las sociedades cooperativas prestadoras de servicios de pesca deportiva y turística, que ven en la pesca deportiva una alternativa de ingresos.

SEGUIMIENTO A TORNEOS DE PESCA DEPORTIVA

Cada año se realizan en la entidad un total de 26 torneos de pesca deportivo-recreativa, mismos que son clasificados en 2 infantiles, 2 juvenil y 22 profesionales, del total 17 son locales, 7 internacionales y 2 estatales, se menciona que se proporciona mayor atención y apoyo para la realización de los torneos donde se promueve la liberación de las capturas, o la liberación de las especies de pico, acción mas destacada en los torneos que se realizan en la Isla de Cozumel.

Se privilegia la creación de códigos de conducta dentro del sector deportivo para proteger y pescar las especies destinadas a esta actividad, ya que:

Marcar y Soltar

Este es el único camino, si queremos seguir conservando estos grandiosos ejemplares marinos, conservar sus vidas para que mañana nuestros hijos y nietos puedan convivir con ellos y disfrutar lo mismo que nosotros.

ACCIONES DE PROMOCIÓN Y FOMENTO

En el esquema de la promoción de esta importante actividad deportiva, especial importancia reviste **la niñez y los jóvenes** Quintanarroenses que representan un grupo social que participa activamente en los eventos de este tipo, por ello cada año se organiza en coordinación con el DIF estatal y los DIF municipales 2 torneos, 1 infantil denominado **"El Niño y el Mar"** bajo el lema **"Dale un pez a un niño y comerá un día, enséñalo a pescar y comerá toda la Vida"** actualmente en su versión XIII y otro juvenil, estando ya en su versión IV, en las eliminatorias que se realizan a nivel municipal participan anualmente alrededor de 1,500 infantes y jóvenes, en edades de 8 a 12 y de 13 a 17 años, provenientes de 14 localidades de los 8 municipios de la entidad.

Los niños y los jóvenes son nuestro tesoro, que empiezan a descubrir la vida, y garcías a sus padres pescadores aprenden esta actividad de la pesca, que bien entendida, los llevará a ser más respetuosos de la naturaleza y de la sociedad.

El llevar a cabo esta actividad de fomento se hace de manera responsable y tiene como finalidad inculcar este deporte en la niñez Quintanarroense, propiciar la convivencia de los padres con los hijos, con el mar, sus recursos y generar un espacio para nuestros niños menores y jóvenes, propiciando la integración familiar y consolidar una cultura en la pesca deportivo-recreativa, inculcándose el respeto, la protección y conservación de las especies destinadas a esta importante actividad pesquera. Contribuyen igualmente para un mejor desarrollo de estos eventos, cuidado y atención de todos los niños y jóvenes participantes: el sector pesquero, la Secretaría de Marina, Capitanía de Puerto y la Cruz Roja Mexicana.

NORMATIVIDAD

Esta actividad esta regulada en base a lo estipulado en la Ley de Pesca, su Reglamento y la Norma Oficial Mexicana NOM-017-PESC.1994, que determina los límites máximos de captura por especie y embarcación por día. Estableciéndose que el destino de las capturas realizadas son exclusivamente para consumo, donación o taxidermia, prohibiéndose estrictamente sea con fines de comercialización. Promoviendo la normatividad vigente a través de reuniones previas a los torneos de pesca deportiva y con los agentes que participan como prestadores de servicios y pescadores deportivos. Promoviéndose igualmente la expedición y trámite de los permisos de pesca deportiva.

Survey of Resident Participation in Recreational Fisheries Activities in the US Virgin Islands

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ABSTRACT

The USVI Division of Fish and Wildlife (DFW) through its recreational fisheries assessment program is currently using various methods to gather information from all aspects of the recreational fishery. One of the sampling methods that the Division is currently evaluating is the use of telephone surveys to gather information from recreational anglers. A household telephone survey was conducted from December 1998 to July 1999. The USVI phone directory was divided in two stratums: (1) St. Croix and (2) St. Thomas/St. John. Attempts were made to contact households units on each stratum listed in the US Virgin Islands telephone directory on a monthly basis. The response rate in St. Croix stratum was 75 % whereas the response rate in St. Thomas/St. John was 55 %. Of all household units contacted, 1 1% of households in St. Croix and 13.5 % of St. Thomas/St. John stratum had at least one recreational angler. A number of 3,294 recreational anglers were estimated from St. Croix and 7,705 recreational anglers for St. Thomas/St. John stratum. Based on this survey, St. Croix recreational fishermen landed an estimated number of 35,225 pounds annually with a fishing effort of 11,844 hours. St. Thomas/St. John recreational fishermen landed an estimated number of 137,412 pounds annually with a fishing effort of 42,820 hours. The results of this survey indicate that during this study, 9.2 % of the residents of the US Virgin Islands (approximately 11,000 individuals) fished recreationally.

KEY WORDS: Recreational fisheries, angler survey, USVI

Estudio de la Particpación en las Actividades Pesqueras Recreacionales de los Residentes de las Islas Vírgenes Estadounidenses

La pesca recreativa de agua salada en las islas virgenes estadounidenses es muy popular y puede se categorizada en tres tipos. (1) pesca deportiva en aguas profundas (2) pesca de bote en aguas someras (3) pesca de orilla (muelle, marinas, playa). Un numero estimado de 10,800 pescadores (casi 10.8% de los residentes) pescaron recreacionalmente a mediados de la decada de los ochenta. (Jennings, 1992). Las areas de pesca al norte de las islas virgenes estadounidenses son muy reconocidas por la pesca de la aguja. La pesca de la aguja contribuye approximadamnte 5.5 millones de dolares a la economia local (Adams, 1995)

La Division de Pesca y Vida Silvestre del Gobierno de las Islas Virgenes Estadounidenses dentro de su programa de evaluacion de pesca recreativa condujo

un censo de residentes envueltos en actividades de pesca recreativa durante Diciembre 1998 hasta Julio del 1999. Se utilizo el muestreo de numeros telefonicos residenciales como metodologia. Los resultados del censo indican que en 1999, 9.2% de los residentes en las Islas Virgenes Estadounidenses (Aproximadamente,11,000 individuos) pescaron recreativamente. Un punto interesante fue que la taza de participacion de residentes envueltos en actividades de pesca recreativa no ha cambiado mucho durante los ultimos 13 anos. Las proporciones de pescadores de bote, orilla, y de bote/orilla en St Croix y St. Thomas/St. John para 1999 fueron bastante parecidas a los encontradas en 1986 por Jennings (1992).

Otros resultados del censo indican que la metodologia de muestrear numeros telefonicos residenciales unicamente no es un metodo suficiente para evaluar una pesqueria que consiste de muchas especies como la pesca recreacional de de Islas Virgenes Estadounidenses debido a problemas como la exactitud y exageracion en los reportes de captura y la identificacion especies. Otras metodologias como el muestreo de rampas, marinas (point access) deben ser consideradas como alternativas prar obtener informacion exacta y precisa de captura. El manejo efectivo de la pesca recreativa en las islas virgenes estadounidenses require una fuente de datos continuos que puedan describir todos los aspectos de la pesqueria. Es muy importante que en cualquier clase de pesca se este muestreando la coleccion de datos sea consistente y estadisticamente valida para que pueda permitir comparaciones directas de anos previos.

PALABRAS CLAVES: Pesca recreativa, censo de residentes, las Islas Virgenes

INTRODUCTION

Saltwater recreational fishery in the United States Virgin Islands (USVI) is very popular and can be characterized into three types:

i) Big game fishing (offshore fishing),
ii) Boat fishing (inshore fishing) and
iii) Shoreline fishing (pier, dock, beach, etc.).

An estimated number of 10,800 anglers (almost 10.8 % of the residents in the Virgin Islands) fished recreationally during the mid 1980s (Jennings 1992). The fishing grounds north of the USVI have been well known for its billfish fishery. It has been estimated that the St. Thomas billfish fishery contributes approximately 5.5 million of dollars to the local economy (Adams 1995).

The USVI Division of Fish and Wildlife (DFW) through its recreational fisheries assessment program is currently using various methods to gather information from all aspects of the recreational fishery, including logbooks, shoreline roving creel surveys, dockside interviews and fishing tournaments. One of the sampling methods that the DFW is currently evaluating is the use of telephone surveys to gather information from recreational anglers. Telephones surveys have been widely used to collect household demographic characteristics (Groves et al. 1988) and have also

been used in recreational fisheries (Essig and Hollida 1991, Wheitman 1991, Jennings 1992). The objective of this study is to evaluate the use of a telephone survey as a feasible methodology to collect recreational fisheries data.

METHODS

The telephone survey was conducted from December 1998 to July 1999, following a testing period of the questionnaire. The USVI phone directory was divided in two stratums: (1) St. Croix and (2) St. Thomas/St. John. Currently, there are 53,110 household units listed in the USVI phone directory; 28,772 household units in St. Thomas/St. John and 22,168 in St. Croix (personal communication with the Virgin Islands Telephone Company).

Listings in the Virgin Islands telephone directory were numbered, and survey respondents were chosen randomly. Using computer generated random numbers, pages from the phone directory were selected for each month. One hundred random numbers were selected from the total numbers on the selected page in the phone book as target respondents for that month. During the last week of each month respondents were chosen for the next month. Attempts were made to contact 50 households on each stratum listed in the USVI telephone directory on a monthly basis.

Calling periods were selected from 4:00 PM to 9:00 PM in an effort to maximize the potential to contact individuals. At least five attempts were made to each number to screen for households. When a number was dialed, the telephone was allowed to ring five times before it was classified as no answer. When a household with an angler was contacted, if the angler was not able to answer the survey at the time, four additional attempts were made. If a phone number had been disconnected or currently not working, a new number was dialed as a replacement.

Fishing effort of anglers contacted during this survey was divided into three categories: boat, shore, and boat and shore. Fishing gear among all categories were divided into rod and reel, hook and line, spear guns, and nets. Differences between fishing effort and harvest estimates among categories were analyzed by Kruskall-Wallis One-Way ANOVA after log(x+1) and square root transformation failed to pass Kolmogorov-Lilliefors Normality Test (Sokal and Rohlf 1981).

RESULTS

A total of 1,089 phone calls were attempted on the telephone survey; 557 were made in St. Croix and 532 were made in St. Thomas/St. John. The response rate in St. Croix was 75 %, 23 % were unsuccessful calls and the refusal rate was 2 %. The response rate in St. Thomas/St. John was 55 %, 44 % were unsuccessful calls and refusal rates were 1 % (Figure 1).

Of all household units contacted, 11 % of households in St. Croix and 13.5 % of St. Thomas/St. John households had at least one recreational angler (Figure 2).

A number of 3,294 recreational anglers were estimated from St. Croix and 7,705 recreational anglers for St. Thomas/St. John.

Of the 44 anglers interviewed in St. Croix, 16 (36 %) fished in the last month. Of 40 persons interviewed in St. Thomas and St. John, 20 (50 %) had at least fished once in the latest month. Due to the small sample size of interviews where the fishing activity occurred in less than a month, an estimate of the average of hours fished, number of trips and pounds caught were used for subsequent analysis.

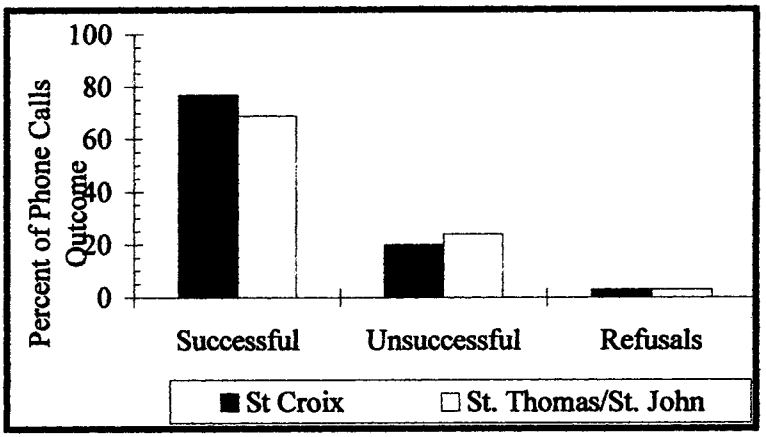

Figure 1. Proportion of successful unsuccessful and refusal rates for St. Croix (n = 452) and St. Thomas/St. John stratums (n = 300).

Angler effort was characterized into three main components: boat, shore, and boat and shore. There were more anglers fishing from the shore (60%) than from boats (19 %) in St. Croix, while 21 % of the anglers in St. Croix fished from boats and shore. St. Thomas/St. John anglers fished more from boats (50%) than from shore (12 %) and 38 % of anglers fished from boats and from shore (Figure 3). There were no significant differences between crew size, fishing trip length and number of trips per month among categories in St. Croix and St. Thomas/St. John stratums ($p > 0.05$; $df = 2$). However, boat fishing trip duration was significantly higher than shore in St. Thomas/St. John stratum ($p < 0.05$; $df = 2$). The most popular fishing activity among St. Croix and St. Thomas/St. John recreational fishermen was bottom fishing (66 %, 54 %, respectively), followed by trolling (30 %, 32 %, respectively) (Figure 4). The most common fishing gear used in by St.

Croix anglers was the handline (64 %) followed by rod and reel (23 %). The most common fishing gear used in by St. Thomas/St. John anglers was rod and reel (46 %) followed by handline (39 %) (Figure 5). St. Croix recreational anglers prefer to fish in the evening (43 %) and early morning hours (33%) (Figure 6) on a monthly basis (57 %) (Figure 7). St. Thomas/St. John recreational anglers prefer to go fishing at night hours (50 %) and afternoon hours (21 %) (Figure 6) on a weekly basis (45 %) (Figure 7).

Although there are many fishing locations around the USVI, some areas seemed to be more popular than others. Frederiksted pier (24 %) followed by Altona Lagoon (10 %) were the most common fishing spots among the St. Croix shore anglers while the boat anglers preferred the offshore waters at the east end of Buck Island (10 %) as one of their major fishing grounds (Table 1). The most popular shore fishing spot was for St. Thomas/St. John shoreline anglers was the Charlotte Amalie waterfront (23%), while boat anglers preferred to fish on the north side of St. Thomas (10 %) (Table 1).

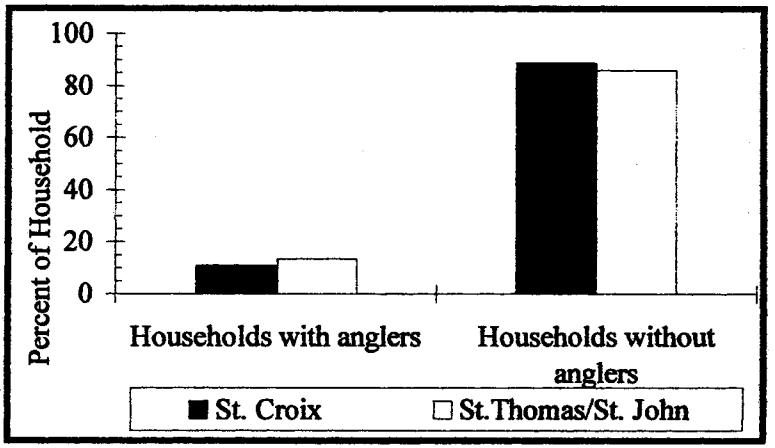

Figure 2. Proportion of households with or without recreational fishermen for St. Croix (n = 400) and St. Thomas/St. John (n = 295) stratum.

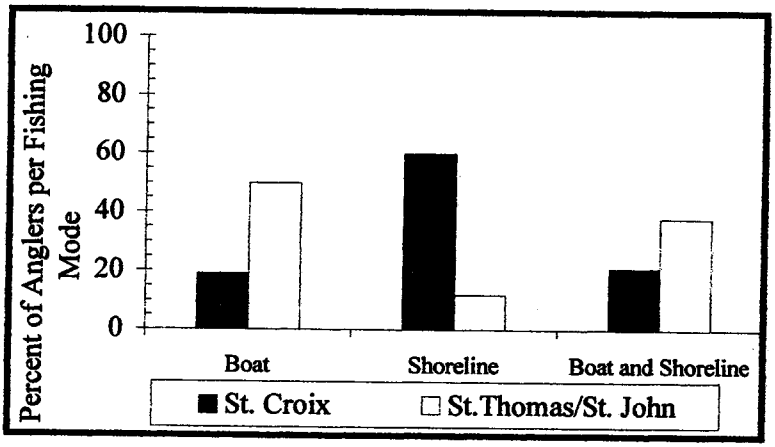

Figure 3. Proportion of anglers by fishing category for St. Croix and St. Thomas/ St. John stratums

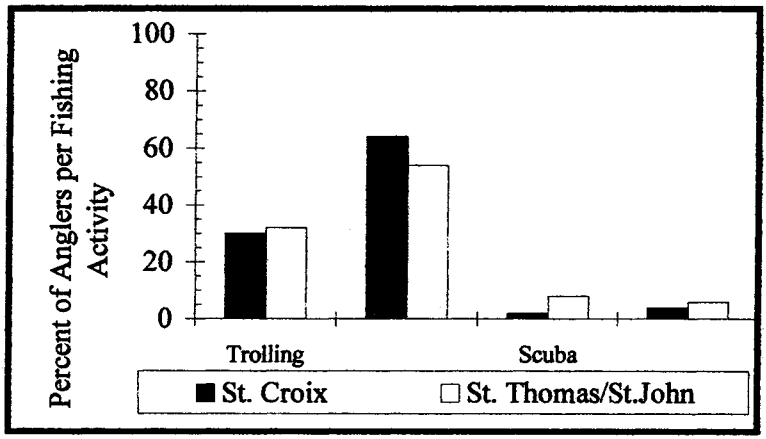

Figure 4. Proportion of anglers per fishing activity for St. Croix and St. Thomas/St.John stratums

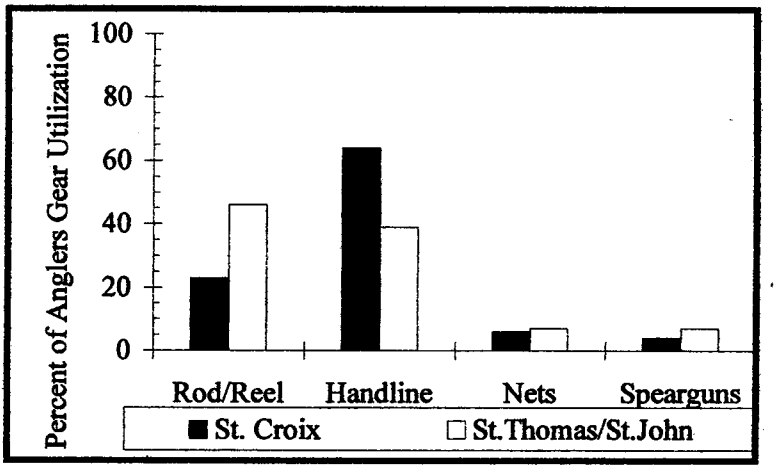

Figure 5. Proportion of fishing gear utilization by St. Croix and St. Thomas/St. John anglers

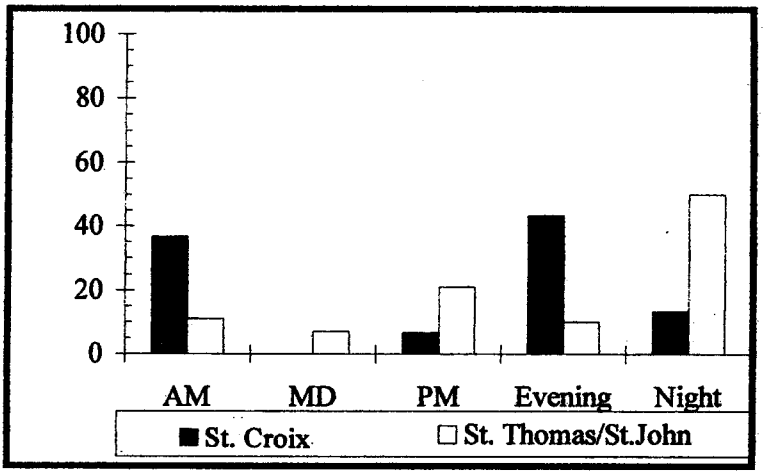

Figure 6. St. Croix and St. Thomas/St.John anglers fishing time preferences

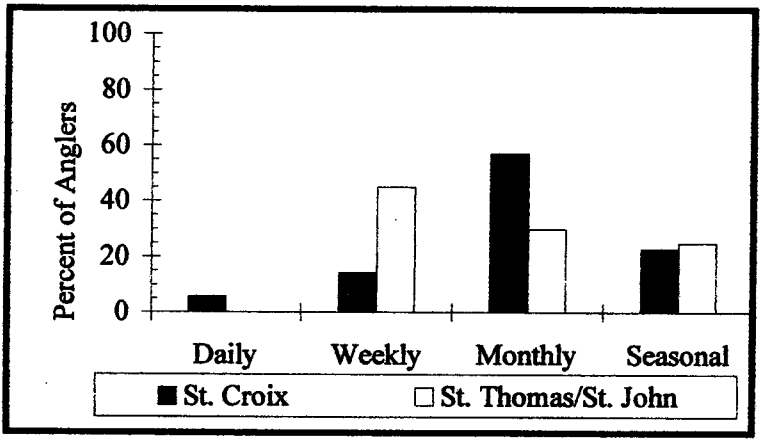

Figure 7. St Croix and St. Thomas/St. John anglers seasonal preferences for fishing activities

Angler Success

There were significant differences among mean angler success among categories in St. Croix and St. Thomas/St. John stratum ($p < 0.05$, $df = 2$). Anglers who fished from boats and shore had significantly higher mean number of pounds harvested than shore fishermen on both stratums ($p < 0.05$, $df = 2$). Mean angler success by category ranged from 3.04 to 29.1 pounds in the St. Croix and 2.9 to 20 pounds in the St. Thomas/St. John (Table 2).

The reef fish species composition in the St. Croix inshore recreational fishery were dominated by members of the families Lutjanidae and Scaride, where the yellowtail snapper *Ocyurus chrysurus* and the stoplight parrotfish *Sparisoma viride* were reported by local fishermen as the most commonly caught species. The species most commonly caught from the offshore fisheries were dolphin (*Coryphaenidae hippurus)* and wahoo (*Acanthocybium solanderi)* (Table 3). In St. Thomas/St. John, the species reported as most commonly caught species from the inshore recreational fishery catch were members of the families Lutjanidae (yellowtail snapper *Ocyurus chryusurus)* and Holocentridae (squirrelfish *Holocentrus adcensionis)*. The offshore fisheries species composition were dominated by tuna and dolphin (Table 3).

Based on this survey, St. Croix recreational fishermen landed an estimated number of 35,225 pounds annually with a fishing effort of 11,844 hours (Table 4). It was also estimated that St. Croix anglers made 8,823 fishing trips. St. Thomas/St.

John recreational fishermen landed an estimated number of 137,412 pounds annually with a fishing effort of 42,820 hours (Table 4) and made approximately 19,733 fishing trips.

Approximately 50% of the anglers queried were opposed for a recreational fishing license program in both St. Croix and St. Thomas/St. John stratums. It was felt that paying for recreational fishing license would reduce the enjoyment of their fishing experience. They also said that the USVI Government should not regulate recreational fisheries unless there is proof the stocks are over-fished (Figure 8).

Table 1. Most Popular fishing sites by St. Croix and St. Thomas/St. John anglers (some anglers cited more than one sites during the interviews).

St. Croix Stratum			St. Thomas/St. John Stratum		
Site	Number	Percent	Site	Number	Percent
Frederiksted Pier	15	24.2	Waterfront	16	23.2
Altona Lagoon	6	9.7	Northside	7	10.1
Offshore East Buck Island	6	9.7	Crown	5	7.2
West Shoreline	3	4.8	Southside	5	7.2
Christiansted Dock	3	4.8	Subbase	5	7.2
Cramer Park	3	4.8	Tropical	4	5.8
Cane Bay	3	4.8	All Over	2	2.9
Sandy Point	2	3.2	FrenchCap	2	2.9
Sprat Hall	2	3.2	National Park Service Dock	2	2.9
Grassy Point	2	3.2	Saba	2	2.9
Northeast of St. Croix	2	3.2	Sorgenfri	2	2.9
Teague Bay	2	3.2	Water Island	2	2.9
Ham Bluff	2	3.2	Airport	1	1.4
Krausse Lagoon	1	1.6	Brass	1	1.4
Good Hope	1	1.6	BVI	1	1.4
Great Pond	1	1.6	Lagoon	1	1.4
Lang Bank	1	1.6	Mandahl	1	1.4
Coakley Bay	1	1.6	Pillsbury	1	1.4
Green Cay	1	1.6	Red Hook	1	1.4
Princess	1	1.6	Southside St. John	1	1.4
Richmond Pier	1	1.6	Hans Lollick	1	1.4
La Valle	1	1.6	Anegada/Norman Is.	1	1.4
Davis Bay	1	1.6	John Brewers Bay	1	1.4
Molassess Dock	1	1.6	Krum Bay	1	1.4
			Long Bay	1	1.4
			Vessup	1	1.4
			Coki	1	1.4
TOTAL	62		TOTAL	69	

Table 2. Summary of estimates of fishing effort and harvest parameters during 1999 telephone angler survey on St. Croix and St. Thomas/St. John (SE = Standard Error, N = number of samples).

		St. Croix Stratum			St. Thomas/St. John Stratum		
		Boat	Shore	Boat and shore	Boat	Shore	Boat and shore
Party size	Mean	1.50	2.50	2.40	3.15	2.75	4.40
	SE	0.22	0.26	0.25	0.33	0.22	1.43
	N	8.00	26.00	5.00	13.00	20.00	5.00
Hours Fished	Mean	4.33	3.50	3.20	5.85	4.22	5.60
	SE	0.57	0.31	0.81	0.48	0.23	0.93
	N	8.00	26.00	5.00	13.00	20.00	5.00
Harvest (lb.)	Mean	14.50	3.04	29.10	19.76	2.95	20.00
	SE	6.65	0.92	15.40	5.31	0.47	7.74
	N	8.00	26.00	5.00	13.00	20.00	5.00
Trip Number	Mean	2.00	2.17	4.75	2.91	2.25	2.20
	SE	0.31	0.38	2.40	0.39	0.33	0.49
	N	8.00	25.00	4.00	13.00	20.00	5.00

When St. Croix anglers were asked about what the government agencies can do to improve recreational fishing in the USVI, they had different opinions on effective recreational fishing management. Twenty percent of the respondents cite enforcement as a major drawback in improving the fishing quality in the USVI. Some respondents stated that there were insufficient personnel to put the fishing regulations into action. Others responded that a strong public educational program on marine resources was necessary to make people aware about their environment. Some respondents were concerned about pollution and sewage disposal problems and how it could potentially affect coastal habitats (Figure 9). St. Thomas/St. John anglers responded that their major concerns were enforcement issues and public access. Additional comments included that foreign longliners were overharvesting large quantities of fish in the territory, the number of recreational fishing boats should be controlled, and there should be regulations on unattended gillnets and fishpots to help reduce "ghostfishing," (Figure 10).

DISCUSSION

Angler surveys provide fishery managers with effort and angler success data crucial to the management of fisheries stocks. They are also effective in gathering demographic and socioeconomic parameters in resource management. Several methods have been used to survey recreational fishermen: on-site methods including roving creel surveys and point access surveys, while off-site methods including mail surveys, door to door surveys and telephone surveys. However, each type of method has its characteristic sampling and non-sampling errors (Essig and Holliday, 1991). For telephone surveys, the sampling errors can be categorized as non-

coverage errors when a survey is being taken on incomplete frames. Non-sampling errors include response and non-response bias. Misreporting of the data and prestige bias are among the common errors found in response bias; whereas, refusals and non-working numbers are the most common sources of non-response bias.

Table 3. List of common finfish caught in St. Croix and St. Thomas/St. John (some anglers cited more than one species per interview).

Local Name	Family	Common Name	St. Croix Frequency	St. Thomas/St. John Frequency
*	Acanthuridae	Doctorfish	0	1
Olewife	Balistidae	Queen trigger fish	0	2
Gar	Belonidae	Houndfish	3	0
Flatfish*	Bothidae	Flounder	1	0
Crevalle	Carangidae	Crevalle jack	3	0
Cobbler	Carangidae	Permit	2	0
*	Carangidae	Jacks	1	7
King	Carangidae	King mackerel	0	4
Hardnose	Carangidae	Blue runner	0	3
	Coryphaenidae	Dolphin	3	2
Silverfish	Gerreidae	Slender mojarra	3	0
	Haemulidae	Grunt	6	10
Wenchman	Holocentridae	Squirrelfish	5	14
*	Lutjanidae	Snapper	14	8
*	Lutjanidae	Yellowtail snapper	5	16
Virgin Snapper	Lutjanidae	Mutton snapper	2	0
Goatee	Mullidae	Goatfish	3	0
Bluefish	Scaridae	Stoplight parrotfish	5	1
Gutto	Scaridae	Parrotfish	3	4
Pink Chump	Scaridae	Redtail parrotfish	1	0
Macka	Scaridae	Midnight parrotfish	1	0
*	Scombridae	Tuna	3	2
*	Scombridae	Wahoo	2	0
Robin	Scombridae	Round mackerel	1	0
Bonito (offshore)	Scombridae	Skipjack	1	2
*	Scombridae	Blackfin tuna	1	0
Bonito (inshore)	Scombridae	Little tunny	0	3
Butterfish	Serranidae	Coney	3	0
*	Serranidae	Grouper	1	2
Hind	Serranidae	Red hind	0	7
*	Sparidae	Porgy	0	3
Barra	Sphyraenidae	Barracuda	4	4

* No local names for these species were found

Table 4. Summary of the Estimated Effort and Harvest Parameters for the USVI Recreational Fishery during 1999.

St. Croix	Boat	Shore	Boat and shore	Total	St. Thomas/ St. John	Boat	Shore	Boat and shore	Total
Effort (hr)	2,711	6,919	2,214	11,844	Effort (hr)	22,522	3,901	16,396	42,820
Harvest (lb.)	9,077	6,011	20,137	35,225	Harvest (lb.)	76,125	2,727	58,557	137,412
Fishing trips	1,252	4,284	3,287	8,823	Fishing trips	11,211	2,080	6,441	19,733

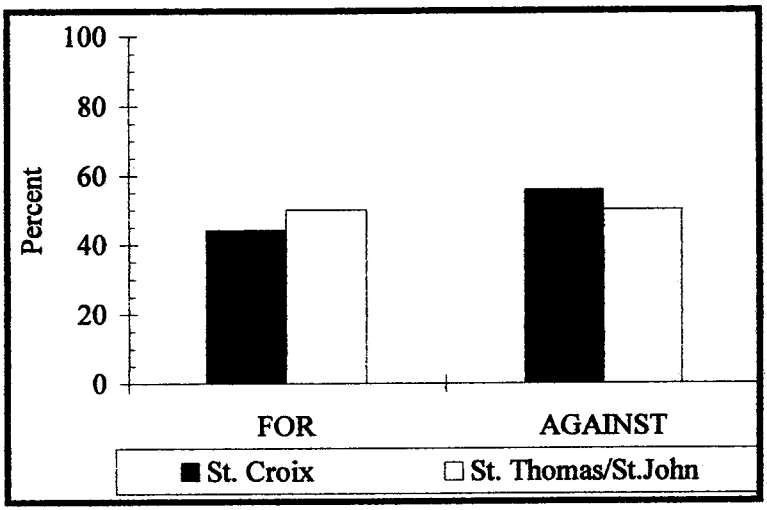

Figure 8. St. Croix and St. Thomas/St. John Anglers attitudes for recreational fishing license program implementation

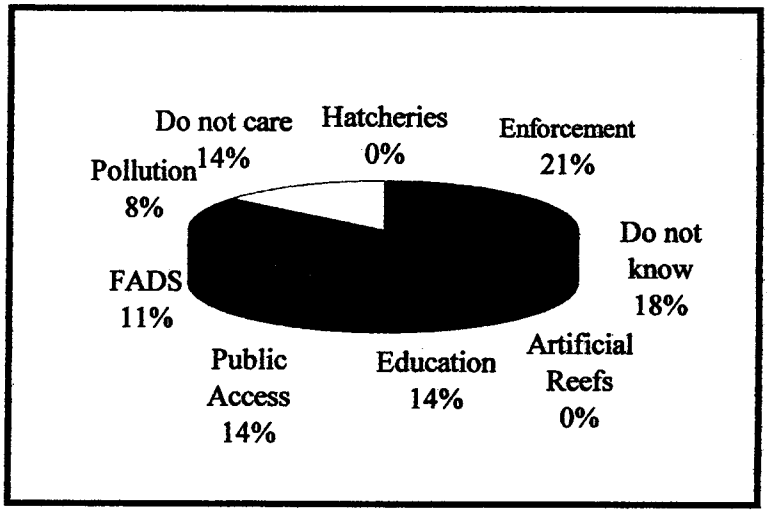

Figure 9. St. Croix anglers opinions on how the government can improve recreational fisheries in the USVI

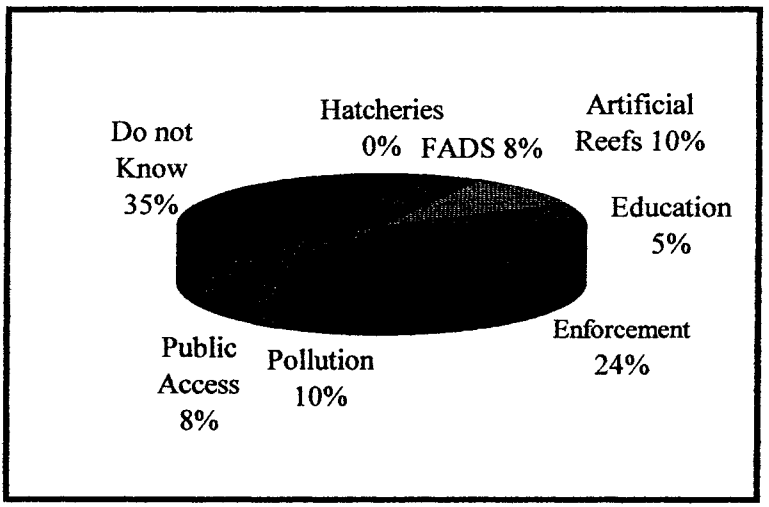

Figure 10. St. Thomas/St.John anglers opinions on how the government can improve recreational fisheries in the USVI

When samples frames are known, telephone surveys, mail surveys and door to door surveys are appropriate survey techniques (Brown 1991). These techniques have been applied to fishing license holders, boat registration holders and charter boat captains. The most important step in planning this survey is to select a sample frame that can adequately represents the whole population. However, when the population, represented by sample frames, is not entirely covered, results of telephone surveys may be biased by particular exclusion of groups whose fishing patterns are different from the actual covered group. In this survey, more than 80% of the USVI households units have a telephone and only 4% of the household units with telephone are unlisted in the USVI phone directory. Therefore, the survey had a slight chance of bias of non-coverage errors.

Non-response bias can be a serious problem in any household survey due to the different answers between non-respondent and respondent. Adjustments for non-responses bias phone surveys have not well addressed in previous surveys. The telephone response rates for St. Croix (75 %) and St. Thomas/St. John (55 %) were higher in this survey than the previous telephone angler survey (less than 50 %) (Jennings 1992). Our study achieved higher response rates because many of the calls were placed on evening hours when most of the household residents were at home after their normal working hours.

Telephone surveys along with mail surveys and door to door surveys are all techniques for collecting angler reported data. They are especially helpful on

gathering information on angler effort and demographic characteristics. However, catch reports on any of these surveys should be interpret cautiously due to the problems caused by prestige bias (when there is an exaggeration of the catch reported), misidentification of the species caught and recall bias (when the angler interviewed do not remember the details of their last fishing trip). Nevertheless, telephone surveys can be very useful for obtaining catch information about memorable species, specially offshore species such as dolphin, wahoo, tunas, marlin, etc. During the survey, anglers who fished offshore were more skillful on identifying offshore species than reef species. Most of the fishermen who fished from shore were limited to associate the fish they caught to a family level, since the inshore fishery has a high diversity of species. Many anglers surveyed used local common names to report their catch. Some difficulties could arise because local common names for Caribbean marine fishes often differ from accepted common names and can also differ between islands (Jennings 1992). This problem can raise doubts about the validity of the angler reported catch information.

Previous studies on telephone surveys have paid attention to recall bias (Fisher et al. 1991). There have been suggestions that shorter recall periods (two to four weeks) would give better estimates than extensive recalling periods (two to four months). As a result, information gathered from anglers who had shorter recall periods (less than a month) from the time they were interviewed; were entered into the DFW recreational fishery database. However, only 16 anglers from 39 interviewed in St. Croix, and 20 anglers from 38 interviewed in St. Thomas, fished in less than a month from the time they were interviewed, consequently, this data exhibited a recall bias. Furthermore, the harvest rates (PPUE = pound per unit effort) for boat fishermen phone interviews were rather lower than estimates based on boat angler logbook and intercept interviews. These results were precluded from statistical comparison due to low sample size (Table 5a, 5b).

A household survey of anglers can tell us demographic characteristics as well as attitudes toward regulation management plans. It can also give a brief estimate of angler abundance and participation on a large region but with questionable precision. A major drawback conducting this type of study is that there are not many people who like to fish recreationally and sampling a phone directory will limit the probability to find an angler who can give reported data. In addition, there is going to be a major limitation of the data especially on catch reports when people interviewed do not remember very well their fishing trip nor the species they caught. A possible recommendation to improve data quality on future telephone surveys is to develop a recreational license program so the information gathered can be strictly direct from anglers. If catch reports are desired in the survey, they have to be with shorter recall periods and species that are very easy to identify. There have been previous studies that were successful in including catch reports surveying from an angler license frame (Wheitman 1991, Wheitman and Haverland 1991). However, a major problem arises because the USVI fishery is a multi-species one, and most of these angler telephone surveys have been done in lakes and reservoirs that have a limited number of species. Another approach is to supplement information from

telephone angler surveys with on-site creel surveys. The Marine Recreational Fisheries Statistics Survey have developed over the years a telephone access design which consists of two parts: 1.) a random digit dialing telephone survey to estimate fishing effort and 2). a point access survey to estimate catch rate. Catch and catch per unit effort are best estimated on-site where the catch can be inspected, but effort may be estimated off-site as well as on-site and an off-site effort survey may be less expensive to conduct (Essig and Holliday 1991).

Table 5a. Fishing Effort and Harvest Estimates per Categories for St. Croix Stratum from Telephone Interviews, Roving Shoreline Creel Surveys Interviews and Non-Charter Angler Interviews. All values are Means with standard error (SE) in parenthesis, N = Number of samples, PPUE = Pounds of Fish Caught per Effort.

		St. Croix Phone Interviews		St. Croix Stratum Creel Surveys Interviews	
		Boat	Shore	Boat	Shore
Effort (hr)	Mean	5.00	3.00	4.92	1.29
	SE	0.63	0.45	0.19	0.12
	N	5.00	6.00	58.00	31.00
Total Weight(lb.)	Mean	10.40	4.17	81.22	2.35
	SE	7.58	1.97	11.87	0.43
	N	5.00	6.00	58.00	31.00
PPUE (lb./hr)	Mean	2.41	1.87	16.92	2.04
	SE	1.91	1.03	2.49	0.43
	N	5.00	6.00	58.00	31.00

Table 5b. Fishing Effort and Harvest Estimates per Categories for St. Thomas/St. John Stratum from Telephone Interviews, Roving Shoreline Creel Surveys Interviews and Non-Charter Angler Interviews. All values are Means with standard error (SE) in parenthesis, N = Number of samples, PPUE = Pounds of Fish Caught per Effort.

		St. Thomas/St. John Phone Interviews		St. Thomas/St. John Creel Surveys Interviews	
		Boat	Shore	Boat	Shore
Effort (hr)	Mean	5.50	4.44	7.70	1.19
	SE	0.59	0.31	0.09	0.10
	N	8.00	10.00	293.00	52.00
Total Weight (lb.)	Mean	21.10	2.70	285.98	1.91
	SE	6.57	0.36	18.98	0.59
	N	8.00	10.00	291.00	25.00
PPUE (lb./hr)	Mean	3.75	0.71	37.08	2.00
	SE	0.92	0.13	2.39	0.64
	N	8.00	10.00	291.00	25.00

CONCLUSION

The data suggests that recreational fishing continues to be an important outdoor activity for local residents in the USVI. The results of this survey indicate during this study, 9.2 % of the residents of the USVI (approximately 11,000 individuals) fished recreationally. One interesting finding was that the proportion of USVI resident participation in recreational fishery activities has apparently not changed during almost thirteen years. The percentages of household units with at least a fisherman in St. Croix and St. Thomas/St. John stratums were similar to those found on the 1986 telephone survey conducted by Jennings (1992). The present survey also found that the proportions of boat, shoreline, and boat/shoreline anglers in both stratums were very similar to those found on the previous survey.

The results from the telephone survey show that, due to the recall bias, species identification and prestige bias associated with catch reports, a telephone survey is not an efficient method to access a multi-species fishery, such as the USVI recreational fishery. Others survey methods, such as point access surveys, should be considered as an alternative to collect precise and accurate angler catch information.

Effective management of saltwater fishing in the USVI requires an ongoing source of data that can best describe all aspects of the fishery. It is very important that whatever angler groups are surveyed, the data collected should be consistent and statistically valid to allow for direct comparison to previous years.

ACKNOWLEDGMENTS

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Régimen de Captura y Esfuerzo en la Pesquería Artesanal de Especies Pelágicas en la Isla de San Andrés, Caribe Occidental

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RESUMEN

La Isla de San Andrés forma parte del Archipiélago colombiano de San Andrés, Providencia y Santa Catalina, ubicado en el occidente del Mar Caribe abarcando una extensión de más de 250.000 Km^2. Durante el período comprendido entre agosto de 1998 y julio de 1999 se muestrearon los desembarques provenientes de 5 áreas de pesca, en la cooperativa de pescadores más importante de la Isla.

La captura anual estimada fue 40 ton, siendo las especies más representativas *Thunnus atlanticus* (bonito) y *Acanthocybium solandri* (sierra) con el 27.94% y 22.94% respectivamente, seguidos por *Elagatis bipinnulata* (ocean), *Sphyraena barracuda* (barracuda) y *Coryphaena hippurus* (dorado), mientras que los Carcharinidae (tiburones), Carangidae (jureles) y *Makaira nigricans* (marlin) estuvieron poco representados. Se encontraron diferencias en las capturas entre las áreas de pesca relacionadas principalmente con cambios en el esfuerzo pesquero y posiblemente con variaciones en la abundancia de los recursos. Las mayores capturas se registraron en la época seca (febrero – julio), mientras que durante los meses de agosto y septiembre se observó un comportamiento atípico en la composición de capturas respecto a años anteriores, coincidente con condiciones meteorológicas anómalas.

El esfuerzo pesquero se mantuvo constante a lo largo del año, aunque presentó fuertes variaciones en su distribución espacial, relacionadas principalmente con las condiciones climatológicas y oceanográficas imperantes, y en menor grado con la distancia al área de pesca, la autonomía de la embarcación y la destreza del pescador.

Finalmente se evidenció una gran complejidad en los regímenes de captura y esfuerzo pesquero, los cuales dependen de múltiples covariables de tipo ambiental, económico y socio cultural, siendo indispensable establecer un programa de monitoreo que permita modelar el sistema y definir estrategias de ordenamiento pesquero.

PALABRAS CLAVES: Pesquería Artesanal, Especie Pelágicas, San Andrés, Colombia

Catch and Effort Regime in Pelagic Small Scale Fishery in San Andres Island, West Caribbean

San Andrés island makes part of Colombian Archipiélago of San Andrés, Providencia y Santa Catalina, located in the west Caribbean, covering an area of over 250.000 km^2. During august 1998 to July 1999, landings from 5 fishing areas were evaluated at the most important fishers cooperative of the island. Annual capture was estimated in 40 ton, being *Thunnus atlanticus* (black bonito) y *Acanthocybium solandri* (king fish) the most representative species, 27.94% y 22.94% respectively, followed by *Elagatis bipinnulata* (ocean), *Sphyraena barracuda* (barracuda) y *Coryphaena hippurus* (dolphin), while Carcharinidae (sharks), Carangidae (jacks) and *Makaira nigricans* (marlin) were poorly represented. Differences found in captures between fishing areas were due mainly to different fishing efforts and possibly to variations in resource abundance. The greatest captures were registered during the dry season (February to July), whereas during August and September an atypical behavior of the composition, relative to past years, was observed in coincidence with anomalous meteorological conditions.

Fishing effort was constant all year round, although showing strong spatial distribution variations, related basically to climatologic and oceanographic prevailing conditions, and in a lesser degree, to distance to the fishing area, boat autonomy and fishers' ability. Finally, a great complexity in the catch and effort regimes was evident, depending upon multiple ambient, economic and socio-cultural co variables, making it imperative to establish a monitoring program that permits modeling the system and defining fishery ordering strategies.

KEY WORDS: Catch, Effort, Pelagic

INTRODUCCIÓN

Las especies pelágicas en el mundo revierten gran interés comercial y soportan importantes pesquerías. En América Latina y el Caribe la producción de pescado alcanzó niveles sin precedentes en 1994 de 24 millones de toneladas, equivalentes al 22% de total mundial, representando los peces pelágicos alrededor del 75 % (FAO 1996).

En la isla de san Andrés la extracción artesanal de peces pelágicos ha ganado importancia en los últimos años como consecuencia de la progresiva disminución de peces demersales de hábitos arrecifales. Pomare (1999) reporta capturas anuales de 236.5 toneladas representando los pelágicos más del 70 %. La flota pesquera está integrada aproximadamente por 80 embarcaciones, la mayoría con esloras entre 4.5 y 7.3 m y mangas entre 1 y 2 m, dotadas de motores fuera de borda a gasolina de 40 – 60 H.P., tripuladas por 1 ó 2 pescadores que realizan faenas diarias empelando línea monofilamento de mano con anzuelo, carnada ó señuelo (Grandas 2002).

A pesar de la creciente importancia de la pesquería no se cuenta con estadísticas continuas que permitan analizar la tendencia de la misma. Son pocos los trabajos

pesqueros desarrollado en el Archipiélago de San Andrés, Providencia y Santa Catalina, destacándose los realizados por: Barriga et al. (1969), registran algunas especies de importancia pesquera y alertan sobre la disminución de las especies arrecifales; García (1980), diagnostica la pesca artesanal y aporta información sobre las capturas y unidades usuales de pesca; Gallego (1997), describe los artes y métodos de extracción empleados artesanalmente, y Pomare (1999) y Grandas (2002), identifican centros de desembarques, describen artes de pesca y evalúan las capturas artesanales en la isla de San Andrés.

La investigación se realizó en el marco del Programa de Evaluación y Monitoreo de los Recursos Pesquero ejecutado por la Secretaria de Agricultura y Pesca del Departamento Archipiélago de San Andrés, Providencia y Santa Catalina, entidad que tiene a su cargo desde el año 2000 la administración de la actividad pesquera en la región, y tiene por objeto contribuir en el conocimiento de la pesquería, profundizando en aspectos hasta ahora poco evaluados, como el análisis espacial y temporal de la captura y el esfuerzo pesqueros y sus relaciones con algunos parámetros ambientales.

MATERIALES Y MÉTODOS

Área de Estudio

La isla de San Andrés y los cayos aledaños Courtown Cay y Albuquerque, integran el área central del presente estudio (Figura 1), forman parte del Archipiélago de San Andrés, Providencia y Santa Catalina, el cual se encuentra ubicado en el occidente del mar Caribe (IGAC 1986), abarcando una extensión de más de 250.000 km² de aguas territoriales y zona económica exclusiva de Colombia (Márquez y Pérez 1992).

La Isla de San Andrés ubicada a los 12° 32' Norte y 81° 41' Oeste es la de mayor extensión con 25 Km² de superficie; Courtown Cay, también conocido como Cayo Bolívar tiene un área aproximada de 0.77 km² y se encuentra localizado entre los 12° 10' Norte y 81° 51' Oeste; Cayo Albuquerque alcanza una extensión de 0.18 km² y se encuentra ubicado entre las coordenadas 12° 24' Norte y 81° 41' Oeste (IGAC 1986).

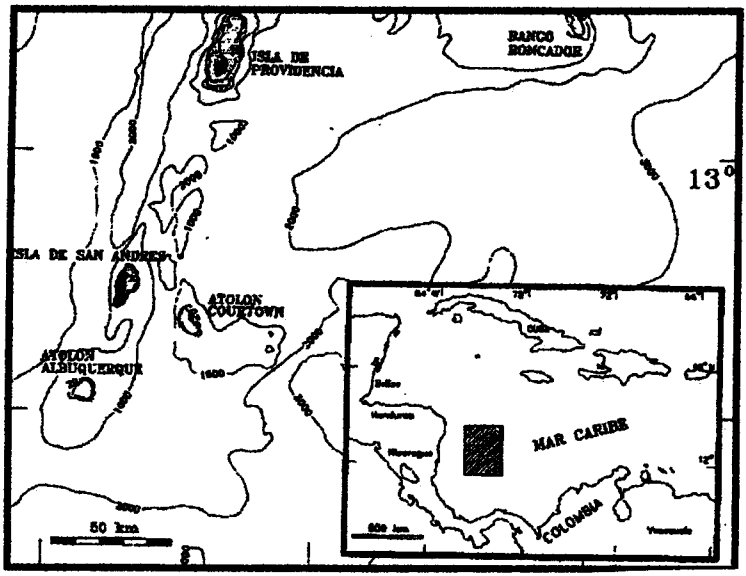

Figura 1. Localización área de estudio- modificado de Díaz et al., 1996

MÉTODO DE ESTUDIO

Se realizó un muestreo a 728 desembarques de pescadores artesanales en el principal núcleo pesquero de la isla de San Andrés, la Cooperativa Roos Carlos Barker, entre agosto de 1998 y julio de 1999. La unidad de muestreo principal fue la embarcación y se tomó información referente a la fecha de desembarco, días de faena, área de pesca, número de pescadores y captura por especie.

Se realizó una análisis espacial para identificar las áreas de pesca que contribuyeron en mayor proporción a las capturas, aquellas sometidas al mayor esfuerzo pesquero y las que presentaron mayor producción por unidad de esfuerzo. El análisis contempló una estratificación por áreas de pesca, a saber: Outside bank, Under the Lee, South End bank, Courtown Cay (Cayo Bolívar) y Cayo Albuquerque (Figuras 1 y 2). En cada una de los estratos se estimó la captura, esfuerzo y captura por unidad de esfuerzo, y se hicieron comparaciones mediante análisis de varianza en una vía ANOVA ó pruebas de Kruskal Wallis con ($p < 0.05$), dependiendo el tipo de distribución de los datos. Cuando los análisis ANOVA arrojaron como resultado una diferencia estadísticamente significativa, se aplicó el test de rango múltiple (LSD 95%) para establecer grupos homogéneos, entendidos estos como aquellos estratos que no presentan diferencia significativa entre los mismos. La identificación de los grupos cuando se corrió la prueba de Kruskal Wallis se realizó haciendo gráficos entre las medianas de tipo "Box and Winkler plot".

La evaluación de las variaciones a lo largo del año de muestreo de la captura, esfuerzo y captura por unidad de esfuerzo para cada uno de los grupos de especies

se hizo mediante un análisis temporal, tomando como unidad de análisis principal el mes, para lo cual se corrieron las mismas pruebas estadísticas descritas para el análisis espacial.

Adicionalmente, la captura y el esfuerzo pesquero fueron correlacionados con algunos parámetros meteorológicos, específicamente: temperatura media mensual, velocidad del viento media mensual y precipitación. Los datos meteorológicos se tomaron de los reportes del Instituto de Hidrología, Meteorología y Estudios Ambientales IDEAM, estación aeropuerto en la isla de san Andrés entre 1959 y 1999.

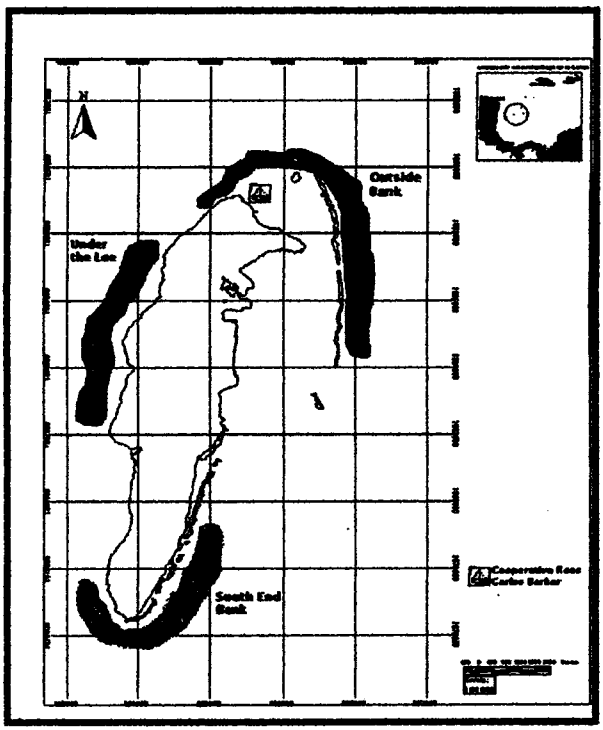

Figura 2. Areas de pesca en la zona aledaña a la isla de San Andrés.

RESULTADOS

Captura

La captura anual estimada en la Cooperativa Roos Carlos Barker fue de 50.228 kg, representando las especies pelágicas el 81.74 %, compuesta por más de 22 especies pertenecientes a las familias Scombridae, Coryphaenidae, Istiophoridae,

Carangidae, Sphyraenidae y Carcharinidae. Por facilidad en los análisis las especies fueron agrupadas de la siguiente manera:

i) *Sierras* — representado principalmente por *Acanthocybium solandri* y en menor proporción por *Scomberomorus cavalla*,
ii) *Atunes* — aproximadamente el 90 % corresponde a la especie *Thunnus atlanticus*, seguida por las especies *Katsuwonus pelamis* y *Euthynus alletteratus*, mientras que *Auxis thazard, Thunnus obesus* y *Thunnus albacares* son poco frecuentes en las capturas,
iii) *Dorado* — *Coryphaena hippurus*,
iv) *Marlin* — *Makaira nigricans*
v) *Ocean* — *Elagatis bipinnulata*,
vi) *Jureles* — representados en su mayor proporción por las especies *Caranx latus* y *Carangoides ruber*, y en menor por *Caranx lugubris, C. crysus, C. hippos, Alectis ciliaris, Seriola fasciata* y *Seriola durmerli*,
vii) *Barracuda* — *Sphyraena barracuda*, y
viii) *Tiburones* — varias especies de la familia Carcharinidae, que no fueron posibles de identificar por ser fileteados antes del desembarco.

Los atunes y sierras fueron los grupos más capturados aportando el 27.94 y 22.49% respectivamente, seguidos por el ocean (14.05 %) y la barracuda (8.06%), mientras que los tiburones, marlin y jureles estuvieron poco representados (Tabla 1).

El análisis espacial de las capturas por medio de la prueba de Kruskal–Wallis ($p < 0.05$) arrojó que se presentan diferencias significativas entre las áreas de pesca, conformándose los siguientes grupos homogéneos:

i) Outside Bank y Cayo Bolívar, que representan más del 85% del total capturado y
ii) Under the Lee, South End Bank y Cayo Albuquerque, comparativamente con bajas capturas.

El análisis referido a cada uno de los grupos de especies muestra por lo general un esquema similar al anterior, arrojando diferencias estadísticas significativas para los grupos de atunes, sierras, ocean, barracudas y jureles, presentando entre ellas algunas variaciones en el patrón de conformación de los grupos homogéneos relacionadas principalmente con diferencias en la composición porcentual de los volúmenes de capturas entre las áreas de pesca. Los marlin y tiburones no mostraron diferencias significativas, dado que sus capturas fueron bajas en todas las áreas de pesca (Tabla 1).

Las mayores capturas se presentan en el período comprendido entre los meses de febrero y julio, aportando más del 70 % de las mismas, con picos en los meses de abril y junio, mientras que en el resto del año estas bajan considerablemente (Figura 3). No obstante, el análisis estadístico (ANOVA $p < 0.05$), no arrojó diferencias significativas a lo largo del año, debido a la alta variabilidad diaria de las capturas al interior de cada uno de los meses de muestreo.

Tabla 1. Capturas de especies pelágicas por área de pesca. Agosto 1998 a Julio 1999.

	Outside	Under the Lee	South End	Cayo Bolivar	Cayo Alburquerque	Total
Sierras	4878,05	238,13	81,00	4904,81	1194,13	11296,12
Atunes	8033,43	262,06	195,76	5008,89	532,70	14032,84
Dorados	1314,22	0	22,50	1505,68	115	2957,40
Marlin	135,54	0	0	265,24	216,30	617,08
Ocean	2432,89	126,90	174,72	3895,23	427,33	7057,07
Barracuda	1596,54	48,15	7,80	1845,22	552,69	4050,39
Jureles	138,04	18,00	0	366,46	189,75	712,25
Tiburones	154,79	0	0	116,37	61,28	332,43

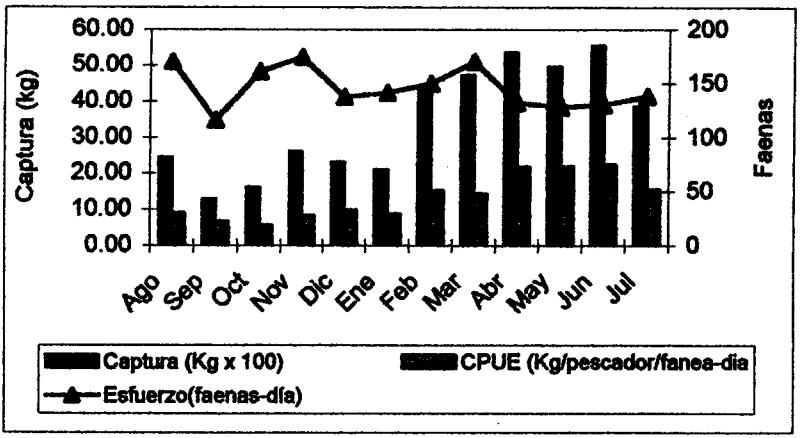

Figura 3. Variación temporal de la captura, el esfuerzo pesquero y la captura por unidad de esfuerzo para las especies pelágicas. Agosto 1998 – Julio 1999.

El análisis temporal en cada uno de los grupos de especies mostró patrones diversos (Figura 4), no encontrándose diferencias significativas para los atunes, sierras, barracudas y júreles. El dorado y el ocean mostraron diferencias significativas, el primero con picos de captura entre abril y mayo con el 68.95% del total de las mismas, y el segundo en abril (19.23%) y junio (34.01%). Los marlin y tiburones por su parte, mostraron diferencias significativas generadas por periodos de captura y no captura dado que su extracción es ocasional. No obstante, entre los meses de captura no presentan diferencias significativas.

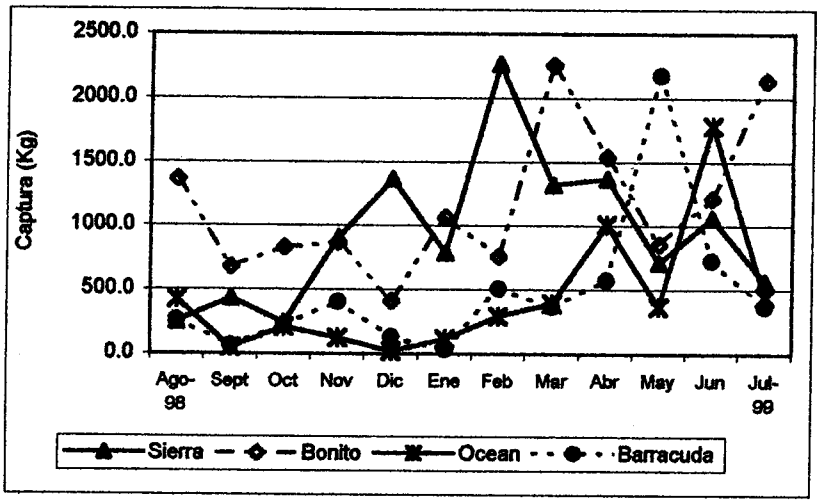

Figura 4. Variación temporal de las capturas de los principales grupos de especies pelágicas (agosto 1998 a Julio 1999).

Relación Captura vs Parámetros Ambientales

La temperatura durante el período de muestreo mostró la misma estacionalidad presentada para los últimos 40 años, resaltándose que se registraron las máximas temperaturas para los meses de agosto y septiembre del periodo referido. En general, se encontró una relación inversa entre la temperatura y las capturas de especies pelágicas, observando las mayores capturas entre febrero y junio, que coinciden con los meses menos cálidos. No obstante, la relación existente entre las variables no es muy alta, arrojando el Coeficiente de Correlación un valor de - 0.405. El mismo patrón se presentó para la mayoría de grupos de especies los cuales tuvieron relaciones inversas y coeficientes de correlación bajos, a excepción de las sierras, marlin y tiburones y el grupo del ocean que mostró una relación positiva, pero con un coeficiente de correlación muy bajo. Los coeficientes de correlación para cada grupo de especies fueron los siguientes: Sierras (- 0.836), atunes (- 0.09), dorado (- 0.02), marlin (- 0.58), barracuda (-0.00), ocean (0.03), tiburones (- 0.58) y jureles (- 0.46).

Al igual que la temperatura, las precipitaciones durante el período de muestreo mantuvieron el patrón estacional de los últimos 40 años, resaltándose nuevamente posibles condiciones atípicas en los meses de agosto y septiembre los cuales registraron valores bastante bajos. Se encontró una relación inversa entre la precipitación y las capturas de especies pelágicas, con mayores capturas entre febrero y junio que coinciden con los meses más secos. No obstante, la relación no es muy fuerte, resultando un coeficiente de correlación de – 0.474. Al nivel de los grupos de especies, se mantienen las relaciones inversas excepto para la barracuda. Se presentaron correlaciones muy bajas, salvo las sierras y atunes. Los coeficientes

de correlación obtenidos para cada grupo de especies son: Sierras (- 0.462), atunes (- 0.51), dorado (- 0.17), marlin (- 0.05), barracuda (0.02), ocean (0.27), tiburones (- 0.24) y jureles (- 0.31).

La velocidad del viento presentó un comportamiento estacional característico, lastimosamente no se cuenta con registros para los meses de octubre y noviembre de 1998. Nuevamente cabe destacar condiciones atípicas en el mes de septiembre el cual registra las velocidades de vientos más bajas de los últimos años. Se encontró una relación positiva entre la velocidad del viento y las capturas de especies pelágicas, pero con coeficientes de correlación relativamente bajos (0.39). Los coeficientes obtenidos para cada grupo de especies fueron: Sierras (0.25), atunes (0.33), dorado (0.27), marlin (0.14), barracudas (0.14), ocean (0.18), tiburones (0.10) y jureles (0.08).

Esfuerzo Pesquero

El esfuerzo estimado durante el periodo de muestreo fue de 1755 faenas/año, soportando todas las especies pelágicas un esfuerzo similar debido a que la pesquería es multiespecífica, las especies por lo general están presentes en las mismas áreas y el pescador no dirige su trabajo a una especie en particular, excepto cuando se dedica a la captura de atún para emplearlo como carnada.El área de pesca más visitada fue Outside bank, recibiendo el 72.14 % del total de faenas, seguido de cayo Bolívar con el 20.28 %, mientras que cayo Albuquerque, South End bank y Under the Lee fueron poco visitados (Figura 5). Al realizar un análisis espacial del esfuerzo pesquero mediante la prueba de Kruskal - Wallis, se encontró que existen diferencias significativas, conformándose tres grupos homogéneos:

i) Under the Lee - South End – Albuquerque,
ii) Bolívar y
iii) Albuquerque

A escala temporal el esfuerzo pesquero se mantuvo relativamente constante a lo largo del año, no arrojando diferencias significativas (ANOVA $p < 0.05$). Los mayores esfuerzos se registraron en los meses de agosto, noviembre y marzo, y los más bajos en septiembre (Figura 3).

Captura por Unidad de Esfuerzo

La captura por unidad de esfuerzo calculada para todas las especies en el año de muestreo fue de 15.81 kg/pescador/faena-día, y de 12.91 kg/pescador/faena-día para las especies pelágicas. Las mayores CPUE las registraron los atunes y sierras, seguidos por el ocean y la barracuda, mientras que para los demás grupos de especies fueron comparativamente bajas.

A escala espacial, las mayores CPUE se registraron en Cayo Albuquerque y Cayo Bolívar, encontrando diferencias significativas entre la CPUE de especies pelágicas (ANOVA, $p < 0.05$), integrando por medio de la prueba de rango múltiple (LSD 95%) los siguientes grupos homogéneos:

i) South End – Under – Outside y
ii) Albuquerque – Bolívar.

El análisis espacial por grupos de especies, mostró diferencias significativas para la mayoría. En los atunes y barracudas se observaron mayores CPUE en las áreas de Bolívar y Albuquerque, grandes diferencias entre Under The Lee y Cayo Bolívar fueron encontradas en el dorado, mientras que los marlin presentaron valores mucho más altos en Cayo Alburquerque. No se encontraron diferencias significativas para las sierras, tiburones y jureles.

La CPUE presenta un comportamiento temporal similar a las capturas (Figura 3), con mayores valores en el semestre comprendido entre febrero y julio, y menores el resto del año. El análisis temporal mostró que no existen diferencias significativas (ANDEVA $p < 0.05$) a lo largo del año, por lo que no se hace necesario discriminar el análisis temporal para cada uno de los grupos de especies, ni realizar correlaciones respecto a parámetros ambientales, ya que se obtendrían los mismos patrones resultantes para las capturas.

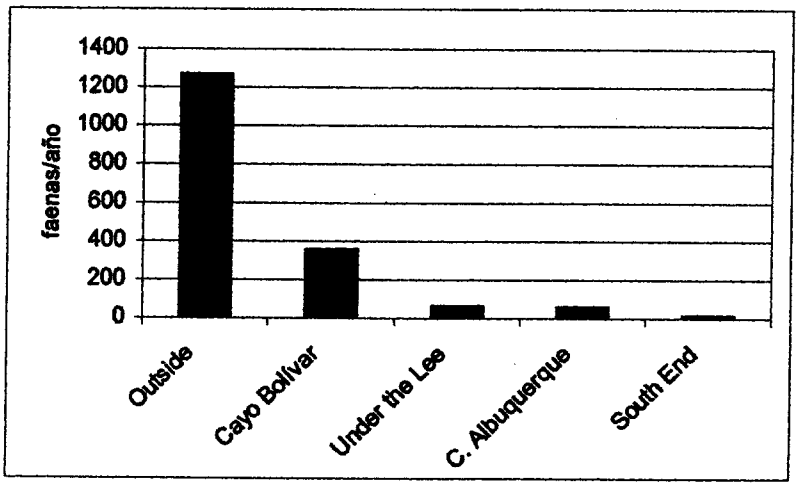

Figura 5. Esfuerzo pesquero en cada área de pesca entre agosto de 1998 y julio 1999

DISCUSIÓN DE RESULTADOS

Los resultados del presente trabajo confirman la creciente importancia de las especies pelágicas en la pesquería, las cuales aportaron el 81.74 % de las capturas. Pomare (1999) reporta que las mismas contribuyeron con cerca del 70% entre 1994 a 1995. El aumento de la extracción de especies pelágicas y en particular oceánicas como consecuencia de la sobrepesca de especies arrecifales se ha generalizado en el Caribe (Sadner y Ratter 1997, Ratter 1997). La composición porcentual de las

capturas fue muy similar a la encontrada por Pomare (1999), dominando los atunes y sierras. Sin embargo, se observaron comportamientos anómalos en los volúmenes de capturas de los jureles, barracudas y ocean durante los meses de agosto y septiembre, coincidiendo con condiciones meteorológicas atípicas.

Las diferencias encontradas a escala espacial entre las áreas de pesca están relacionadas con un mayor esfuerzo pesquero en Outside bank y Cayo Bolívar. Mientras que el análisis para la CPUE muestra un mayor valor para Bolívar y Albuquerque, lo cual permite inferir si consideramos la CPUE como un indicador indirecto de la abundancia, que hay mayor disponibilidad de recursos en estas áreas de pesca, esta hipótesis es respaldada por los pescadores. Las condiciones que generan esta situación sobrepasan el alcance de esta investigación, sin embargo, se plantean las siguientes hipótesis:

i) La plataforma insular de San Andrés ha soportado una mayor presión pesquera que los Cayos Bolívar y Albuquerque, viéndose afectado el stock pesquero,
ii) Los asentamientos humanos en la isla de San Andrés han generado desequilibrios en el ecosistema, conllevando a la disminución de la biomasa de algunas especies de importancia comercial, y
iii) Las mayores disponibilidades de recursos en los Cayos Bolívar y Alburquerque es producto de contar con plataformas insulares más anchas que las de la isla de San Andrés.

El hecho de no encontrar diferencia estadísticamente significativa en el análisis temporal no descarta del todo la estacionalidad en las capturas, lo cual posiblemente es reflejo de la alta variabilidad de las capturas desembarcadas al interior de cada uno de los meses muestreados. Además, hay que considerar que la unidad de análisis temporal "mes" es definida teniendo en cuenta la forma de agrupación de las estadísticas oficiales y no una condición intrínseca del complejo sistema pesquero, siendo posible que no fuese la mejor manera de estratificar para analizar las variaciones a lo largo del año.

Las capturas como era de esperarse estuvieron fuertemente correlacionadas con el esfuerzo pesquero en Cayo Albuquerque ($r = 0.956$), Cayo Bolívar ($r = 0.958$) y Under the Lee (0.979). Llama la atención el caso de Out Side Bank donde no se encontró relación, lo cual posiblemente evidencia una sobrepesca en el área, particularmente en el segundo semestre del año.

No se encontraron fuertes relaciones entre las capturas y los parámetros ambientales analizados. El patrón observado de relaciones inversas de las capturas con respecto a la precipitación y velocidad del viento es típica de sistemas con surgencia costera, pero con correlaciones mucho más altas. En el área un factor que podría explicar además del esfuerzo pesquero el hecho que se presenten diferencias espacio–temporales en la captura y CPUE de algunas especies pelágicas, son los procesos de enriquecimiento descritos por Diaz et al. (1995), generados por microsurgencias locales a las cuales se le suman aportes de agua enriquecidas que llegan de la elevación de Nicaragua influenciadas por descargas de los ríos Orinoco y Magdalena y de los sistemas de surgencia de la costa de Colombia y Venezuela.

Si bien el esfuerzo pesquero es prácticamente constante a lo largo del año, no lo es su distribución, lo cual se confirma al hacer correlaciones entre el esfuerzo pesquero y las diferentes áreas de pesca, obteniendo una relación inversa entre el número de faenas realizadas a Outside bank y las efectuadas a Cayo Bolívar (- 0.616), y un comportamiento similar respecto a South End Bank (- 0.498). El patrón de distribución del esfuerzo, se refleja fuertemente en las capturas, dado que se presentan diferencias significativas en la CPUE a escala espacial entre las áreas de pesca, por ende las mayores capturas registradas entre febrero y julio son en parte consecuencia de un mayor esfuerzo a cayo Bolívar y por supuesto un mayor aporte de este a las capturas.

El comportamiento prácticamente constante del esfuerzo a lo largo del año, pero con fuertes diferencias a escala espacial, resulta lógico para el sistema analizado, ya que diariamente se realizan aproximadamente el mismo numero de faenas, variando el esfuerzo a cada área de pesca según las condiciones meteorológicas imperantes. Bajo condiciones de calma hay pescadores que siempre realizan sus faenas a Outside bank y otros a Cayo Bolívar, siendo las dos áreas importante por la frecuencia de visitas, pero en condiciones adversas sin ser extremas la totalidad de pescadores realizan faenas en las áreas más cercanas a la isla. Lo anterior, evidencia que el mayor número de faenas en Outside bank es consecuencia en primera instancia de su cercanía al sitio pesquero Roos Carlos Barker, facilitando la realización de faenas por parte de embarcaciones de poca autonomía, pescadores de avanzada edad y bajo condiciones meteorológicas adversas.

El análisis realizado demuestra la complejidad del sistema pesquero en referencia a las relaciones existentes entre la captura, el esfuerzo y los parámetros ambientales y permite establecer que las áreas de pesca más importantes son Outside Bank y Cayo Bolívar, mientras que cayo Albuquerque a pesar de presentar las mayores CPUE no es tan importante. Weng y Sibert (2000), afirman que áreas con altas capturas son importantes aún cuando su CPUE sea baja, dado que capturar peces es el propósito de la pesquería, así mismo, áreas con altas CPUE son importantes solamente si tienen altas capturas y contribuyen significativamente a la producción total de la pesquería, mientras que áreas con alto esfuerzo se consideran importantes independiente de su CPUE, ya que son zonas de actividades pico, y porque un alto esfuerzo con baja CPUE puede indicar la degradación del recurso.

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Groupe de Travail Petites Antilles sur le Développement Durable de la Pêche Associée aux DCP Ancrés

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RESUME

Après plusieurs décennies d'expérimentation les DCP ancrés se sont développés dans la Caraïbe où ils sont souvent mis en œuvre dans le cadre d'actions d'aménagement de la pêche côtière. Un soutien scientifique et technique au développement durable de la pêche associée aux DCP ancrés s'avère nécessaire en particulier dans les petites Antilles où cette activité prend de l'importance. Un groupe de travail mis en place sous l'égide de la FAO/COPACO avec le soutien de l'Ifremer a permis d'identifier certaines problématiques scientifiques et techniques. Les premiers travaux de ce groupe de travail ont essentiellement porté sur l'élaboration d'un état de référence, l'impact de la pêche associée aux DCP sur les ressources, les suivis statistiques à mettre en place et les soutiens techniques nécessaires. De nombreux travaux scientifiques doivent être entrepris pour apporter aux pêcheurs et gestionnaires les informations leur permettant d'assurer la durabilité de cette nouvelle exploitation. Un programme d'observation acoustique est lancé par l'Ifremer afin de décrire l'influence de l'environnement et de l'exploitation halieutique sur la dynamique des agrégations autour des DCP ancrés. Les scientifiques de la Caraïbe sont sollicités pour travailler sur les questions soulevées par cette nouvelle activité.

MOTS CLÉS : DCP, Groupe de Travail, Petites Antilles

Working group for the Lesser Antilles on Moored FAD Fishing Sustainable Development

Experiments on moored FAD's have been undertaken for several decades. They were often used as a means to implement coastal fisheries management program. Scientific and technical support for the sustainable deployment of fisheries using moored FADs are necessary in the Lesser Antilles, where this activity is expanding. To satisfy those needs a working group was established under the aegis of FAO/COPACO with Ifremer's support. The initial work sessions of the group, were focused on the setting of a reference point, the impact of FAD's fishing on the resources, the type of monitoring and technical support needed to meet its objectives. It identified specific scientific studies that were still needed in order to

assist fishermen and managers in the sustainable development of this new activity. An acoustic observation program is implemented by Ifremer to describe the influence of the environment and the exploitation on the fish aggregation dynamic around moored FAD's. A request is submitted to other Caribbean scientists to focus work that is required to answer questions arising from this new fishing activity.

KEY WORDS: FAD, working group, Lesser Antilles

INTRODUCTION

Les grands poissons pélagiques sont traditionnellement exploités par les petites unités de pêche de la Caraïbe, au-dessus des monts sous-marins ou autour d'épaves dérivantes où se concentrent ces espèces. L'absence de condition hydrologique pouvant favoriser une augmentation de la densité des poissons dans le rayon d'action des petites unités, est certainement la raison de cette pêche effectuée sur les agrégations autour d'objets flottants ou de monts sous-marins.

Les premiers essais de développement des DCP ancrés sont relativement anciens dans la région caraïbe. L'objectif était de répondre aux besoins des pays de la région qui étaient importateurs de produits de la mer avec une demande, tant de la population locale que de l'industrie du tourisme, qui allait en augmentant. Par ailleurs, les ressources des plateaux étaient jugées fortement exploitées. Les ressources pélagiques paraissaient être les seules à offrir un potentiel suffisant pour augmenter les débarquements des petits pays insulaires et réduire le déficit de leurs échanges extérieurs. Le résultat des expérimentations de DCP a commencé à apparaître au début des années 1990 avec le développement de nouvelles pêcheries dans plusieurs pays.

Les DCP ancrés présentent un certain nombre d'avantages qui amènent à penser que leur développement se poursuivra dans la Caraïbe, au bénéfice des pêcheries artisanales. Ils sont utilisés dans beaucoup de cas pour détourner une partie de l'effort de pêche qui s'exerce sur les ressources benthiques et démersales des plateaux, généralement très exploitées, vers les ressources du large. L'implantation de DCP ancrés est parfois utilisée pour faciliter la mise en place de zone marine protégée. Ces dispositifs offrent aux pêcheurs la possibilité de trouver, sans changement de leur outil de production, un autre moyen de subsistance. Les DCP ancrés sont facilement accessibles aux petites embarcations artisanales. Ils permettent une exploitation moins aléatoire des grands poissons pélagiques, réduisent de façon sensible la consommation de carburant et les distances parcourues à la recherche d'épaves dérivantes. Ils permettent d'améliorer les rendements et de diminuer les efforts tant physiques que financiers consentis à chaque sortie par rapport aux types de pêche traditionnels. La réduction de ces prospections laisse espérer un ralentissement du développement des puissances motrices et une limitation des incursions des pêcheurs dans les ZEE voisines. Les DCP rendent l'emploi moins précaire en permettant une exploitation continue des ressources du

large habituellement pêchées pendant 6 mois de l'année autour des bois dérivants. L'installation de jeunes pêcheurs aurait été rendue possible par le développement des DCP dans certaines îles (Martinique, Guadeloupe) (Reynal et al. 2000).

LES CONDITIONS DU DÉVELOPPEMENT DURABLE

En application du code de conduite des pêches responsables (FAO 1995), cette pêche en cours de développement doit faire l'objet d'attention particulière afin de garantir le caractère durable de l'exploitation et le partage équitable des ressources hautement migratrices de grands poissons pélagiques. Pour cela, un groupe de travail Petites Antilles a été mis en place par la FAO/COPACO avec le soutien de l'Ifremer. Son objectif est de contribuer au développement durable de la pêche associée aux DCP ancrés. Ce groupe de travail utilisera une approche pluridisciplinaire et s'intéressera aux espèces exploitées autour des DCP, mais aussi aux espèces et pêcheries qui interagissent avec la pêche associée aux DCP.

Ce groupe de travail constitue une organisation de base à partir de laquelle des échanges pourront se faire. La mise en place de suivi statistique et la conduite de recherches sur le système pêche modifié par le développement des DCP sont nécessaires. Elles devront apporter aux gestionnaires les informations dont ils ont besoin pour assurer la durabilité de l'exploitation des ressources de grands pélagiques et leur partage équitable entre utilisateurs. Cependant, il n'existe pas de méthode pour aborder un champ de questions aussi vaste. Certains axes de travail ont été identifiés à partir de premières études d'impact de la pêche associée aux DCP ancrés ou de demandes formulées par les professionnels de la pêche et par ceux qui ont en charge le développement du secteur. Ces premiers travaux ont été abordés lors de la première réunion du groupe de travail sur le développement durable de la pêche associée aux DCP ancrés.

LES PREMIERS TRAVAUX DU GROUPE DE TRAVAIL

Au cours de sa première réunion en octobre 2001, le groupe de travail s'est attaché à établir, à partir des données disponibles par pays, un point de référence sur la pêche des grands poissons pélagiques au sein des petites Antilles, afin de pouvoir identifier ultérieurement d'éventuel changement pouvant être mis en relation avec le développement des DCP (Looby 2002, Dilrosun 2002, Sebastian 2002, Diaz et al. 2002, Doray et al. 2002, Baldeo 2002, Heyliger 2002, James 2002, Johnson 2002, Lalla 2002). Puis un état des lieux a été réalisé sur le développement des DCP. L'objectif était à la fois de compléter le point de référence et d'identifier pour chaque pays les éventuels problèmes rencontrés pour le développement de cette nouvelle pêche (Looby 2002, Van Buurt 2002, Sebastian 2002, Diaz et al. 2002, Doray et al. 2002, Baldeo 2002, Heyliger 2002, James 2002, Johnson 2002, Lalla 2002). Une réflexion a ensuite été conduite sur le développement durable de la

pêche associée à ces dispositifs (Singh-Renton 2002), sur l'analyse des premiers impacts de cette pêche et sur les premières réponses à apporter aux questions soulevées.

La Pêche des Grands Poissons Pélagiques dans les Petites Antilles (Doray et Reynal 2002)

Les flottilles de pêche des grands poissons pélagiques des Petites Antilles sont variées et très majoritairement artisanales. L'abondance relativement faible de poissons pélagiques, l'imbrication des nombreuses ZEE et le faible niveau de développement global imposé en partie par le caractère insulaire de ces pays ont contribué au développement des pêcheries pélagiques sur le mode artisanal, bien adapté aux conditions locales.

Le nombre de pêcheurs professionnels qui seraient susceptibles d'exploiter au moins une partie de l'année les poissons pélagiques hauturiers dans les Petites Antilles s'élèverait à 25 894 dont 4 730 pratiqueraient la pêche à plein temps. Le nombre d'embarcations serait au total de 8 053 se décomposant en 7 348 unités non pontées et 705 pontées. Les embarcations faisant effectivement la pêche des pélagiques hauturiers au moins une partie de l'année seraient au minimum de 1 904. Dans certains pays les flottilles sont pluri-métiers et le nombre d'unités ciblant effectivement les pélagiques n'est pas connu (Tableau 1). La production moyenne annuelle de grands pélagiques des Petites Antilles au cours de la décennie 90 est de 5 600 tonnes (ICCAT 2001).

Tableau 1. Flottilles ciblant les grands poissons pélagiques aux Petites Antilles

Flottille	Longueur moyenne (m)	Nb potentiel	Nb avéré	Type de pêche principal	Motorisation
Palangriers pontés	15	111	90	Palangre de surface	Diesel inboard
Ligneurs pontés polyvalents	10	594	463	Traîne	Diesel inboard
Palangriers non pontés	7	109	109	Palangre de surface	Essence outboard
Ligneurs non ponté polyvalent	7	4623	1242	Traîne	Essence outboard
Ligneurs DCP non pontés polyvalents	7	2616	?	Traîne et palangre verticale dérivante	Essence outboard

Les flottilles ciblant les grands poissons pélagiques ont été décrites à partir du type d'embarcation et des engins de pêche mis en œuvre. Les embarcations pontées équipées de moteur diesel intérieur ont été distinguées des unités non pontées à moteur essence hors bord. Les engins mis en œuvre pour cibler les grands poissons pélagiques sont essentiellement la palangre horizontale dérivante, la ligne de traîne de surface ou sub-surface, la palangre verticale dérivante.

Les ligneurs sont généralement polyvalents. Les lignes de traîne sont mises en œuvre avec un hameçon et le plus souvent avec des leurres artificiels pour capturer les thunnini (thons et bonites) et scombrini (thazards) et des appâts frais pour *Coryphaena hippurus*. Une seule ligne est traînée par personne embarquée, sauf à Trinidad où des tangons en bambou sont utilisés pour gérer 4 à 6 lignes de traîne. La traîne se fait soit au large sur banc libre ou sur bois dérivant soit près de côte sur des monts sous-marins ou sur les accores. Depuis quelque temps, les ligneurs pêchent autour de DCP ancrés à la ligne de traîne ou à la palangre verticale dérivante munie d'un hameçon et souvent appâtée à l'aide d'une petite bonite vivante pêchée en surface.

Les palangriers exploitent entre 30 m et 50 m de profondeur. La principale espèce ciblée est *Thunnus albacares*. Le nombre d'hameçons utilisés varie selon le type d'embarcation ; les unités pontées mettent à l'eau entre 300 et 1000 hameçons et les non pontées entre 100 et 250.

D'autres types de pêche capturent les grands poissons pélagiques sans que cela soit leur prise principale, comme les sennes de plage ou les pêches de poissons volants. Des unités industrielles extérieures à la zone ont également été mentionnées mais leur activité n'est pas connue.

Les données statistiques disponibles sur les pêcheries de grands poissons pélagiques hauturiers au sein des Petites Antilles, sont imparfaites et ne permettent pas de faire un point zéro très détaillé. Les valeurs de production totale annuelles sont les données les plus communément disponibles. Elles doivent cependant être analysées avec précaution car elles sont souvent d'avantage représentatives de l'étendue de la couverture du système de collecte de données que des captures réelles.

Le Tableau 2 regroupe les quelques données disponibles sur l'effort de pêche déployé et les CPUE enregistrées par les îles des Petites Antilles. L'effort est en général mesuré en heures de sortie (temps de route compris) et les CPUE sont des prises moyennes par heure de sortie ou à défaut des rendements par sortie. Ce sont ces dernières données de CPUE qui sont le plus fréquemment disponibles, mais pour comparer les résultats des différentes flottilles des différentes îles, il faut garder à l'esprit que les durées de sortie, les zones de pêche et les engins mis en œuvre sont différents. Ce sont les palangriers, qu'ils soient pontés ou non, qui réalisent les rendements par sortie et par heure de sortie les plus élevés. Parmi les ligneurs, ce sont ceux des Antilles françaises qui réalisent les captures par sortie et par heure de sortie les plus élevés. Les ligneurs non pontés martiniquais travaillant autour des DCP réalisent les rendements horaires moyens les plus élevés, proche de ceux des palangriers pontés de Curaçao.

Les pêcheries de grands poissons pélagiques sont en plein essor aux Petites Antilles avec notamment le développement de la pêche à la palangre et de la pêche associée aux DCP ancrés. Les îles du Sud des Petites Antilles ont un développement différent (développement de la palangre horizontale) des îles du Nord qui est rendu

possible par la remontée saisonnière d'eau enrichie en matière organique par les fleuves amazoniens qui attirent les poissons pélagiques hauturiers.

Tableau 2. Données d'effort de pêche et CPUE fournies par les îles des Petites Antilles *Données estimées en italique*

Ile	Flottille	Unité d'effort	Effort moyen par sortie (h)	CPUE moyenne par sortie (kg/h)	Captures moyennes par sortie (kg)
Grenada	*Palangriers pontés (11 à 20 m)*	*sortie*			*750*
Curaçao	Palangriers pontés	heure de sortie	61,6	10,1	620
Grenada	*Palangriers non pontés (8,7 à 10,7m)*	*sortie*			*135*
Martinique	Ligneurs non ponté polyvalent	heure de sortie	8,5	7,2	80
Grenada	*Palangriers non pontés (4,7 à 6m)*	*sortie*			*60*
Guadeloupe	Ligneurs DCP non pontés polyvalents	heure de sortie	7,2	7,5	58
St. Vincent	Ligneurs non ponté polyvalent	sortie			50
Curaçao	Ligneurs pontés polyvalents 9 - 12 m	heure de sortie	15,2	3,2	48
Martinique	Ligneurs DCP non pontés polyvalents	heure de sortie	6,5	8,3	47
Curaçao	Ligneurs pontés polyvalents 7 - 9 m	heure de sortie	8,8	1,6	14
Curaçao	Ligneurs non ponté polyvalent 5 - 7 m	heure de sortie	7,2	1,4	10
Grenada	*Ligneurs DCP non pontés polyvalents*	*sortie*			*10*
Curaçao	Ligneurs non ponté polyvalent < 5 m	heure de sortie	5,6	0,9	5

Le Développement de la Pêche Associée aux DCP Ancrés

D'après les participants au groupe de travail, au moins 254 DCP ancrés seraient en activité dans les eaux des Petites Antilles (Tableau 3). Mais le niveau et le mode de développement de la pêche associée aux DCP ancrés varient d'une île à l'autre de même que le type de dispositif. Le financement public intégral de la pose et de la maintenance semble être le seul mode d'organisation qui permette le maintien de DCP lourds et coûteux comme à Curaçao. Le coût moins élevé de DCP légers laisse la place à l'initiative privée dans le déploiement des dispositifs. Les plus coûteux des dispositifs légers sont en général mis à l'eau et exploités par des groupes formels (Comité des Pêches, associations, ...) ou non de professionnels (Martinique, Dominique). Les DCP artisanaux financés en général par des pêcheurs individuels sont les plus rudimentaires. Ce système de gestion des DCP semble favoriser un développement rapide de cette pêche (Guadeloupe) (Doray et Reynal, 2002).

L'intervention des pouvoirs publics se fait à différents niveaux du développement ou de l'encadrement de la pêche associée aux DCP ancrés. Des expérimentations ou des actions de développement (mise en place d'une première série de DCP financée par la collectivité) sont souvent le point de départ des pêcheries associées aux DCP. L'intervention des pouvoirs publics est indispensable pour l'encadrement de l'activité par la définition de règles :

i) De balisage (respect des règles de navigation),
ii) De pose (déclaration à l'administration des lieux d'implantation, déclaration aux AVURNAV),
iii) D'accès aux ressources agrégées autour des dispositifs,
iv) D'exploitation des ressources.

Les pouvoirs publics interviennent également par le financement des DCP sur de longues périodes (plusieurs années), comme à Curaçao ou en Martinique.

Il faut noter que l'accès de tous les pêcheurs à tous les DCP situés dans les eaux territoriales de leur île est la règle généralement adoptée. Dans le cas des DCP individuels de Guadeloupe, l'exploitation du DCP est réservée au propriétaire du DCP, uniquement lorsqu'il est présent. Il est vraisemblable que les usages soient différents et qu'en particulier les DCP financés et entretenus par des groupes de pêcheurs soient majoritairement exploités par eux. Les autres pêcheurs subissant la pression du groupe pour participer aux charges d'exploitation du dispositif ou pour s'en éloigner. Les DCP ancrés implantés dans les Petites Antilles semblent être réservés prioritairement aux professionnels de la pêche (Martinique), mais aucune enquête n'a été conduite sur les rapports entre pêche sportive et professionnelle autour des DCP.

Tableau 3. Etat du développement des DCP dans les Petites Antilles en 2001

Ile	Nb DCP connus	Type de DCP	Financement	Type de pêche
Antigue et Barbude	6	Artisanal	Privé	Traîne sportive
St Kitts	?	?	Privé	Traîne
Guadeloupe	> 200	Artisanal	Privé	Traîne et bidon
Dominique	9	Léger ou artisanal	Public ou privé	Traîne et bidon
Martinique	> 31	Léger	Public ou privé	Traîne et bidon
Sainte Lucie	1	Léger et lourd	Public	Traîne et bidon
Saint Vincent	0	Radeau de bambou	Public	Traîne
Grenade	2	Léger ou artisanal	Public	Traîne
Trinidad	0	Radeau de bambou	Public	
Curaçao	6	Lourd	Public	Traîne

Les règles d'exploitation des DCP ne semblent pas être une préoccupation forte. Les rivalités entre types d'unités de pêche n'ont pas été mentionnées. Les unités non pontées sont pratiquement les seules à exploiter les DCP. Les incompatibilités d'engins ne semblent pas pour l'instant poser de problème majeur en raison vraisemblablement de leur faible diversité. Actuellement, les pêcheurs de toutes les îles utilisent la ligne de traîne pour exploiter les poissons agrégés près de la surface

autour des DCP. Dans quelques îles (Guadeloupe à Sainte Lucie) la palangre verticale dérivante (« bidon ») est utilisée pour exploiter les couches profondes.

Les conditions de réussite du développement de la pêche associée aux DCP ancrés n'ont pas été clairement identifiées au cours de la première réunion du groupe de travail. Cinq éléments peuvent être évoqués pour leur rôle probablement déterminant dans le démarrage ou le développement d'une pêche associée aux DCP ancrés :

i) *Type de DCP*— est une des principales préoccupations de ceux qui ont en charge le développement des DCP. Dans les Petites Antilles les DCP sont de conception et de durée de vie très variables. Aucune relation entre conception et longévité des dispositifs ne peut être établie en raison de l'insuffisance de données disponibles. La maintenance joue d'ailleurs un rôle incontestable sur leur pérennité. Cependant, certains DCP inadaptés au site d'implantation se détériorent rapidement. C'est ce qui est probablement une cause d'abandon de certaines tentatives de développement des DCP.

ii) *Lieu d'implantation des DCP* — est parfois choisi proche de la côte ou la mer est plus calme, de façon à garantir une plus grande longévité des DCP. Ces sites s'avèrent inadéquats pour les poissons pélagiques hauturiers qui semblent s'agréger plus sur les DCP situés hors du plateau insulaire (par des profondeurs de 1500 – 2000 m ou plus).

iii) *Règles d'accès aux Concentrations de Poissons* — conditionnent également le démarrage des pêches associées aux DCP. Elles doivent être en harmonie avec le mode de financement et de maintenance des dispositifs. Lorsque des individus ou groupes de pêcheurs financent sur fonds propres un DCP, ils conçoivent difficilement d'avoir les mêmes droits d'accès aux concentrations que ceux qui n'ont pas contribués au paiement des charges liées à l'implantation du dispositif. Au démarrage des pêches associées aux DCP, lorsque les règles d'accès aux concentrations de poissons ne sont pas établies, ils se développent des conflits parfois graves qui découragent les acteurs de poursuivre cette activité.

iv) *Techniques de Pêche Utilisées autour des DCP* — dans les Petites Antilles sont d'abord les techniques traditionnelles des artisans pêcheurs, c'est à dire les lignes de traîne de surface ou sub-surface. L'adoption de la palangre verticale dérivante a augmenté sensiblement les rendements autour des DCP en permettant la capture des gros poissons situés à des profondeurs plus élevées (80 à 150 m). L'amélioration des résultats de pêche avec la palangre verticale dérivante, contribue à accélérer et à pérenniser la pêche associée aux DCP ancrés

v) *Le Système de Gestion des DCP* — joue certainement un rôle non négligeable dans le développement de la pêche associée à ces dispositifs. Le financement privé des DCP (collectif ou individuel) favorise une prise en charge par les pêcheurs eux-mêmes et probablement un développement

plus rapide. Mais sans un encadrement très rigoureux des pouvoirs publics, ce mode de gestion des DCP ne permet pas un contrôle et une régulation aisée de l'activité.

Des travaux restent à faire pour préciser les conditions d'utilisation optimales des facteurs identifiés. Il est également probable que d'autres facteurs interviennent dans la réussite ou non des programmes de développement de la pêche associée aux DCP ancrés.

Impacts Potentiels du Développement de la Pêche Associée aux DCP ancrés sur les Ressources (Reynal et Doray 2002)

L'objectif du développement de la pêche associée aux DCP ancrés a généralement été la préservation des ressources côtières par un redéploiement de la pêche sur les ressources du large. Les effets de cette nouvelle pêche sur les ressources tant côtières que du large sont encore difficiles à évaluer en raison du manque de données chiffrées suffisamment détaillées. Aucune donnée ne permet aujourd'hui d'évaluer l'effet du développement de la pêche associée aux DCP sur les ressources côtières. Quelques données sur la pêche en Martinique ont pu être utilisées pour identifier les espèces sur lesquelles les prises ont augmenté ou pourraient s'accroître à l'avenir et celles sur lesquelles des captures de juvéniles sont effectuées. L'existence d'éventuels rejets a également pu être vérifiée. Mais il faut garder à l'esprit que la pêche associée aux DCP ancrés est encore en cours d'évolution dans les Petites Antilles, il est donc possible que de nouvelles espèces apparaissent dans les débarquements et que la proportion des espèces capturées évolue.

Une comparaison des prises par sortie effectuées ces dernières années autour des DCP ancrés avec celles des autres types de pêche des grands poissons pélagiques n'a pu être faite que sur des données non représentatives de la pêcherie. Elle révèle une composition spécifique différente selon le type de pêche. De 75 à 85 % des prises des trois types de pêche des grands poissons pélagiques pratiquée en Martinique se font sur deux ou trois espèces. Sur les hauts-fonds, se sont *Sphyraena barracuda* (33 % du poids débarqué), *Thunnus atlanticus* et *Scomberomorus cavala* qui constituent l'essentiel des débarquements. A la traîne au large, *Coryphaena hippurus* domine largement dans les captures (plus de 50 % du poids) avec *Acanthocybium solandri*. Quant à la pêche associée aux DCP ancrés elle réalise 85 % de ses captures avec *Makaira nigricans*, *Thunnus albacares* et *Thunnus atlanticus* (Tableau 4).

Les prises de marlin bleu (*M. nigricans*) sont importantes en tonnage et ne se font qu'autour des DCP. Par conséquent, le développement de la pêche associée aux DCP ancrés va favoriser une augmentation des captures de marlin bleu. Pour les autres espèces, leurs prises évolueront selon la façon dont l'activité se répartira entre les différents types de pêche. Il est possible d'imaginer plusieurs scénarios selon que la pêche associée aux DCP ancrés se développe en plus des autres types de pêche ou qu'elle s'y substitue totalement ou partiellement. Dans ce dernier cas,

l'effort de pêche devrait diminuer sur le barracuda (*S. barracuda*), les thazards (*A. solandri* et *S. cavala*) et sur la dorade coryphène (*C. hippurus*) et augmenter sur les thons noir et jaune (*T. albacares* et *T. atlanticus*).

Tableau 4. Composition spécifique pondérale des débarquements (en %) en fonction du type de pêche (données Martinique, mai 1998 à mai 2001).

Espèce	DCP	Traîne au large	Hauts-fonds
Thunnus albacares	26	8	4
Thunnus atlanticus	15	3	26
Katsuwonus pealmis	5	7	4
Makaira nigricans	44	3	2
Xyphidae et Istiophoridae	4	0	0
Coryphaena hippurus	2	52	5
Acanthocybium solandri	1	22	5
Scomberomorus cavalla	0	0	18
Sphyraena barracuda	0	0	33
Autre	1	4	1

L'examen des tailles des captures en fonction des types de pêche des grands poissons pélagiques a également été réalisé sur des données non représentatives de débarquement de la Martinique. La comparaison des prises révèle un changement de diagramme d'exploitation avec le développement de la pêche associée aux DCP ancrés. Celui-ci a entraîné une augmentation des prises de juvéniles de plusieurs espèces et en particulier de celles débarquées en nombre élevé comme *Thunnus atlanticus* (75 %), *Katsuwonus pelamis* (88 %), *Thunnus albacares* (93 %) et secondairement *Euthynnus alleteratus* et *Coryphaena hippurus*. Sur l'ensemble des prises, la pêche associée aux DCP ancrés capture une proportion plus élevée de juvéniles que la pêche à la traîne au large (respectivement 79 et 45 %). Cette différence est due, entre autres, au fait que les techniques de pêche utilisées autour des DCP, pour la capture de gros poissons, font appel à des appâts vivants constitués par les petits individus pêchés en surface. De ce fait, la proportion des juvéniles ne peut qu'être supérieure à celles des adultes (Tableau 5).

Il faut noter qu'aucun rejet de la pêche associée aux DCP ancrés n'a été observé jusqu'ici. Des juvéniles de thonidés capturés près de la surface servent d'appât vivant pour la capture des gros poissons profonds (*T. albacares* et *M. nigricans*). Lors de la remontée des lignes profondes ces poissons sont conservés pour la vente, s'ils n'ont pas été consommés ou abîmés par des prédateurs.

La présence d'espèces non exploitées autour des DCP ancrés, constituant un potentiel appréciable pour les pêcheurs, a pu être mise en évidence par des pêches expérimentales réalisées en Martinique et en Guadeloupe. C'est le cas du thon noir (*T. atlanticus*), dont les prises ne sont pas négligeables, mais restent faibles par rapport aux concentrations observées en plongée sous-marine à des profondeurs supérieures à celles exploitées à la traîne par les pêcheurs. La taille de ces thons noirs observés et capturés lors de pêches expérimentales, est supérieure à celle des

individus pêchés par les professionnels autour des DCP (Taquet et al. 1998 et 2000).

Tableau 5. Proportion des juvéniles dans les captures de poissons pélagiques hauturiers en Martinique (1998 -2001)

Espèces	Pêche associée aux DCP		Traîne au large		Traîne côtière	
	Taille de l'échantillon	% de juvéniles	Taille de l'échantillon	% de juvéniles	Taille de l'échantillon	% de juvéniles
Acanthocybium solandri	71	38 %	614	14 %	48	17 %
Coryphaena hippurus	88	74 %	793	56 %	51	45 %
Euthynnus alletteratus	124	100 %	9	0 %	17	59 %
Katsuwonus pelamis	1106	88 %	342	22 %	48	10 %
Makaira nigricans	74	8 %	3	100 %		
Scomberomorus cavalla	4	25 %			247	2 %
Sphyraena barracuda	36	42 %	20	55 %	1170	68 %
Thunnini	2	0 %			2	100 %
Thunnus albacares	565	85 %	385	100 %	70	100 %
Thunnus atlanticus	2661	75 %	202	30 %	601	16 %
Istiophoridae	32	34 %				
TOTAL	**4763**	**79 %**	**2368**	**45 %**	**2254**	**45 %**

Des pêches expérimentales ont révélé la présence pendant la nuit d'espadon autour des DCP en Martinique et en Guadeloupe alors que cette espèce n'est qu'exceptionnellement capturée par les pêcheurs qui ne travaillent que le jour (Taquet et al. 1998, Diaz et al. 2002). D'autres espèces, capturées à proximité des DCP, ont un intérêt économique probablement moindre comme *Taractichthys longipinnis* (Taquet et al. 1998). Des interrogations subsistent sur le potentiel que représentent certaines espèces qui ne sont capturées que très rarement par les pêcheurs des Petites Antilles et dont la présence est notée dans la littérature et les prises enregistrées dans les statistiques de pêche régionales. Parmi celles-ci, on peut citer les thons obèse (*Thunnus obesus*) et germon (*Thunnus alalunga*) et dans une moindre mesure le thon rouge (*Thunnus thynnus*).

L'état Actuel des Ressources Exploitées (Reynal et Doray 2002)

Parmi les stocks exploités ou potentiels pour la pêche associée aux DCP ancrés, certains sont évalués par la Commission Internationale pour la Conservation des Thonidés de l'Atlantique (CICTA), il s'agit de *T. albacares*, *T. alalunga*, *K. pelamis*, *T. thynnus*, *T. obesus*, et des poissons à rostre *M. nigricans*, *T. albidus* et *X. gladius*. Une base de données est élaborée sur d'autres espèces qui pour l'instant ne font pas l'objet d'évaluation. Il s'agit des requins ou de ressources dont la CICTA préconise la gestion à un niveau régional ou sub-régional : *A. solandri*, *Scomberomorus spp*, *A. thazard*, *E. alletteratus*, *T. atlanticus*. La CICTA ne prend pas en compte la dorade coryphène (*Coryphaena hippurus*) et les barracudas (*Sphyraena spp.*).

Parmi les trois principales espèces exploitées autour des DCP, deux ont fait l'objet d'une évaluation récente par la CICTA, il s'agit de *T. albacares* et *M. nigricans*. La troisième, *T. atlanticus*, est une espèce dont l'aire de répartition se limite à la Caraïbe.

Les résultats des évaluations réalisées par la CICTA, sur les espèces retenues ci-dessus, sont résumés dans le Tableau 6. Il s'agit d'espèces importantes au plan économique et dont la production est proche sinon dépasse la production maximale équilibrée (PME). Des mesures de gestion de ces ressources ont été établies ; elles visent à réguler les prises et l'effort et sont parfois complétées par des tailles minimales de capture.

Le stock Atlantique de *Thunnus albacares* est très important. Sa production maximale équilibrée est estimée à 150 000 tonnes par an. Les prises estimées sont proches de la PME. La CICTA, recommande pour cette espèce de ne pas augmenter l'effort de pêche effectif au-delà du niveau observé en 1992, mais surtout de rechercher des moyens efficaces en vue de réduire la mortalité par pêche des petits individus. Pour cela, un poids minimal de capture de 3,2 kg a été fixé. Cette mesure devrait donc être appliquée par les pays des Petites Antilles. Une tolérance de 15 % du nombre des individus débarqués, de poids inférieur à la limite réglementaire a été néanmoins accordée (CICTA, 2001).

Selon les données d'échantillonnage de Martinique, les prises de cette espèce sont constituées d'une proportion élevée d'individus n'ayant pas la taille minimale fixée, tant pour les techniques traditionnelles de traîne autour de bois dérivant ou sur des hauts fonds (100 % d'individus sous taille) que pour la pêche associée aux DCP ancrés (85 %). Il faut cependant rapporter ces quantités au total des débarquements du stock (135 200 t en moyenne sur la décennie 90). La production annuelle des îles des Petites Antilles est en moyenne de 1 388 t (moins de 1 %) dont 589 effectuées par les palangriers.

Tableau 6. Liste des espèces observées autour des DCP ancrés, niveau d'exploitation en cours.

Species	Evaluation CICTA	PME (tonne)	Production (tonne)	B / B_{PME}	F / F_{PME}
Dorade (*Coryphaena hippurus*)	Non (*)				
Bécune (*Sphyraena barracuda*)	Non (*)				
Thazard bâtard (*Acanthocybium solandri*)	Non (*) - (Base de données)				
Thazard (*Scomberomorus spp*)	Non (*) - (Base de données)				
Auxis thazard	Non (*) - (Base de données)				
Thonine commune (*Euthynnus alletteratus*)	Non (*) - (Base de données)				
Bonite à ventre rayé (atlant. ouest) (*Katsuwonus pelamis*)	Oui	Non estimée	26 406 (2000)	Non estimée	Non estimée
Thon noir (*Thunnus atlanticus*)	Non (*) - (Base de données)				
Albacore (*Thunnus albacares*)	Oui	144 600 à 152 200	135 200 (2000)	1,03	0,88 à 1,16
Germon (atlant. nord) (*Thunnus alalunga*)	Oui	32 600	33 134 (2000)	0,68 (1999)	1,10 (1999)
Thon rouge (atlant. ouest) (*Thunnus thynnus*)	Oui	3500 à 7 700	2395 (2000)	0,36 à 1 (1999)	1,37 à 2,22
Thon obèse (*Thunnus obesus*)	Oui	79 000 à 94 000	98 608	0,57 à 0,63	1,50 à 1,82 (1998)
Marlin bleu (*Makaira nigricans*)	Oui	2 000 (2 à 3 000)	3 155 (2000)	0,4 (0,25-0,60) (2000)	
Marlin blanc (*Tetrapturus albidus*)	Oui	1 300 (900 à 2 000)	839 (2000)	0,15 (2000)	> 7 (1999)
Espadon (atlantique nord) (*Xiphias gladius*)	Oui	13 370	11 914	0,65 (1999)	1,34
Requins	Non (*) - (Base de données)				

La dernière évaluation du stock de *Makaira nigricans* a mis en évidence la faible importance de cette ressource dont la production maximale équilibrée serait de l'ordre de 2000 à 3000 tonnes par an. Les résultats des études génétiques et de marquage-recapture ont conduit à retenir l'hypothèse d'un stock atlantique unique pour la gestion de cette espèce (CICTA 2001). L'évaluation faite à partir des données disponibles suggère que le stock se situe à 40 % de la biomasse associée à la production maximale équilibrée (BPME) et que la mortalité par pêche est environ

4 fois supérieure à celle associée à la production maximale équilibrée (FPME). Cependant, des incertitudes subsistent sur cette évaluation. Les données historiques de prises et d'effort doivent être validées et des recherches poursuivies sur la biologie de cette espèce afin de réduire ces incertitudes. Des mesures de réduction des débarquements ont été adoptées ; elles s'appliquent aux pêches à la palangre et à la senne (CICTA 2001). Les chiffres officiels sur les prises de *M. nigricans* réalisées dans la zone des Petites Antilles représentent 8,6 % de la PME estimée par la CICTA. Se pose donc avec le développement de la pêche associée aux DCP ancrés un problème de répartition des captures entre flottilles. Cette espèce est pour l'essentiel une capture accessoire des palangriers et une espèce cible des pêcheurs artisans pour l'alimentation des marchés locaux.

Les autres espèces évaluées par la CICTA sont peu ou pas exploitées autour des DCP ancrés, dans les eaux des Petites Antilles. Leurs prises pourraient augmenter avec le développement de la pêche associée aux DCP ancrés, c'est la raison pour laquelle il est nécessaire de les prendre en compte dès à présent, afin d'identifier celles qui devraient a priori faire l'objet d'attention particulière.

Les espèces se trouvant dans la zone Atlantique Centre Ouest (FAO 31) et dont les stocks ne sont pas évalués par la CICTA sont en général des espèces qui ont un impact économique moindre à l'échelle de l'Atlantique. Elles sont exploitées le plus souvent par des unités artisanales dont les débarquements sont difficiles à échantillonner. Elles ont par contre un intérêt non négligeable pour les pêcheries artisanales des Petites Antilles, comme l'illustre le Tableau 4. C'est ainsi que *C. hippurus* représenterait plus de 50 % des débarquements de la pêche à la traîne au large et *A. solandri* plus de 20 %; *S. cavalla* et *S. barracuda* représenteraient respectivement 18 et 33 % des débarquements de la traîne côtière à la Martinique. Le bon état de ces stocks est donc important pour les pêcheries côtières des petites îles de la Caraïbe. Des réflexions sont conduites actuellement notamment au niveau FAO/COPACO, afin de mieux prendre en compte ces ressources à une échelle sub-régionale (Walters 2002).

Le thon noir, *T. atlanticus*, est l'une des principales espèces cible de la pêche associée aux DCP ancrés. D'après l'échantillonnage des captures réalisé en Martinique, cette espèce représenterait 15 % en poids des débarquements de cette pêche et constituerait la principale espèce capturée en nombre d'individus avec 56 % des prises. *T. atlanticus* est également fortement représenté dans les prises de la traîne au large ainsi que de la traîne côtière avec respectivement 8 % et 27 % du nombre d'individus. Les prises de juvéniles de cette espèce seraient importantes autour des DCP (75 % du nombre des individus débarqués). La CICTA suggère la prise en compte de la gestion de cette ressource à un niveau sub-régional. L'organisation de celle-ci paraît indispensable, compte tenu du fait que la pêche déjà importante s'intensifiera certainement sur cette ressource.

Le Suivi de la Pêche (Doray et al. 2002)

Une analyse des données statistiques existantes a également été entreprise au cours du groupe de travail de façon à mieux appréhender leur fiabilité et formuler des recommandations sur la nature des données à collecter pour suivre le développement de la pêcheries émergentes DCP.

Les données disponibles sont des données statistiques de production, d'une part et des données relatives à l'effort de pêche qui a permis cette production, d'autre part. Les données de production récoltées concernent la quantité de poissons débarqués par espèce ou groupe d'espèces mais également la distribution en fréquence de taille des espèces capturées. L'effort de pêche est exprimé dans des unités relativement rudimentaires comme le nombre de navires, la sortie de pêche ou la durée de la sortie. Quelques données plus détaillées sur l'effort de pêche ont été collectées aux Antilles françaises incluant la composition de l'équipage, les caractéristiques de l'embarcation et sa motorisation, la consommation de carburant, l'engin de pêche mis en œuvre, la nature du dispositif d'agrégation ou de la concentration exploité, le temps de sortie et de pêche effectif.

Plusieurs systèmes de collecte de données sont appliqués aux Petites Antilles. Ils permettent une couverture plus ou moins complète de la pêcherie et des degrés de précision variables des données collectées. On peut globalement distinguer 4 systèmes de collecte : l'échantillonnage des débarquements (lorsque les moyens sont insuffisants, il peut ne pas être représentatif), l'échantillonnage des débarquements commercialisés en marché officiel, les livres de bord et l'échantillonnage détaillé d'une partie (représentative ou non) des débarquements.

L'échantillonnage d'une petite partie des débarquements s'avère intéressant pour permettre une bonne analyse à micro échelle des évolutions de l'effort de pêche effectif exercé sur les stocks. Il peut fournir également des données permettant d'aborder l'analyse socio-économique de l'activité. Ces échantillonnages détaillés doivent être complétés par des données plus globales sur la pêcherie. La collecte des données sur les engins et techniques utilisés est apparue primordiale pour appréhender les changements rapides de diagramme d'exploitation et les variations de l'effort de pêche effectif exercé sur les différentes cohortes. Les données sur les fréquences de tailles par espèce sont indispensables pour aborder les problématiques de sélectivité qui doivent faire l'objet d'une attention particulière autour des DCP. La consommation de carburant est une unité d'effort de pêche nominal intéressante pour comparer la productivité des différents types de pêche artisanaux de grands poissons pélagiques. La différenciation des types de pêche des grands poissons pélagiques devrait être faite sur différents critères dont la nature du dispositif d'agrégation exploité, car elle influe sur la composition spécifique des prises. Une liste d'espèces à suivre en raison de leur importance, a été établie par le groupe de travail, il s'agit de : thazard bâtard (*Acanthocybium solandri*), thazards barré et tacheté (*Scomberomorus spp*), barracuda (*Sphyraena barracuda*), dorade coryphène (*Coryphaena hippurus*), albacore (*Thunnus albacares*), thon obèse (*Thunnus obesus*), thon blanc (*Thunnus alalunga*), thon rouge (*Thunnus thynnus*), thon noir

(*Thunnus atlanticus*), listao (*Katsuwonus pelamis*), marlin bleu (*Makaira nigricans*), marlin blanc (*Tetrapturus albidus*), espadon (*Xiphias gladius*), requins et balistes (balistidae).

Les Échanges Techniques

Les échanges techniques permettent de favoriser une harmonisation du développement entre les différents pays riverains et ainsi un partage plus équitable des ressources. Le développement de la pêche associée aux DCP nécessite dans une première phase un accompagnement technique et la recherche d'un mode de gestion adapté au contexte et garantissant un bon usage des dispositifs.

La conception des DCP et leur coût sont fonction de leur mode de gestion et des financements disponibles. Différents modèles de DCP existent dans la Caraïbe. Des plans de ces dispositifs ont été présentés lors de la première réunion du groupe de travail (Van Buurt 2002, Gervain et Diaz 2002, Doray et al. 2002, Johnson 2002, Lalla 2002). Afin de répondre aux demandes sans imposer un type de dispositif, un logiciel d'aide à la conception de DCP est en cours de réalisation à l'Ifremer. Une modélisation du comportement des dispositifs en fonction des mouvements de la mer est réalisée. Elle permet d'évaluer les tensions s'exerçant sur les cordages ainsi que la position du flotteur du DCP et son éventuelle immersion en fonction de la houle et des vitesses du courant à différents niveaux de profondeur (Lebeau 2002). Une connaissance des courants marins doit cependant être acquise afin de définir les caractéristiques optimales des DCP dans la zone où ils sont implantés.

Les techniques de pêche mises en œuvre conditionnent le résultat de la pêche autour des DCP. Les techniques de pêche profondes permettent la capture des poissons adultes de grandes tailles, alors qu'en surface ce sont essentiellement de jeunes individus qui se concentrent. L'expérimentation de techniques de pêche autour des DCP est nécessaire afin d'évaluer leur sélectivité spécifique ou par taille. En particulier, il doit être recherché des techniques permettant la capture des adultes sans utilisation des juvéniles comme appât vivant comme cela se pratique actuellement. A cet effet, un inventaire des techniques de pêche utilisées autour des DCP a été présenté au groupe de travail (Prado 2002).

L'outil de pêche gagnerait également à être amélioré grâce à une meilleure adaptation de l'embarcation à cette nouvelle pêche ou à la réalisation d'étude sur les conditions de travail et de sécurité. Certaines phases de la pêche associée aux DCP ancrés semblent en effet augmenter les risques d'accidents. Il s'agit par exemple de la mise à l'eau de DCP surtout à partir de petites embarcations ou de la capture à l'aide de ligne a main ou de l'embarquement de grosses prises (poissons à rostre). La concentration d'embarcations de pêche en activité de traîne sur un espace réduit peut également favoriser les collisions en mer.

La mise en œuvre de programme de formation et de soutien technique pour l'aide au développement durable de pêcheries associées aux DCP ancrés est indispensable pour favoriser le transfert et la valorisation des travaux du groupe de travail et éviter ainsi une propagation non raisonnée de cette nouvelle pêche. Ces

actions doivent, conformément aux recommandations du groupe, favoriser le co-management et une approche responsable de cette nouvelle activité incluant la mise en œuvre, dès le démarrage, des suivis statistiques préconisés.

LES PROBLÉMATIQUES DE RECHERCHE SUR LE DÉVELOPPEMENT DURABLE DE LA PÊCHE ASSOCIÉE AUX DCP ANCRÉS

Le système constitué par la pêche associée aux DCP comprend cinq ensembles qui interagissent. Il s'agit du *milieu marin* dans lequel évoluent naturellement les *grands poissons pélagiques* qui se concentrent autour des *DCP ancrés* où ils sont capturés par les *pêcheurs* qui les vendent aux *consommateurs* (Figure 1). Ce système se trouve dans un système pêche plus large comprenant d'autres types de pêche exploitant les mêmes espèces, d'autres métiers exploitant d'autres zones de pêche et d'autres espèces (ex. exploitation simultanée ou saisonnière des espèces démersales du plateau insulaire) mais aussi d'autres pays. Les questionnements scientifiques se posent pour chaque ensemble et aux intersections (relations) entre ceux-ci.

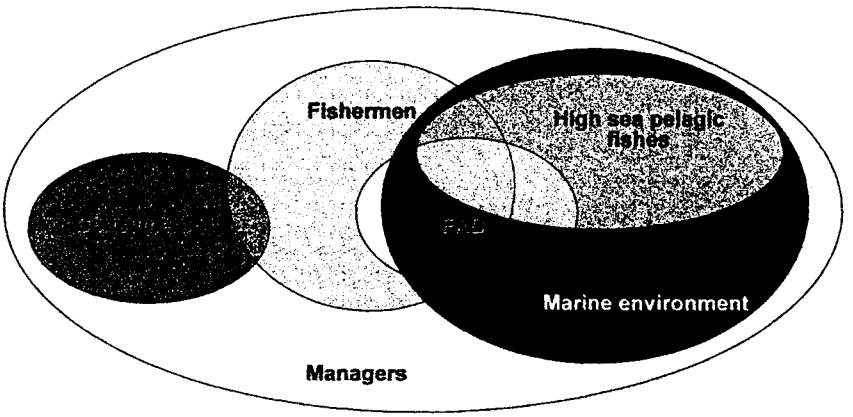

Figure 1. Différents ensembles constituant le système pêche associée aux DCP ancrés

Les questions actuelles des professionnels portent essentiellement sur la connaissance des espèces agrégées autour des DCP ou leur comportement vis à vis des dispositifs. Ils s'interrogent sur les conditions environnementales et les facteurs biologiques favorisant l'exploitation des espèces sous DCP: localisation, déplacements journaliers et saisonniers, comportement alimentaire, etc. L'effet de la position des DCP (près de côte ou au large) sur la nature et l'importance des concentrations est également une préoccupation pour les pêcheurs. Les interactions possibles entre différents DCP sont un sujet souvent évoqué, ainsi qu'entre pêche

autour de DCP et certains autres types de pêche essentiellement côtiers, comme la senne de plage qui capturerait moins de petits thonidés. La réponse à ces questions permettra aux professionnels d'adapter leur outil de production et leur mode d'exploitation afin de mieux exploiter les ressources disponibles autour des DCP.

Au niveau de la pêcherie les questions portent essentiellement sur le renouvellement des ressources autour des DCP et sur l'optimisation socio-économique de l'activité. Les informations apportées par les scientifiques dans ce domaine permettraient aux gestionnaires de mettre en œuvre des outils de régulation:

i) De l'activité de pêche en agissant sur les techniques de pêche et les équipements à employer, les espèces cible (tailles et quantités) ou sur l'accès aux DCP (licence, ...)
ii) Du parc de DCP (nombre, position).

Les DCP sont souvent utilisés pour réduire l'activité de pêche sur les plateaux insulaires étroits des pays des petites Antilles. Il serait par conséquent nécessaire d'évaluer l'impact de la pêche associée aux DCP sur les ressources benthiques et démersales côtières.

LES PROPOSITIONS DE PROGRAMMES SCIENTIFIQUES ET TECHNIQUES

D'ores et déjà des expérimentations de nouveaux DCP et de techniques de pêche sont proposées. Des suivis statistiques devraient également être réalisés dans différents pays au fur et à mesure du développement des DCP. Un logiciel a été réalisé sous Access pour faciliter la saisie et le traitement des données qui seraient collectées en dehors des systèmes statistiques nationaux. Ces suivis permettront de répondre à certaines questions des aménageurs, de mieux cerner le développement de la pêche associée aux DCP ancrés et d'en évaluer ses impacts.

Des propositions de programmes de recherche ont également été faites pour répondre aux premières interrogations. L'Ifremer de Martinique propose de réaliser un programme d'étude de la dynamique des ressources en fonction des paramètres biologiques et environnementaux et des prélèvements de la pêche autour des DCP ancrés. L'observation des concentrations sera faite principalement par acoustique et complétée par des pêches expérimentales autour de trois DCP positionnés à des distances différentes de la côte et sur deux façades maritimes de l'île.

Aucun économiste n'ayant participé à la première réunion du groupe de travail, une réflexion est en cours pour initier des études socio-économiques sur la pêche associée aux DCP ancrés. L'impact social et économique de cette nouvelle pêche est à évaluer dans les différents contextes économiques des pays des Petites Antilles. Une étude socio-économique comparative sur les modes de gestion des DCP est également souhaitable afin d'identifier et évaluer les avantages et inconvénients des différents systèmes de gestion des DCP.

CONCLUSIONS

Alternative à la pêche artisanale sous bois dérivants, le DCP ancré permet aux petites unités d'accéder toute l'année à des ressources de grands poissons pélagiques. L'émergence de cette nouvelle pêche résulte de travaux conduits pendant plusieurs décennies dans la région. La pêche associée aux DCP ancrés répond aujourd'hui aux attentes, ce qui explique son extension et son développement rapide dans la Caraïbe. Une approche pluridisciplinaire a été adoptée au sein du groupe de travail Petites Antilles mis en place sous l'égide de la FAO, afin de répondre à la multitude de problématiques que soulève le développement durable. Lors de sa première réunion le groupe de travail s'est attaché à établir un point de référence sur la pêche des grands poissons pélagiques et sur la pêche associée aux DCP dans les Petites Antilles. L'exploitation des grands poissons pélagiques paraît en plein essor avec un développement de la pêche à la palangre dans les îles du Sud et le développement des DCP, plus marqué dans le Nord des Petites Antilles. Les premiers impacts de cette dernière activité sur les ressources ont été identifiés à partir des données disponibles. Les données statistiques nécessaires au suivi de cette pêche émergente ont été discutées et un logiciel de saisie et traitement des données a été proposé. Un soutien technique est d'ores et déjà proposé pour la recherche de techniques de pêche plus sélectives permettant en particulier de limiter les prises de juvéniles et de mieux exploiter les gros poissons adultes. Une aide à la conception des DCP adaptés au contexte hydrologique régional sera apportée grâce à la rédaction de logiciel de calcul et à l'organisation d'échanges entre pays. Des travaux de recherche sont entrepris sur la biologie et le comportement des poissons agrégés autour des DCP.

Pour avoir le plus de chances d'atteindre l'objectif, il serait souhaitable que les scientifiques de la Caraïbe s'intéressent à ces nouveaux sujets et contribuent par leurs travaux à apporter les connaissances nécessaires au développement durable de la pêche associée aux DCP ancrés. Le groupe de travail Petites Antilles sur le Développement durable de la pêche associée aux DCP ancrés est ouvert à tous ceux qui souhaitent contribuer à ses travaux.

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Retrospective Determination of Trophic Relationships among Pelagic Fishes Associated with *Sargassum* Mats in the Gulf of Mexico

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ABSTRACT

Stable isotopic composition of flora and fauna associated with floating *Sargassum* mats in the NW Gulf of Mexico was measured to identify the origin(s) of organic matter used by pelagic fishes and determine trophic relationships of associated taxa. Stable carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) isotopes were quantified from tissue samples of the primary autotrophs and several other members of the *Sargassum* complex (herbivores through apex predators). Distinct $\delta^{13}C$ values were observed among autotrophs: *Sargassum natans* (-17.1 ± 0.4‰), *Sargassum fluitans* (-16.3 ± 0.2‰), epiflora (-18.3 ± 0.9‰), and phytoplankton (particulate organic matter) (-21.0 ± 0.5‰), suggesting the approach has promise for identifying source(s) of organic matter. In addition, nitrogen stable isotopes indicated that four distinct trophic levels were present in the *Sargassum* complex. Spatial and temporal patterns in $\delta^{13}C$ and $\delta^{15}N$ values were observed for selected autotrophs and heterotrophs; however, signatures were relatively stable over scales investigated. Based upon expected modification due to fractionation, a simple mixing model predicted that the majority of organic matter reaching top-level consumers originates from phytoplankton production. Findings from this study challenge the theory that *Sargassum* is a direct source of energy to pelagic fishes, and therefore the value of this unique complex may be limited to its role as refuge for pelagic fauna.

KEY WORDS: Diet, pelagic fishes, stable isotopes, Gulf of Mexico

Determinación Retrospectiva de las Relaciones Tróficas entre Peces Pelágicos Asociados a las Matas de *Sargassum* en el Golfo de México

La composición isotópica de la flora y fauna asociada con el sargazo flotante en el noroeste del Golfo de México fue medida para identificar el origen ó origines de la materia orgánica utilizada por los peces pelágicos y así determinar la relación

trófica asociadas a estos grupos taxonómicos. Isótopos estables de carbono ($\delta^{13}C$) y nitrógeno ($\delta^{15}N$) fueron cuantificados en muestras de tejidos provenientes de tres autotrofos primarios y de varios otros miembros del complejo de *Sargassum* (herbívoros hasta depredadores superiores). Valores muy distintivos de ($\delta^{13}C$) fueron observados entre los autótrofos: *Sargassum natans* (-17.1 ± 0.4‰), *Sargassum fluitans* (-16.3 ± 0.2‰), algas epifitas (-18.3 ± 0.9‰), and fitoplancton (partículas de materia orgánica) (-21.0 ± 0.5‰), lo que sugiere que este acercamiento es prometedor para la identificación la(s) fuente(s) energéticas. Además, los isótopos estables de nitrógeno indican la presencia de cuatro niveles tróficos dentro del complejo de *Sargassum*. Patrones de variación temporal y espacial en las medidas de los $\delta^{13}C$ y $\delta^{15}N$ fueron observadas en un grupo selecto de autótrofos y heterótrofos; sin embargo, las señales fueron relativamente estables dentro de las escalas estudiadas. Partiendo de modificaciones esperadas por fragmentación, un modelo de mezcla simple predijo que la mayoría de la materia orgánica que llega a los consumidores superiores se origina en la producción del fitoplancton. Este estudio es contrario a la teoría de que el sargazo (*Sargassum*) es la fuente directa de energía para los peces pelágicos, por lo que el valor de este complejo esta limitado al papel de proveedor de refugio para la fauna pelágica.

PALABRAS CLAVES: *Sargassum*, peces pelágicos, Golfo de México, composición isotópica

INTRODUCTION

Sargassum is a free-floating brown alga that is of particular interest to scientists and fishery managers because of its putative value as essential fish habitat. Survey work indicates that several highly valued species utilize *Sargassum* mats (e.g. amberjack, cobia, dolphin, triggerfish, tuna), particularly during early life (e.g. Coston-Clements et al. 1991, Wells and Rooker In press). Due to the complexity this habitat affords, *Sargassum* may enhance early life survival by reducing predation-mediated mortality and enhancing prey availability. If this assumption is valid, survival and recruitment success of certain pelagic fishes will be linked to the distribution and abundance of *Sargassum*, and these mats will play a critical role sustaining marine fisheries throughout the Gulf. In response, the National Oceanic and Atmospheric Administration (NOAA) recently classified *Sargassum* as essential marine fish habitat and recommended that research on ecosystem structure and function of pelagic *Sargassum* was critical for maintaining and enhancing living resources in the Gulf (SAFMC 1998).

In addition to its presumed importance as habitat of pelagic fishes, *Sargassum* is one of the few sources of energy for pelagic food webs, and scientists have speculated that this unique complex (defined here as *Sargassum* + epiphytic algae + heterotrophic bacteria) contributes to primary and secondary production in nearshore and offshore waters (Peres 1982). Preliminary findings from stable isotope and fatty acid analyses support the premise that a portion of organic material

supplied to pelagic fishes originates in the *Sargassum* complex, indicating these mats afford more than "refuge" to associated fauna (Rae 2002). Despite its potential value as both habitat and source of organic matter to consumers, we know very little about the role or significance of this complex. As a result, integrated studies establishing relationships of habitat use, primary productivity, trophodynamics, and biogeochemical cycling are critically needed.

In this study we examine the structure and dynamics of pelagic *Sargassum* in the Gulf of Mexico, and evaluate its ecological value using stable carbon and nitrogen isotopes. Stable isotopes serve as useful tracers of nutritional history since consumer tissues reflect the isotopic composition of prey in a predictable manner (Peterson and Fry 1987). The stable isotope approach is based is based on premise that primary producers take up naturally occurring isotopes of carbon and nitrogen in different ratios, and the isotopic ratio is conserved to some degree by consumers. Stable isotope ratios of carbon ($\delta^{13}C$) provide information on the source(s) of organic matter to heterotrophs while isotope ratios of nitrogen ($\delta^{15}N$) are often used to delineate trophic positions of consumers (Michener and Schell 1994, Hobson and Wassenaar 1999). The aim of the current study is to determine the source(s) of organic matter supporting pelagic fishes and delineate pathways of energy flow through the *Sargassum* complex (from juvenile fishes to apex predators) using stable carbon and nitrogen isotopes. Our working hypothesis is that the *Sargassum* complex plays a significant role in primary and secondary production, and is a primary source of organic matter to pelagic fishes.

METHODS

Natural variation in stable isotope signatures of primary and secondary producers was examined for taxa associated with *Sargassum* in the northwest Gulf of Mexico in 2000. Flora and fauna associated with *Sargassum* were collected in northwest regions of the Gulf (20 - 70 km offshore), and collections were taken over a 4-month period (May - August) to assess temporal variation in stable isotope signatures. Several different sampling gears were used to collect primary producers [(*Sargassum*, epiflora (*Cladophora sp.*), phytoplankton (based on < 40 μm size fractions of particulate organic matter-POM)] and consumers associated with the *Sargassum* mats, including plankton nets and purse seines (Wells and Rooker In press). In addition, large apex predators feeding within or near the *Sargassum* complex (wahoo, dolphin, yellowfin and blackfin tuna) were collected using hook and line. Plants and animals were placed on dry ice in the field and later moved to freezers in the laboratory.

Plant and animal tissues were ground and approximately 0.6 mg of material were used for isotopic determination. Isotopic ratios and percent carbon and nitrogen were determined using a Finnigan MAT DeltaPlus continuous-flow stable isotope mass spectrometer attached to a Carlo Erba elemental analyzer at the University of Texas at Austin Marine Science Institute.

Stable carbon and nitrogen ratios are expressed as $\delta^{13}C$ or $\delta^{15}N$ according to the following equation: $\delta^{13}C$ or $\delta^{15}N$ (‰) = $[R_{sample}/R_{standard})-1 \times 1000$ where R is $^{13}C:^{12}C$ or $^{15}N:^{14}N$. Isotopic values of carbon and nitrogen are reported relative to Peedee belemnite and atmospheric nitrogen standards, respectively. Similar to Herzka and Holt (2000), accuracy of isotopic measurements was verified using a secondary standard reference material (chitin of marine origin, Sigma Aldrich Co., USA, No. C-8908).

RESULTS

Primary Producers

Stable carbon and nitrogen isotope ratios were estimated for *S. fluitans*, *S. natans*, epiflora (*Cladophora* sp.), and POM (Table 1). Distinct $\delta^{13}C$ values (mean ± 1 SE) were observed for each autotroph, and *S. fluitans* (-16.3 ± 0.2‰) *Sargassum natans* (-17.1 ± 0.4‰) were enriched (1-4‰) relative to epiflora (-18.3 ± 0.9‰), and POM (-21.0 ± 0.5‰). Stable nitrogen isotope ratios of primary producers varied between 2.3 and 9.1‰, and $\delta^{15}N$ of both *S. fluitans* (2.8 ± 0.5‰) and *S. natans* (2.3 ± 1.0‰) were depleted by 6 –7‰ compared to POM (8.5 ± 0.8‰) and epiflora (9.1± 0.5‰).

Consumers

Consumers exhibited patterns of enrichment in $\delta^{13}C$ and $\delta^{15}N$ with increasing trophic position (Table 1). $\delta^{13}C$ values were most depleted for juvenile shrimps and crabs (-17.4 to -18.2‰). A shift in $\delta^{13}C$ values was observed for juvenile fishes (blackfin tuna *Thunnus atlanticus*, yellowfin tuna *Thunnus albacares*, gray triggerfish *Balistes capriscus*), and values increased by approximately 1.0 to 1.5‰; however, certain taxa maintained relatively depleted $\delta^{13}C$ values: planehead filefishes *Monacanthus hispidus* (-18.4 ± 0.7‰), greater amberjack *Seriola dumerili* (-18.3± 0.1‰), and sargassumfish *Histrio histrio* (-17.8± 0.8‰). Stable carbon isotope ratios of adult fishes varied (-15.9 to -17.5‰), and the heaviest $\delta^{13}C$ values were observed for wahoo *Acanthocybium solanderia* (-15.9± 0.4‰), blue marlin (-16.8± 0.3‰), and king mackerel (-16.9± 0.4‰). Enrichment of $\delta^{15}N$ also occurred with increasing trophic position and patterns were more consistent than $\delta^{13}C$. Again, the lowest values were observed for juvenile crustaceans: *Leander* sp. (6.5± 0.4‰), *Latreutes* sp. (6.0± 0.7‰), *Portunus* sp. (8.7± 0.7‰). Juvenile fishes ranged from 8.0 to 10.2‰ with $\delta^{15}N$ values over 10.0‰ for blackfin tuna, planehead filefish, and greater amberjack. $\delta^{15}N$ values of tertiary consumers ranged from 11.8 to 15.6‰, and estimated trophic position was highest for king mackerel *Scomberomorus cavalla*, blackfin tuna, and yellowfin tuna ($\delta^{15}N$ ranged: 13.0 to 15.6‰).

Table 1. $d^{13}C$ and $d^{15}N$ values (mean ± 1 SE) of producers and consumers associated with *Sargassum* in the NW Gulf of Mexico. Sample size (N) and stage (P = primary producer, I = intermediate, J = juvenile, A = Adult) are given. Predicted trophic position based on POM $d^{15}N$ value and fractionation of 3‰ per trophic level.

Common Name	Scientific Name	Stage	N	$d^{13}C$	$d^{15}N$	Trophic Position
Macroalgae	**Sargassum natans**	P	7	-17.08±0.41	2.32±1.03	
Macroalgae	*Sargassum fluitans*	P	10	-16.27±0.14	2.82±0.40	
POM		P	10	-21.00±0.49	8.59±0.82	
Epiflora	*Cladophora sp.*	P	6	-18.83±0.85	9.12±0.47	
Shrimp	*Latreutes fucorum*	I	6	-18.01±0.33	5.95±0.74	0.65
Shrimp	*Leander tenuicornis*	I	16	-17.40±0.23	6.50±0.35	0.83
Yellowfin Tuna	*Thunnus albacares*	J	2	-16.60±0.35	7.97±1.19	1.32
Gray Triggerfish	**Balistes capriscus**	J	39	-16.61±0.90	8.41±0.23	1.47
Sargassum Crab	*Portunus sayi*	J	6	-18.17±0.20	8.67±0.66	1.56
Sargassumfish	*Histrio histrio*	J	10	-17.94±0.26	9.00±0.34	1.67
Blue Runner	*Caranx crysos*	J	23	-17.29±0.07	9.53±0.19	1.84
Planehead Filefish	*Monocanthus hispidus*	J	11	-18.36±0.20	10.11±0.37	2.04
Blackfin Tuna	*Thunnus atlanticus*	J	7	-16.42±0.10	10.14±0.58	2.05
Greater Amberjack	*Seriola dumerili*	J	6	-18.34±0.13	10.22±0.44	2.07
Wahoo	*Acanthocybium solandri*	A	5	-15.86±0.38	11.82±0.70	2.61
Dolphinfish	*Coryphaena hippurus*	A	9	-17.07±0.11	12.24±0.27	2.75
Blue Marlin	*Makaira nigricans*	A	3	-16.79±0.27	12.37±1.19	2.79
Lesser Blue Crab	*Callinectes sapidus*	A	7	-17.16±0.64	12.98±0.23	2.99
Greater Amberjack	*Seriola dumerili*	A	6	-17.54±0.11	12.99±0.37	3.00
Yellowfin Tuna	*Thunnus albacares*	A	5	-17.40±0.43	13.08±0.46	3.03
Blackfin Tuna	*Thunnus atlanticus*	A	5	-17.41±0.67	13.90±0.19	3.30
King Mackerel	*Scomberomorus cavalla*	A	6	-16.85±0.35	15.57±0.51	3.86

Temporal Variability

Seasonal variation in $\delta^{13}C$ and $\delta^{15}N$ values was evaluated for *S. fluitans* and two consumers (gray triggerfish, *Balistes capriscus* and blue runner *Caranx crysos*)(Table 2). $\delta^{13}C$ values of *S. fluitans* were similar among months examined; values ranged from -16.2 to -17.8‰ (ANOVA, $p > 0.05$). Monthly differences in $\delta^{13}C$ values of blue runner were negligible, with mean monthly values all within 0.1‰ (ANOVA, $p > 0.05$). Conversely, monthly shifts in $\delta^{13}C$ of gray triggerfish were more apparent (range: -14.5 to –18.8‰) and a significant difference in monthly signatures was detected (ANOVA, $p > 0.05$). Seasonal shifts in $\delta^{15}N$ values of *S. fluitans* ranged from 2.0 - 4.0‰ with values lower during June and July; nevertheless, no seasonal difference in $\delta^{15}N$ was observed. $\delta^{15}N$ values of both consumers were similar across months investigated (ANOVA, $p > 0.05$).

DISCUSSION

Three main autotrophs were present in offshore waters of the Gulf of Mexico (*Sargassum spp.*, epiflora, and phytoplankton), and stable isotopic ratios of these producers were distinct. Based on $\delta^{13}C$ values, *Sargassum* was the most enriched producer while epiflora (*Cladophora* sp.) is more depleted (1 - 2‰). Observed values for both taxa are within the common range of values observed for marine marcoalgae (Michener and Schell 1994, Kaehler et al. 2000), and both are markedly different from our observed value for phytoplankton (-21‰), which is consistent with the estimate provided by other researchers in the Gulf of Mexico (Herzka and Holt 2000). $\delta^{13}C$ values between -18 to -24‰ are typically observed for marine phytoplankton while nearshore and estuarine phytoplankton are often more depleted (-22 to 30‰) (Fry and Sherr 1984,Fogel et al. 1992, Deegan and Garritt 1997). $\delta^{15}N$ of primary producers was also distinct with both species of *Sargassum* being depleted (6–7‰) relative to phytoplankton or epiflora, and the large disparity likely indicates differences in the ability of these plants to fix N_2 from the atmosphere (Peterson and Fry 1987). Marked differences in $\delta^{13}C$ and $\delta^{15}N$ values of producers in this study indicate that the approach has promise for delineating trophic relationships of consumers in the *Sargassum* complex.

Table 2. Intrannual variation in $d^{13}C$ and $d^{15}N$ values (mean ± 1 SE) of selected roducer and consumers associated with *Sargassum* in the NW Gulf of Mexico.

Common Name	Scientific Name	May	June	July	August
Macroalgae	*Sargassum fluitans*	$d^{13}C$ –16.20±0.03 $d^{15}N$ 4.03±0.54	$d^{13}C$ –17.48±0.49 $d^{15}N$ 1.98±0.24	$d^{13}C$ –16.61±0.21 $d^{15}N$ 1.97±0.24	$d^{13}C$ –17.75±0.18 $d^{15}N$ 3.72±0.44
Blue Runner	*Caranx crysos*	N/A N/A	$d^{13}C$ –17.36±0.30 $d^{15}N$ 9.75±0.65	$d^{13}C$ –17.37±0.04 $d^{15}N$ 9.76±0.28	$d^{13}C$ –17.27±0.06 $d^{15}N$ 9.43±0.22
Gray Triggerfish	*Balistes capriscus*	$d^{13}C$ –18.80±0.17 $d^{15}N$ 9.34±0.49	$d^{13}C$ –17.84±0.20 $d^{15}N$ 8.17±0.72	$d^{13}C$ –17.54±0.09 $d^{15}N$ 8.89±0.16	$d^{13}C$ –14.50±2.27 $d^{15}N$ 7.75±0.35

Enrichment of $\delta^{13}C$ and $\delta^{15}N$ was observed with increasing trophic position in the *Sargassum* community and comparable results have been reported in other studies examining multiple trophic levels (e.g. Jennings et al. 1997, Kaekler et al. 2000). Based on $\delta^{13}C$ and $\delta^{15}N$ enrichment of approximately 1.5 ‰ and 3.0 per trophic level, respectively, signatures of consumers exhibited $\delta^{13}C$ and $\delta^{15}N$ values similar to phytoplankton (based on POM signature) and epiflora production. As a consequence, the majority of organic matter reaching top-level consumers appears to originate from phytoplankton and epiflora production. Unfortunately, $\delta^{13}C$ and $\delta^{15}N$ values of both producers overlap, thus limiting our ability distinguish the relative contribution of organic matter provided by each producer to consumers. $\delta^{13}C$ and $\delta^{15}N$ values exhibited by consumers were not consistent with the enrichment of organic matter derived from either *S. natans* or *S. fluitans*. As a consequence, findings from this study challenge the theory that *Sargassum* is a direct source of energy to pelagic fishes, and therefore the value of this unique complex may be limited to its role as refuge of pelagic fauna.

Temporal variation in $\delta^{13}C$ is commonly reported for primary producers and consumers (Wiencke and Fisher 1990, Bouillon et al. 2000, Rolff 2000). Observed trends appear related to changes in environmental conditions and several factors (e.g. CO2 supply, growth rate, temperature) have been shown to modify $\delta^{13}C$ of phytoplankton and macroalgae (Fry 1996). No conspicuous seasonal patterns were observed in this study; however, our seasonal assessment was based on a few taxa (*S. fluitans* and two consumers), and the duration of the study was limited to four months. In addition, recent data suggests that isotopic signatures of phytoplankton in the Gulf of Mexico vary over spatial and temporal scales (J. Rooker, unpublished data). Therefore, precaution must be exercised when interpreting stable isotope data, and detailed information on spatial and temporal variation is needed to fully understand energy flow and trophic relationships within the *Sargassum* complex.

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Growth in a Variable Pelagic Environment: The Impact of Current Rings on Reef Fish Larvae

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ABSTRACT

Previous work has shown that reef fish populations at Barbados, West Indies, are largely self-recruiting and that North Brazil Retroflection Current rings frequently impinge upon the island and surrounding waters. In order to examine the impact of these rings on the growth and survivorship of reef fish larvae, we examined the otolith record of successful recruits to the island. New recruits of the bluehead wrasse, *Thalassoma bifaciatum*, were collected from nearshore reefs every two weeks for 18 months. Examination of the otolith record demonstrated that larvae encountering rings exhibited slower growth rates, leading to longer pelagic larval durations. This was especially true for those larvae encountering a ring early in their larval life. Larval growth rates were directly correlated with the salinity of nearshore waters. However, this generally negative impact of rings on larval growth sometimes can be countered by increased larval retention rates during ring events.

KEY WORDS: Current rings, reef fish larvae, retention rates

CRECIMIENTO EN UN MEDIO AMBIENTE PELAGICO VARIABLE: IMPACCION DE "RINGS" SOBRE LARVAS DE PECES DE CORALES

Estudios anteriores han demostrado que las poblaciones de peces de corales en Barbados, Indias Occidentales, son en gran parte reclutados localmente, y que frequentemente, "rings=anillos" de la retrofleccion de la corriente Nor Brasil inciden sobre la isla y las aguas que la rodean. Para estudiar el impacto de estos "rings" sobre el crecimiento y la supervivencia de larvas de peces de corales, hemos examinado el record de los otolítos de los reclutos exitosos en la isla. Nuevos reclutos de Thalassoma bifaciatum fueron colectados en las arrecifes costera cada dos semanas por 18 meses. Analisis de los otolítos demostró que las larvas que se encontraron con "rings" exhibieron un crecimiento mas lento, resultando en un periodo larval más largo. Esto fue mas aplicable para las larvas que encontraron un eddy temprano durante su vida pelágica.Crecimicuto larval estuvo directamiente corelacionado con la salinidad de las aguos costeras. Sinemborgo, este impacto generalmicute nagotivo de los "rings" en el crecimiento larval puede ser balanceado por el aumiento de las tosas de retention duraule los "rings" eventos.

PALABRAS CLAVES: "rings=anillos", larvas de peces de corales, las tosas de retention

INTRODUCTION

As the easternmost island in the Lesser Antilles, Barbados is geographically isolated from the mainland or other islands (its nearest neighbor is 140 km to the east. Lying within the predominantly northwest flowing Guyana Current, Barbados has well-developed coral reefs that support a diverse fish fauna that, due to the island's upstream location, is considered to be largely self-recruited. Larvae settling to island reefs are likely those that spent their pelagic larval period within surrounding waters.

Although the island is situated within a generally uni-directional flow, the waters flushing by the island are not of uniform consistency. This region is regularly dominated by significant, oceanographically distinct features: large anti-cyclonic rings shed at the retroflection of the North Equatorial Counter Current (NECC) and the North Brazil Current (NBC), which move to the northwest along the South American coast. Rings entrain water low salinity water from the Amazon River and translate toward the Lesser Antilles. These low-salinity rings typically encounter the Barbados-Tobago ridge, veer to the north slightly, and pass directly by or around Barbados. These low salinity features frequently impact the pelagic environment surrounding Barbados. Data from satellite altimetry data and temperature-salinity recorders moored off the west coast of Barbados reveal that NBC rings may pass Barbados four to five times each year.

NBC rings potentially influence larval fishes in nearshore waters by affecting their transport or by influencing their growth and survivorship. This presentation will focus on the later. Our working null hypothesis is that growth rates of reef fish larvae that encounter a current ring during some portion of their pelagic larval period will not differ from those that do not experience a current ring.

APPROACH AND METHODS

To examine the effect of major oceanographic features such as the NBC rings on the growth of pelagic larvae and subsequent recruitment strength, juvenile bluehead wrasse, *Thalassoma bifasciatum*, were censused and collected biweekly along the west coast of Barbados for 20 months (April 1996-November 1997). *Thalassoma bifasciatum* was selected as the focal species because it is common throughout the Caribbean and previous studies have documented many aspects of its life history. For each census at each of three sites, two divers censused new recruits (juveniles < 15 mm SL) in 10 randomly placed 1 X 5 m quadrats. To obtain an accurate age as well as a record of larval growth, recruits were collected by divers using hand nets and the anesthetic Quinaldine. Specimens were stored in 95% ethanol until they could be dissected in the laboratory.

The otoliths (ear bones) of *Thalassoma bifasciatum* have an internal structure that enables calculation of an individual's age, timing of settlement, daily growth

rates, and relative size at different ages. Previous studies have confirmed that otolith increments in *T. bifasciatum* are deposited daily and that the transition from the pelagic larval stage to the benthic juvenile, including the metamorphic period, is recorded in the otoliths. Studies have shown that the relationship between fish length and otolith length is strongly correlated in *T. bifasciatum*.

To identify the age structure of new recruits, individuals were selected randomly from each bi-weekly collection for otolith analysis. Standard procedures were used to dissect, read, and interpret the sagittal otoliths. All increments were identified as larval, metamorphic or juvenile and enumerated along the longest radius from the otolith core to the edge. From these data, we obtained measures of larval duration, juvenile age (post-emergence age), timing of settlement, and otolith growth rates (increment widths) for the larval and juvenile periods.

Measurements of the strength and timing of settlement were combined to create a settlement record for the entire 20-month period. This record then was compared to the timing of NBC ring impingement at Barbados. The presence of NBC rings in the vicinity of Barbados was determined from hydrographic records from a CT sensor moored off the south coast of the island. A ring was considered to be present on days when salinities of the 25 m depth bin were less than 34.5 psu.

In order to examine specific growth rates of larvae in the presence or absence of NBC rings, individual otolith records were examined on a daily basis. Mean daily otolith increment widths during the larval period and mean pelagic larval duration were compared for fishes that had encountered a ring for at least seven days during the first half of their larval period (during day 1-20), and those that encountered a ring during days 21-40, to those that encountered no ring at any time during their larval period.

Temperature has the potential to influence larval growth, so to tease apart this potential effect from the influence of NBC rings, we plotted mean larval otolith growth against the mean water temperature during each time period. We similarly examined larval otolith growth versus mean salinity during each event. Temperature and salinity values were obtained for the 25 m depth bin from the CT sensor moored off the south coast of Barbados.

RESULTS AND DISCUSSION

Fishes that encountered a ring during their larval period grew more slowly than did fishes that did not encounter a ring. These growth differences resulted in a difference in the length of the larval period. Fishes that encountered a ring during their larval period spent longer in the plankton. This theoretically should result in lower survivorship. There was no correlation between mean increment width (proxy for larval growth) and water temperature, but otolith growth was directly correlated with salinity.

Examination of the raw settlement recruitment record demonstrates that the low growth associated with rings does not always translate into low recruitment events. Occasionally there are large recruitment events immediately following the passage

of a NBC ring. This suggests that the generally negative effect of NBC rings on larval fish growth can be countered by changes in larval transport. Recent work has shown that depending on the specific angle of approach, the impingement of NBC rings can result in an increase in larval retention at Barbados. Recruitment events are likely the result of successful larval growth and survivorship as well as successful larval retention or transport events.

Biological Surveys to Assess The Relative Abundance and Distribution of Coastal Sharks and Teleosts of the Mexican Gulf of Mexico; 1997, 1998, 2001, and 2002

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ABSTRACT

In efforts to maintain viable shark populations, the National Marine Fisheries Service (NMFS, an agency of NOAA) developed the 1993 Fisheries Management Plan (FMP) for Sharks of the Atlantic Ocean (NOAA 1993). This plan stresses the need for monitoring and assessment of shark populations to determine the efficacy of FMP measures. NMFS Mississippi Laboratories (MSL) instituted field surveys (beginning 1995), with support from the NMFS Highly Migratory Species Division, to assess distribution and relative abundance of coastal sharks in the western North Atlantic Ocean and Gulf of Mexico. In order to assess the extent of shared shark and teleost populations between Mexico and the U. S. within the western North Atlantic Ocean and the Gulf of Mexico, NMFS and the Instituto Nacional de la Pesca (INP) of Mexico instituted a cooperative bottom longline research initiative that operates under auspices of MEXUS-Gulf. The first of a series of cooperative projects was conducted during summer of 1997, with subsequent projects during 1998, 2001 and 2002 [Grace 1997, 1998, 2001 and 2002]. Scientists representing INP, NMFS and several Mexican and U. S. based institutions and universities participated. Gear, survey design and project objectives for the Mexico based effort was consistent with NMFS U. S. based surveys. One hundred and sixty five bottom longline stations were completed during 51 survey days. Captures include 97 sharks, 57 other elasmobranches and 248 teleosts. The MEXUS-Gulf bottom longline surveys have been successful for developing a useful fisheries independent data base.

KEY WORDS: Longline, MEXUS-Gulf, Survey

Estudios Biológicos para Evaluar la Abundancia Relativa y Distribución de Tiburones Costeros y Teleósteos del Golfo de México, 1997, 1998, 2001 Y 2002

En un esfuerzo para mantener viables las poblaciones de tiburón en aguas de los Estado Unidos, el Servicio Nacional de Pesquerías Marinas de los Estados Unidos (the National Marine Fisheries Service, NMFS) implemento a partir de 1993 un Plan de Manejo Pesquero para los Tiburones del Océano Atlántico. Para evaluar la eficacia del plan, el Laboratorio de la NMFS en Mississippi condujo una serie de cruceros de prospección (1995 - 2002), para evaluar la distribución y abundancia relativa de tiburones costeros en la costa occidental de los E.U. del Océano Atlántico Norte y del Golfo de México. Para extender la cobertura de los estudios para varias especies del tiburón, la NMFS y el Instituto Nacional del la Pesca (INP) iniciaron una serie de cruceros de investigación conjuntos (1997, 1998, 2001 y 2002) dentro de las aguas territoriales mexicanas del Golfo de México. El objetivo fundamental del proyecto del Golfo de Mexico fue desarrollar una base de datos de pesquerías independiente para el manejo de las diferentes especies de tiburón (tiburones costeros grandes y pequeños) y teleósteos de importancia comercial (huachinangos y meros). Los objetivos secundarios incluyeron estudios de marcado y muestreo biológico para el conocimiento de las historias de vida de las principales especies.. En cuatro cruceros conjuntos de investigación se realizaron 165 estaciones de palangre de fondo durante 51 días del estudio. Las capturas incluyeron 97 tiburones (11 especies), 57 de otros elasmobranquios (3 especies) y 248 teleósteos.

PALABRAS CLAVES: MEXUS- Golfo de México, estudios biológico,

INTRODUCTION

Use of longline gear to survey fish populations has historical precedents for fisheries surveys. However, some longline surveys lacked sound statistical survey designs or surveys were directed toward a particular species of interest or problem, therefore, there are limitations for the usefulness of historical longline data for current fisheries management purposes. In order to compare fish population trends it is advantageous for biological surveys to be designed and conducted in a uniform manor. This is especially true when trying to assess several different species occupying dissimilar habitats along broad geographical areas. In response to the need for developing a fisheries independent data base that would be useful for determining the efficacy of the 1993 Shark FMP, NMFS MSL instituted bottom longline studies designed to satisfy 5 important assessment principles: stock wide survey, synopticity, well-defined sampling universe, controlling biases and useful precision (Grace and Henwood 1997). During 1999 survey objectives were

expanded to include teleosts of U. S. management interests (e.g., red snapper, *Lutjanus campechanus*).

MATERIALS AND METHODS

The timing for the longline surveys was based on research vessel availability, and even though it is known that shark and finfish catch rates by species may vary seasonally no adjustment for seasonal variations was possible. Type and configuration of fishing gear was based on gear used during NMFS MSL surveys. Monofilament bottom longline gear was selected for the longline projects because it is the preferred gear of the commercial fishing sector, and because comparison of monofilament longline gear versus rope or "Yankee gear" (Branstetter and Musick 1994) indicated that monofilament gear is significantly more efficient. A hydraulic longline reel was used for setting and retrieving the mainline. Radar reflecting buoys were used to mark longline locations. The mainline was weighted (10 kg weights) at the start buoy, midset and end buoy; additional weights were added (between start and midset, between midset and end) for sites in areas of strong currents. Longline gear components included; 1.0 nautical mile of 426 kg (1,000 lb) test monofilament mainline, #3/0 J hooks (1997 and 1998) or #15/0 circle hooks (2001 and 2002) baited with Atlantic mackerel (*Scomber scombrus.* 1997 and 1998 surveys) or Atlantic bonito *(Sarda sarda*, 2001 and 2002 surveys), 3.66 m (12 ft) gangions (leaders) of 332 kg (730 lb) test monofilament. Longline gear (100 hooks) was fished for one hour determined as the time duration between deployment of the last longline set buoy to retrieval of the first buoy to begin haulback. Longline gear was retrieved in the direction of the longline set.

Survey vessels used to conduct the bottom longline surveys were the NOAA Ship OREGON II (51.5 m length) and the Mexican RV ONJUKU (35.0 m length). With minor modifications, these survey vessels proved effective for conducting bottom longline operations. Survey data recorded to characterize gear and catch included gear specifics, environmental and biological data. Biological data for sharks and teleosts included identifications (genus and species), length (mm), weight (kg), sex and mortality. Sea surface to sea bottom environmental profiles were collected at each survey site with a CTD.

SURVEY DESIGN

All longline sites during all surveys were selected at random. The first coordinate for random longline site locations was a randomly selected latitude or longitude (dependent on the perpendicular direction of bathymetric contours), with the second coordinate a random distance from the minimum survey depth of 9 m (5 fm). Sampling density for each survey was a function of available sea days. Longline sites were occupied in the most time efficient manner possible and were not designated day or night sites prior to the survey. Longline locations were allocated

within contiguous 60 n. mile sampling zones to assure allocation throughout survey areas without gaps in coverage.

During 1997 statistical zones were allocated three longline sites with additional longline sites randomly selected or selected midpoint between extreme distances. During 1998, 2001 and 2002 allocation of randomly selected surveys sites was by proportional allocation within 60 n. mile sampling zones based on continental shelf area; sampling zones in areas with a broad continental shelf were allocated more survey sites than sampling zones with a narrow continental shelf. The depth range for longline sites during 1997 and 1998 was 9 m (5 fm) - 55 m (30 fm); during 2001 and 2002 the depth range was 9 m - 366 m (200 fm). During 2001 and 2002, in addition to the randomly selected sites designated by proportional allocation, 2 longline sites were selected at random (not by proportional allocation) between 183 m (100 fm) - 366 m (200 fm). The survey area for the 2001 and 2002 was defined by delineating survey zones along areas of highest catch rates for sharks and teleosts during the 1998 survey. Most bottom longline sets were conducted parallel to depth contours unless survey conditions (i.e. oceanic currents, sea surface conditions) necessitated a different orientation.

RESULTS

During 51 sea days, 165 bottom longline sets were completed (Figure 1 and Table 1). Shark captures constituted 24.1% of the total catch, other elasmobranchs were 14.2% and teleosts were 61.7% (Table 2).

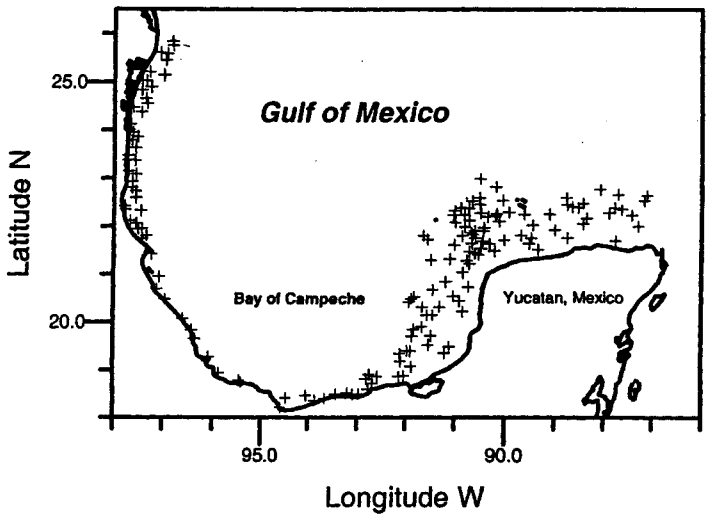

Figure 1. Bottom longline locations for MEXUS- Gulf bottom longline surveys, 1997, 1998, 2001, and 2002.

Table 1. Survey descriptions, MEXUS - Gulf bottom longline surveys, 1997, 1998, 2001 and 2002.

Survey and date	Location	Depth range (m)	Effort (# sets)	Random station selection description
OT-97-04 (227), 8/9 – 8/24/97	U.S. - Mexico boundary to Cabo Rojo, Mexico	9 m - 55 m	25	Longline sites allocated within samplings zones, #3/0 J hooks.
OT-98-02 (231), 7/24 – 8/21/98	Entire Mexican Gulf of Mexico coast	9 m - 55 m	110	Longline sites selected by proportional allocation; #3/0 J hooks.
ONJUKU 6/1 – 6/20/01	Eastern Bay of Campeche	9 m – 366 m	38	Longline sites selected by proportional allocation; #15/0 circle hooks.
ONJUKU 6/28 – 7/5/02	Eastern Bay of Campeche	9 m – 366 m	29	Longline sites selected by proportional allocation; #15/0 circle hooks.

Twelve shark species were captured (97 captures, Table 2) with the most frequently captured shark the Atlantic sharpnose shark (62 captures) followed by the blacknose shark (10 captures). Sixty-eight sharks were tagged and released. Mortality for shark captures was 12.0%. Three species of other elasmobranchs (rays) were captured with the southern stingray the most frequently captured (53 captures).

Twenty-six teleost species were captured (248 captures, Table 2). The most frequently captured teleost was the red grouper (129 captures) followed by the hardhead catfish (24 captures) and the mutton snapper (13 captures). Mortality for teleosts was 2.0 %.

`DISCUSSION AND CONCLUSION

Seasonality may be the primary factor that contributes most to potential sources of survey bias concerning catch per unit effort (CPUE) for sharks. NMFS tag return information indicates for some sharks (i.e., blacktip sharks) there is a spring shark migration north from the Mexican Gulf of Mexico to the U. S. Gulf of Mexico, with a return migration to Mexico during fall [Kohler 2002]. If there is a substantial U.S. - Mexico Gulf of Mexico shark migration then it is possible the summer time frame for the MEXUS-Gulf surveys may reflect a reduced relative abundance for sharks as compared with relative abundance during fall or winter. Though a migration event may be plausible for some sharks, species like the Atlantic sharpnose shark (the most frequently captured during the surveys) and the blacknose shark are not documented to be long-distance migrators. Conducting future surveys during other seasons is a possibility provided research vessel sea days are available.

Table 2. Elasmobranch and teleosts captures for MEXUS-Gulf bottom longline surveys, 1997, 1998, 2001 and 2002.

Genus and species, common name	# Captured	Mean Length, TL	Size Range, TL
Carcharhinus acronotus, blacknose shark	10	881 mm	785 – 980 mm
Carcharhinus falciformis, silky shark	5	924 mm	805 – 1235 mm
Carcharhinus leucas, bull shark	1	2500 mm	
Carcharhinus limbatus, blacktip shark	4	825 mm	730 – 872 mm
Carcharhinus plumbeus, sandbar shark	1	1400 mm	
Carcharhinus isodon, finetooth shark	1	1168 mm	
Rhizoprionodon terraenovae, Atlantic sharpnose shark	62	878 mm	603 – 1025 mm
Galeocerdo cuvier, tiger shark	1	870 mm	
Mustelus canis, smooth dogfish	5	991 mm	700 – 1200 mm
Sphyrna lewini, scalloped hammerhead	3	1343 mm	1012 – 2000 mm
Sphyrna tiburo, bonnethead	3	938 mm	900 – 1000 mm
Ginglymostoma cirratum, nurse shark	1	2500 mm	
Dasyatis sp., stingrays not identified to species	3	1017 mm	800 – 1250 mm, disk width measurement
Dasyatis americana, southern stingray	53	848 mm	485 – 2000 mm, disk width measurement
Aetobatis narinari, spotted eagle ray	1	1520 mm	disk width measurement
Synodus foetens, inshore lizardfish	1	383 mm	
Arius felis, hardhead catfish	24	312 mm	262 – 371 mm
Bagre marinus, gafftopsail catfish	8	472 mm	361 – 555 mm
Gymnothorax funebris, green moray	5	1039 mm	864 – 1450mm
Gymnothorax moringa, spotted moray	9	940 mm	470 – 1509 mm

Table 2 continued.

Genus and species, common name	# Captured	Mean Length, TL	Size Range TL
Gymnothorax nigromarginatus, blackedge moray	2	718 mm	670 – 765 mm
Gymnothorax saxicola, honeycomb moray	2	610 mm	580 – 640 mm
Ophichthus rex, king snake eel	10	1205 mm	1000 – 1750 mm
Prionotus tribulus, bighead searobin	2	296 mm	288 – 305 mm
Diplectrum formosum, sand perch	2	250 mm	230 – 270 mm
Epinephelus nigritus, Warsaw grouper	1	844 mm	
Epinephelus adscensionis, rock hind	1	365 mm	
Epinephelus flavolimbatus, yellowedge grouper	9	685 mm	500 – 965 mm
Epinephelus guttatus, red hind	2	389 mm	373 – 405 mm
Epinephelus morio, red grouper	129	495 mm	285 – 880 mm
Mycteroperca bonaci, black grouper	6	912 mm	530 – 1203 mm
Mycteroperca venosa, yellowfin grouper	1	660 mm	
Remora remora, remora	1	700 mm	fork length measurement
Rachycentron canadum, cobia	3	1022 mm	735 – 1260 mm
Etelis oculatus, queen snapper	1	750 mm	
Lutjanus analis, mutton snapper	13	727 mm	608 – 848 mm
Lutjanus campechanus, red snapper	5	628 mm	487 – 840 mm
Lutjanus cyanopterus, cubera snapper	2	1096 mm	1080 – 1111 mm
Lutjanus griseus, gray snapper	3	508 mm	410 – 595 mm
Menticirrhus americanus, southern kingfish	1	326 mm	
Calamus calamus, saucereye porgy	2	618 mm	602 – 635 mm
Calamus nodosus, knobbed porgy	1	677 mm	
Trichiuridae, snake mackerel not identified to species	1	600 mm	
Batrachoididae, toadfish not identified to species	1	400 mm	

The MEXUS-Gulf surveys were not designed to assess a specific shark or teleost species. The emphasis for the surveys has been to provide data useful for developing a fisheries independent time series and to provide tagging and biological sampling opportunities. Due to high catch variability between surveys and relatively low catch rates for the multi-species complex encountered by the longline gear it would be difficult to establish any meaningful conclusions concerning relative abundance or distribution by species. However, as the time series continues to develop through future surveys the subsequent data should help define important biological profiles for several species.

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A Comparison of Age Estimates from Sagittal Otoliths and the First Dorsal Spine for Cobia (*Rachycentron canadum*) from the Northcentral Gulf of Mexico

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ABSTRACT

Cobia, *Rachycentron canadum*, are migratory, coastal pelagic fish that are distributed worldwide in tropical and subtropical seas, except for the eastern Pacific, and are abundant in the Gulf of Mexico. Previous research established that cobia from the northern Gulf of Mexico could be aged using sectioned sagittal otoliths, however the collection of sagittae from cobia typically requires removal of the entire head for subsequent otolith extraction and sectioning in the laboratory, generally a difficult and time-consuming process. In this study, first dorsal spines and whole sagittal otoliths were assessed as ageing structures for cobia collected from the northcentral Gulf recreational fishery. The accuracy of age estimates, based on counts of opaque bands on whole sagitta and translucent bands on dorsal spine sections, was determined by comparison with age data from sectioned sagittae from the same fish. Spine sections exhibited concentric translucent bands for most fish, but outer bands were often closely spaced and difficult to interpret. Vascular erosion of the central core of spines from some large fish obscured the inner (early) growth bands which required their "replacement". Vague bands were typical of many whole otoliths which led to numerous discrepancies in band counts among readers. Agreement among three readers for the number of bands on sectioned otoliths, whole otoliths and sectioned spines was 100 %, 86.1 % and 97.7 %, respectively. Age agreement between sectioned otoliths and sectioned spines (61.9 %) and sectioned otoliths and whole otoliths (61.3 %) was generally not satisfactory for any age category, and some whole otoliths and spines over- and under-estimated ages by as much as two years. Under- and over-estimations of age obtained from whole sagittae and sectioned spines have obvious implications in estimating mortalities for use in fisheries management. Although dorsal spines were far more practical in terms of ease of collection, they do not represent a viable alternative for deriving age estimates for cobia. This study demonstrated that it is essential to section sagittal otoliths from cobia in order to obtain an accurate age.

KEY WORDS: *Rachycentron canadum*, age, otoliths, spines

Comparacion de la Edad Estimada con Otolitos Sagitales y la Primera Espina Dorsal en Cobia (*Rachycentron canadum*) en el Norte del Golfo de Mejico

Cobia, *Rachycentron canadum*, es un pez costero pelágico y migratorio distribuido en los mares tropicales y subtropicales de todo el mundo, con excepción del Pacífico oriental. Previas investigaciónes establecieron que la edad de la cobia capturada recreacionalmente en el norte del Golfo de Mejico podría ser estimada con exactitud utilizando otolitos sagitales seccionados. La colección de sagittae en la cobia cosechada por los pescadores típicamente requiere la remoción de la cabeza entera para extraer el otolito y luego su disección en el laboratorio, a menudo un proceso difícil que consume mucho tiempo. Realizamos una comparación entre las edades estimadas utilizando los otolitos sagitales enteros y seccionados y las primeras espinas dorsales seccionadas. Los sagittae enteros presentaron las zonas del crecimiento asumidas como acontecimientos anuales, y las secciones de la espina dorsal revelaron una sucesión de bandas opacas y translúcidas alternas, aunque no validas como piezas anuales, fueron utilizadas en la valoracion de la edad. En algunos peces grandes, la erosión vascular de la base central de las espinas dorsales obscureció las bandas (tempranas) internas de crecimiento lo que requirio su reemplazo estadístico. La exactitud de la edad estimada con las lecturas de la sagitta entera y de la espina dorsal seccionada fue comprobada comparando esos datos con los obtenidos con los sagittae seccionados de los mismos peces. Aunque es más difícil colectar, los sagittae proporcionan una información más detallada de la edad, sin embargo, las espinas dorsales son más prácticas en términos de la facilidad de colección y pueden representar una alternativa para derivar las estimaciones de edad para la cobia.

PALABRAS CLAVES: Cobia, *Rachycentron canadum*, edad estimada, otolitos

INTRODUCTION

Cobia, *Rachycentron canadum*, is a migratory, coastal pelagic fish that occurs worldwide in tropical and subtropical seas, except for the eastern Pacific, and is most common in the west-central Atlantic region along the southern U.S. coast, including the Gulf of Mexico (Gulf) (Shaffer and Nakamura 1989). Cobia are rapid-growing fish with moderate life spans, having been aged to eleven years for females and nine years for males in the northern Gulf (Franks et al. 1999). This species appears to follow an annual migratory pattern in Gulf waters, typically over-wintering in south Florida followed by a northward migration along western Florida in early spring (Hendon and Franks 1999). From spring through fall, cobia range off northwest Florida to southwest Louisiana, returning to south Florida waters in late fall. Some fish in the northern Gulf reportedly do not follow this migratory pattern and over-

winter in the northern Gulf in depths of 100 to 125 meters deep (Howse et al. 1992).

Cobia is highly sought by anglers in the northern Gulf, where the majority of U. S. cobia recreational landings occur (Shaffer and Nakamura 1989). From 1997 to 2000, recreational landings of cobia from western Florida to Louisiana averaged over 500,000 kg per year (NMFS pers. comm.). Although a commercial fishery for this species also exists in this region, it is minor (85,000 kg per year over the same time period) compared to its recreational counterpart, and no commercial fishery exists in Mississippi where it is illegal to sell cobia caught in state waters or landed in the state (MDMR, 2001). Because of its popularity, cobia is managed in both state and federal waters in the U.S. Gulf. Both the recreational and commercial cobia fisheries are regulated by a 33-inch (837 mm) fork length (FL) minimum size limit and a two fish/person daily bag (possession) limit in federal waters (GMFMC, 2001). Each of the Gulf states has implemented similar restrictions in its state waters.

Because cobia are sought by a wide range of user groups, this fishery in the northern Gulf must be properly monitored to ensure the health of the stock, and data on the age structure of the current population are needed to adequately assess the status of the fishery. Previous research established that cobia from the northern Gulf recreational fishery could be aged using sectioned sagittal otoliths (Franks et al. 1999). The collection of sagittae from cobia typically requires removal of the entire head for subsequent otolith extraction and sectioning in the laboratory, generally a difficult and time-consuming process. As an alternative to this technique, recent studies have successfully utilized dorsal and anal spines to estimate age in several fishery species, including albacore tuna (Gonzalez-Garces and Farina-Perez 1983), little tunny (Cayre and Diouf 1983), gray triggerfish (Bernardes 2002), swordfish (Tserpes and Tsimenides 1995) and wahoo (Franks et al. 2000).

The objective of this research was to assess the first dorsal spine, a more readily-accessible bony part, from cobia as an ageing structure by comparing age estimates from analyses of sectioned first dorsal spines and sectioned sagittal otoliths. In addition, the accuracy of age estimates obtained from whole sagittae were evaluated by comparison with ages from sectioned sagittal otoliths. Although sectioned sagittal otoliths typically represent the ideal ageing structure, dorsal spines are more practical in terms of ease of collection, particularly for researchers conducting fishery-dependent (dock-side) surveys, and may represent an alternative for deriving age estimates for cobia.

MATERIALS AND METHODS

Cobia were obtained from the northern Gulf recreational fishery, primarily during fishing tournaments, from September 1997 to March 2000. Date of capture, fork length (FL, mm) and sex were recorded for each specimen sampled. The head and first dorsal fin spine were removed from each fish, stored on ice and returned to the laboratory for processing.

Laboratory Preparation and Age Determination

Sagittal otoliths were extracted from cobia heads and, along with first dorsal spines, were thoroughly cleaned of excess tissue and air-dried. Whole otoliths and dorsal spines were weighed to the nearest 0.001 g, and dorsal spines were measured from the condyle base to the tip of the spine to the nearest 0.1 mm. The first dorsal spine and one otolith from each fish were embedded in an epoxy resin and sectioned transversely at 0.3 mm with a Beuhler Isomet low-speed saw. Otoliths were sectioned through the core along a transverse, dorsoventral plane, and spines were cut (on average) at 30 % of their length, extending from the condyle base to the tip.

Sectioned spines and sectioned otoliths were viewed under a dissecting microscope (20 - 40x magnification) using transmitted light. Whole otoliths were viewed on a black background with direct light. The authors were familiar with reading opaque bands on sectioned sagittae (Franks et al. 1999), however we carried out an initial training exercise in the reading of whole otoliths and sectioned spines by making counts on a small subsample of those structures and comparing counts with ages from sectioned otoliths. Subsequent readings were carried out "blind", i.e. the readers did not know the size or sex of the cobia. By using marginal-increment analysis, Franks et al. (1999) determined that age in years for cobia sampled from the northern Gulf was equal to the number of opaque bands observed on sectioned sagittal otoliths. For purposes of this research, age derived from sectioned otoliths was considered to be the "actual age" of the fish.

Because it was beyond the scope of this study to validate markings on sectioned spines as true annuli, a "presumed age" was assigned to each dorsal spine by counting the number of distinctive, concentric translucent bands that appeared to encircle most of the spine's circumference. In some instances, particularly for larger fish, vascular erosion of the central core of spines destroyed the inner (early) growth bands which required the readers to estimate ("replace") the number of bands concealed in this region to arrive at a "corrected age". Therefore, using an image analysis system, measurements of the distance from the spine's core to early growth bands (1st, 2nd and 3rd) observed on legible sections from small spines (young fish) provided guidance for estimating the approximate distance of obscured early growth bands from the spine's core on centrally eroded areas of large spines (older fish). Also, visual comparison of sections from larger dorsal spines with those from smaller spines exhibiting obvious early growth bands provided additional guidance for the "replacement" of missing bands. Examination of other dorsal spine sections from the same fish frequently resolved discrepancies. Spine radius (the straight line distance from the estimated core of the spine section to the right margin of the section) was also measured for legible spine sections.

Age estimates using whole otoliths were made by a combination of:

i) Counting the number of translucent bands on the distal side of the rostrum,
ii) Counting the number of "ridges" along the distal ventral portion of the structure, and
iii) Counting the number of "steps" along the sulcal groove (proximal side).

Based on the findings of Franks et al. (1999) for sectioned cobia sagittae,

opaque growth zones observed on whole sagittae were assumed to represent annual marks.

Independent readings of the ageing structures were made twice by each author, and when disagreement occurred among readings, a mutual assessment of the ageing structure was conducted. If agreement could then not be reached, questionable structures were disregarded.

Statistical Analyses

The relationship between somatic growth and growth of the first dorsal spine was determined by modeling FL with spine length, spine weight and spine radius for each sex using linear regression analysis. To test for a positive correlation between age and spine growth, actual age was compared to spine length, weight and radius with linear regression. Additionally, mean ranks of age estimates were compared between structures with the Friedman test, a nonparametric equivalent to repeated measures analysis of variance (SPSS 1999), to test for statistical difference and to determine whether mean age estimates were over- or under-estimated in relation to actual age. For all analyses, statistical significance was considered at $p < 0.05$, and tests were performed with SPSS for Windows, 10.1 (SPSS 1999).

RESULTS

Sample Collections and Reader Agreement

The first dorsal spine and sagittal otoliths were collected from 46 fish, ranging in size from 890 to 1,651 mm FL. Whole otoliths were available for 38 of the 46 fish, ranging in size from 890 to 1,270 mm. The first dorsal spine and whole otolith were unreadable for one fish, which was removed from further analyses, yielding a total sample size of 45 for sectioned otoliths and spines and 37 for whole otoliths. Fish used in this study were sampled during spring months (March-May; n = 22) and in February (n = 10) and September (n = 13). Females (n = 32) were more abundant than males, by about a 2:1 ratio.

Initial reader agreement on age estimates was 80.4 % for sectioned otoliths, 51.2 % for sectioned spines and 44.4 % for whole otoliths. After mutual assessment by the authors, agreement increased for sectioned otoliths to 100 %, sectioned dorsal spines to 97.7 %, and whole otoliths to 86.1 %. Three sectioned dorsal spines (6.5 %) and two whole otoliths (5.3 %) were deemed unreadable by the authors, and mutual agreement on the number of bands for one sectioned spine and five whole otoliths could not be reached, resulting in a final sample size of 46 sectioned otoliths, 31 whole otoliths and 42 sectioned dorsal spines.

Examples of Ageing Structures

Although all ageing structures considered acceptable by all three readers for deriving age estimates were not of ideal quality, Figures 1, 2 and 3 show examples of the more legible structures (images not shown at same scale). The cross-section

of a first dorsal spine from an age-2 cobia is shown in Figure 1a. The spine's core region and two translucent bands are identified. Spine sections from small fish such as this were used as a general guide to assist readers in locating (replacing) obscured early growth bands in the core of spines from larger fish, such as that from an age-4, 1,150 mm cobia (Figure 1b). Figure 2 identifies the opaque bands (annuli) on a thin-sectioned sagitta and the translucent bands on a whole sagitta and sectioned dorsal spine from an age-4, 1,150 mm FL female cobia. Band counts agreed among all structures. Figure 3 identifies the bands on a sectioned sagitta and the evident bands on a sectioned dorsal spine from a large cobia (1,651 mm FL). Based on band counts from the sectioned otolith, three inner bands are obscured in the core of the sectioned spine. Although there was complete reader agreement for band counts on each structure in Figure 3 (spine band count = 8; sectioned otolith band count = 9), spine age was under-estimated by one year.

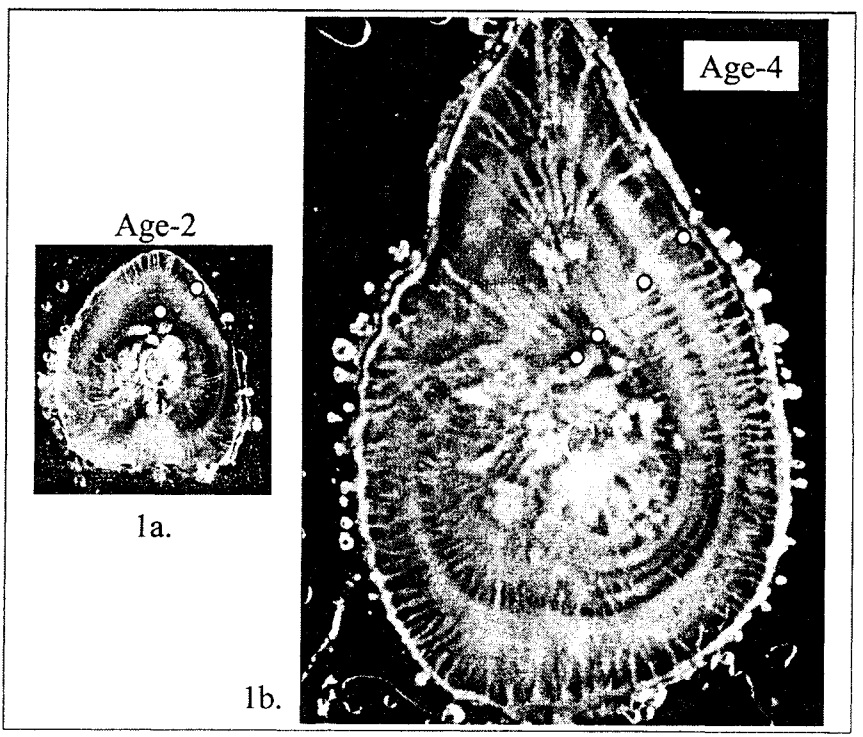

Figure 1. Sectioned first dorsal spine from an age-2 cobia (1a.) used to assist readers in the replacement of obscured inner growth bands in spines from larger fish (e.g., 1b.). o = location of band; C = spine core.

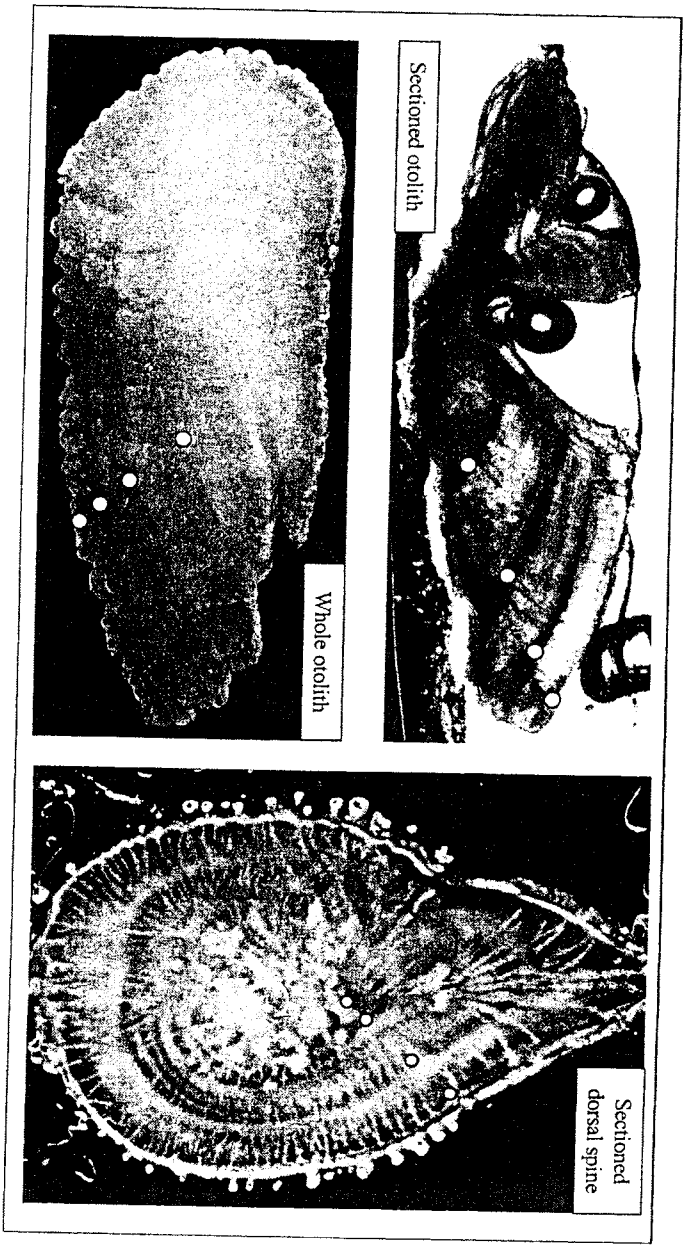

Figure 2. Sectioned sagittal otolith, whole sagittal otolith and sectioned first dorsal spine from an age-4 female cobia (1,150 mm FL). o = location of band; C = spine core.

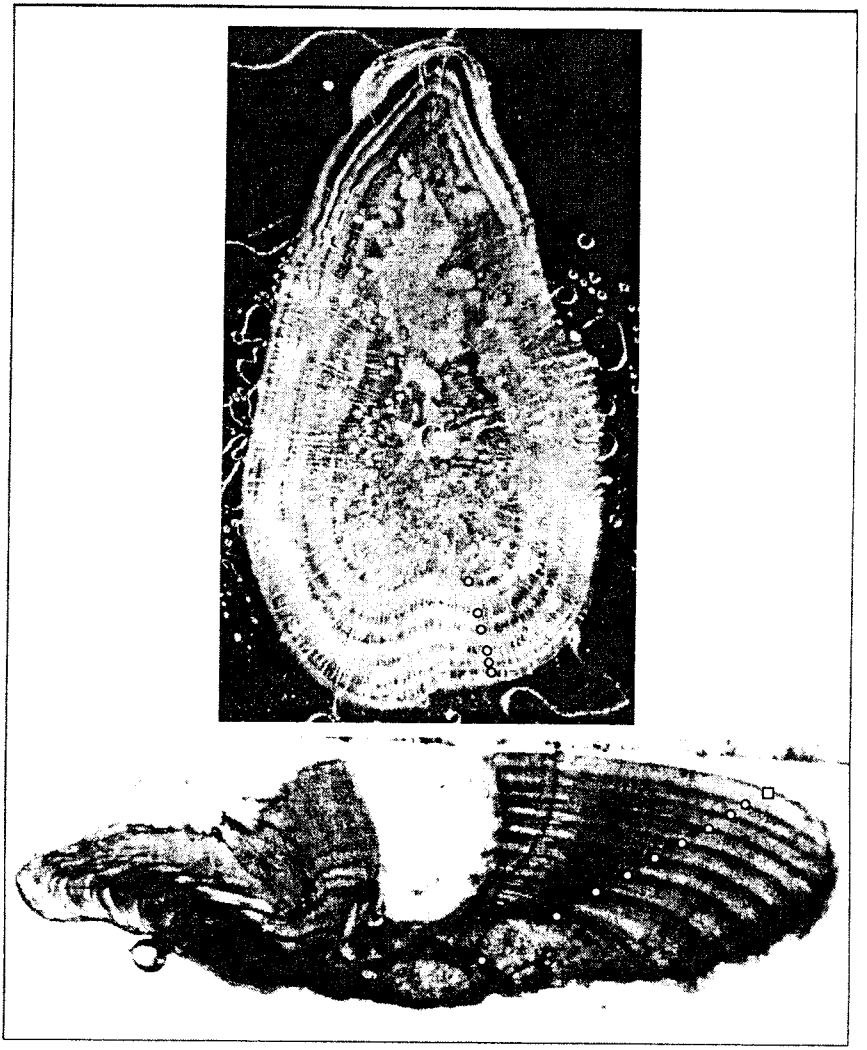

Figure 3. Sectioned first dorsal spine and sectioned otolith from an age-9 cobia (1,651 mm FL). Note: based on sectioned otolith age, three bands are obscured in the core of the sectioned spine. o = location of band; □ = otolith margin, not an opaque band; C = spine core.

Growth Relationships and Age Comparisons

Mean FL, spine length, spine weight and spine radius did not differ between the sexes ($p \geq 0.525$), so data for dorsal spines were pooled for regression analyses. Of the six comparisons between age/FL and spine growth, only three were significant,

and none showed a strong relationship based on linear regression (Table 1). Only spine weight as a function of FL yielded a moderate association ($r^2 = 0.469$).

Table 1. Regression statistics for first dorsal spine measurements relative to FL and age. Values in parentheses are standard errors. Significant relationships are indicated in bold. "DS" = dorsal spine, and "Age" = actual age.

			$Y = a + bX$			
Y	*X*	n	*a*	*b*	*p*-value	r^2
FL	DS Length	22	836.1 (158.0)	19.9 (11.5)	0.098	0.131
FL	DS Weight	17	909.7 (57.3)	731.6 (200.8)	**0.002**	**0.469**
FL	DS Radius	25	748.4 (104.2)	272.4 (83.0)	**0.003**	**0.319**
DS Length	Age	22	10.6 (1.29)	0.80 (0.33)	**0.024**	**0.229**
DS Weight	Age	17	0.157 (0.083)	0.029 (0.021)	0.191	0.111
DS Radius	Age	25	1.063 (0.160)	0.047 (0.041)	0.266	0.053

The number of translucent bands counted on individual dorsal spines (DS-Age) matched the actual age for 26 of the 42 fish (61.9 %), while age estimates from whole otoliths (WO-Age) matched actual age for 19 of the 31 fish (61.3 %). The accuracy of DS-Age (Figure 4a) and WO-Age (Figure 4b) was relatively high for age-3 and 4 fish, with slightly higher accuracy for DS-Age. Conversely, DS-Age was over-estimated for age-2 fish, while WO-Age tended to over-estimate age for age-2 and 3 fish. Both DS-Age and WO-Age under-estimated age for fish age-5 and older, with the exception of WO-Age for an age-9 fish (Figure 4).

Overall, mean ranks of age estimates did not differ between sectioned otoliths (actual age) and whole otoliths ($n = 31$; $\chi^2 = 0.077$; $p = 0.782$), but age ranks were marginal in significance for the comparison between sectioned otoliths and sectioned dorsal spines ($n = 42$; $\chi^2 = 3.556$; $p = 0.059$). Age estimates from sectioned dorsal spines ($\bar{x}_{rank} = 1.41$), on average, tended to underestimate actual age ($\bar{x}_{rank} = 1.59$).

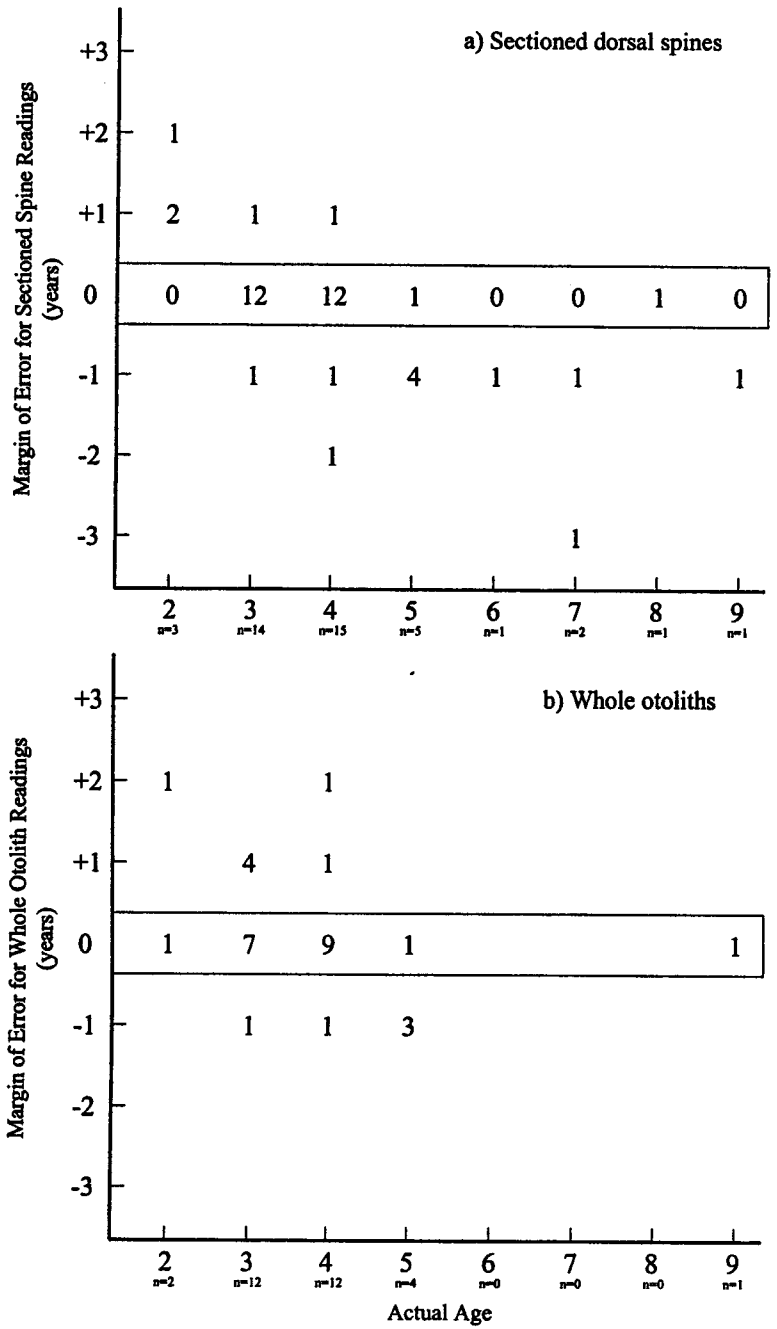

Figure 4. Margin of error for band counts of sectioned first dorsal spines (a) and whole otoliths (b) in relation to actual age (sectioned otoliths) for cobia.

DISCUSSION

In this paper, we examined the merits of sectioned first dorsal spines and whole sagittal otoliths to age cobia, *Rachycentron canadum*, from the northcentral Gulf of Mexico. Our results demonstrated that while sectioned spines and whole otoliths appeared adequate for ageing some fish in our sample, these structures are far less precise for ageing cobia than are sectioned otoliths. Dorsal spines showed a moderately high level of interpretability, however the position of the first, second and often the third transparent band could not be determined consistently, and outer bands were often closely spaced and difficult to discern. Vague, difficult-to-locate bands were typical of many whole otoliths which led to numerous discrepancies in band counts among readers.

Although the linear relationships between age and spine length, FL and spine weight, and FL and spine radius were each significant, there was no strong association between any of these measurements ($r^2 < 0.500$). The lack of a strong association between age and spine length may be attributed to the non-symmetrical growth of some spines. Growth in spine length appears to slow as spine width increases (with increased age), thus reducing the precision of spine length in predicting age in older fish. The weak association between FL and spine weight could be due to increased internal vascularization of the spine as the fish grows, since dissimilar rates of vascularization would cause variations in spine weight among fish of similar size. Based on these factors, spine radius would seemingly be the most accurate measurement for evaluating spine growth, but greater precision relative to the sectioning of spines, i.e. establishing a uniform area on spines for removal of sections, might have produced more positive FL-spine radius and age-spine radius relationships.

Because of the small sample size in this study and the preliminary nature of the research, we did not calculate estimates of precision (repeatability) or an index of average percent error (Beamish and Fournier, 1981) for band counts among readers, but independent readings of each of the three ageing structures were made twice by each reader to arrive at a percent reader agreement. There was total agreement (100 %) among readers on counts of opaque bands on sectioned otoliths, which served as the basis (actual age) for comparison of age estimates derived from whole otoliths and sectioned spines. Although age agreements between sectioned otoliths and sectioned spines (61.9 %) and sectioned otoliths and whole otoliths (61.3 %) were equally unimpressive, there was moderate agreement between sectioned otolith and sectioned spine readings for age-3 and 4 fish, with differences reflected in both slightly lower and higher age estimates. Agreement between sectioned otoliths and whole otoliths was satisfactory only for age-4 fish and the single age-9 fish. Growth bands were not equally clear or consistent on all legible hard parts, and some whole otoliths and sectioned spines over- and under-estimated age by as much as two years.

In summary, we found that whole sagittal otoliths and sectioned first dorsal spines had limited application in estimating the age of cobia, however the caveat regarding small sample size should not be forgotten. Although dorsal spines were

far more practical in terms of ease of collection, they do not represent a viable alternative for deriving age estimates for cobia, based on the results of this preliminary research. This study demonstrated that it is essential to section sagittal otoliths from cobia in order to obtain an accurate estimate of age. Reasons for this include the readability of sectioned otoliths, the continued growth of otoliths with increasing fish size and age, the increase in the number of annuli with size, and indirect validation of opaque bands as annuli (Franks et al., 1999). Annuli on sectioned sagittae are extremely clear and easy to count, even on those from large fish. In contrast, age estimates from whole otoliths and sectioned spines generally tended to be greater for **smaller** fish (actual ages 2, 3 and 4) and **lesser** for larger fish (actual ages > 4) when compared with sectioned otolith ages. Rocha-Olivares (1998) reported that the magnitude of the difference between whole otolith and sectioned otolith age varies from species to species, but the general trend is an underestimation of ages in older fishes. Similarly, Jones and Wells (1998) found that sectioned dorsal spines from black drum, *Pogonias cromis*, tended to under-estimate age, a trend that increased with increasing fish age, and concluded that sectioned otoliths were the clearest and most precise hard part for interpreting age. The results of our research agree with the findings of those studies. Finally, the under- and over-estimations of age obtained from whole sagittae and sectioned spines have obvious implications in estimating mortalities for use in fisheries management, and further research on the accuracy of these structures is needed before their implementation as age determinants for fishery assessments.

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Use of Single-stranded Conformational Polymorphisms (SSCP) to Detect Species Relationship and Population Structure in the Atlantic Sharpnose Shark (*Rhizoprionodon terraenovae*) and the Caribbean Sharpnose Shark (*R. porosus*)

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ABSTRACT

The Atlantic sharpnose shark, *Rhizoprionodon terraenovae,* and the Caribbean sharpnose shark, *R. porosus*, are small coastal-temperate and tropical sharks of the continental shelves that overlap in distribution along the Gulf of Mexico, Florida and around the Yucatan Peninsula to the Caribbean Sea. In order to properly distinguish between the two species, current methods require counting caudal and precaudal vertebrate. These species used to be highly abundant within their prospective ranges, but current fishery pressures have caused declines in landing. Assessment of population size and structure is necessary to determine future management plans for this species. Use of SSCP is a viable method to differentiate between the two species and to measure population structure. SSCP analysis was able to detect 11 unique haplotypes in the Atlantic sharpnose shark and 3 haplotypes in the Caribbean sharpnose. Sequencing confirmed the variation between the species with an estimated nucleotide divergence as high as 1.08%.

KEY WORDS: Mitochondrial DNA, population genetics, sharks

Uso de los Polimorfismos Solo-trenzados de Conformational (SSCPs) de Detectar la Relación de la Especie y la Estructura de la Población en los de *Rhizoprionodon terraenovae* y *R. porosus*

Los tiburones atlánticosde terraenovae el Rhizoprionodon de Sharpnose, y el tiburón del Caribe Sharpnose son tiburones costero-templados y tropicales pequeños de las plataformas continentales que se traslapan en la distribución a lo largo del golfo de México, la Florida y alrededor de la península de Yucatan al mar del Caribe. Para distinguir correctamente entre las dos especies, los métodos actuales hay que contar el vertebrado caudal y precaudal. Estas especies eran altamente abundantes dentro de sus gamas anticipadas, pero las presiones actuales de la industria pesquera

han causado declinaciones en el aterrizaje. El gravamen del tamaño y de la estructura de la población es necesario determinar los planes futuros de la gerencia para esta especie. El uso de SSCPs es un método viable a distinguir entre las dos especies y para medir la estructura de la población. El análisis de SSCP podía detectar los haplotypes únicos indicativos a una especie particular. El uso de ordenar confirmó la variación entre la especie con una divergencia estimada del nucleotide de hasta 1,08%. El análisis de AMOVA que comparaba tiburones atlánticos del sharpnose recogió en la bahía de Campeche con las muestras obtenidas a partir de cuatro otros sitios a través del golfo de México y a lo largo del Océano Atlántico del noroeste encontró que los once haplotypes observados fueron distribuidos uniformemente a través de la gama (ST = 0,022, p = 0.191). Las diferencias al menos significativas fueron observadas en en parejas análisis entre la bahía de Campeche y de otros sitios. Estas diferencias desaparecieron cuando las muestras fueron examinadas basaron en los datos temporales que sugerían que el bottlenecking genético está ocurriendo en los terraenovae del R. a lo largo de la costa mejicana.

PALABRAS CLAVES: SSCPs, Tiburón de atlántico y del Caribe del sharpnose, *Rhizoprionodon terraenovae*, *R. porosus*

INTRODUCTION

Sharks have been subjected to intense directed fisheries in recent years that have caused shark populations to decline. These declines are often attributed to sharks evolving a "k-selected" life history in which few young are born, growth is slow with maturity occurring after several years, and long reproductive cycles (Stone et. al. 1998). Thus, the probability of a stock under exploitation collapsing is high even with moderate fishing pressure. A collapse of shark stocks in the Gulf of Mexico would jeopardize the fisheries and entail significant economic and social costs affecting livelihoods for hundreds of families in the region (Bonfil 1997, Marquez-Farias and Castillo-Geniz 1998). The need to properly assess a particular fishery is of utmost importance in order to create proper management plans if this is to be prevented. Population size, fecundity, immigration, emigration, mortality (both natural and anthropogenic), and genetic composition must be assessed in order to determine susceptibility to fishery pressures. With advances in molecular biology, methods are now available that can aid in the assessment of a fishery, particularly in regards to migration and gene flow. The use of Single-Stranded Conformational Polymorphisms (SSCP) is a relatively new method that can yield a tremendous volume of data regarding population structure at a fraction of the cost using other methods (Orita et al. 1989, Hongyo et al. 1993).

Of particular interest in the Gulf of Mexico and the Caribbean Sea, is the susceptibility of the Atlantic sharpnose, *Rhizoprionodon terraenovae* and the Caribbean sharpnose, *R. porosus*, to fishing pressures. These small coastal sharks are the most common sharks in the western Atlantic, with the Atlantic sharpnose occurring from New Brunswick to Florida in the northwestern Atlantic and

throughout the Gulf of Mexico, being replaced by the Caribbean sharpnose south of the Yucatan peninsula to Brazil (Springer 1964, Compagno 1984). During the early 1990s, landings of the Atlantic sharpnose shark in Mexico and the United States had increased to unprecedented levels. While the United States implemented a management plan in 1995 to regulate the fishery, stocks in Mexican coastal waters remained unprotected. Demographic models predicted that if fishing pressures remained constant, a crash in the population was inevitable (Cortez 1995, Bonfil 1997, Marquez-Farias and Castillo-Geniz 1998). Due to the wide distribution of these species, the need to assess the population structure is important. However, both species are morphologically similar when examined externally. Current methods for differentiating between the two species require counting of precaudal vertebrae (Springer 1964, Compagno 1984). Questions have also been posed whether the two species are separate, or should be considered subspecies to each other. The purpose of this study is to characterize the genetic relationship between *R. terraenovae* and *R. porosus* using SSCP by testing the hypothesis that two distinct species exist.

MATERIALS AND METHODS

Fin clippings of *R. terraenovae* representing three regions and R. porosus were obtained from six different sampling sites (Figure 1). Thirteen samples originating from off the coast of Tabasco and Campeche, Mexico, were obtained through Texas Parks and Wildlife (TPWD). Thirty-two samples were collected off the Texas-Louisiana coast and Dauphin Island from recreation and commercial fishermen between September 2000 and November 2001. Finally, Thirty-two samples were collected with the cooperation of the Virginia Institute of Marine Science (VIMS) during shark longlining cruises in the Chesapeake Bay during July 2001 or originated from Georgia/South Carolina Coast. Twelve fin clippings from positively identified *R. porosus* were obtained from the NSU Oceanographic Center in Florida, where ten originated from Belize, and two were collected off Brazil. All fin clippings collected were preserved in 95 % ethanol and stored at room temperature.

The mtDNA was isolated by cutting the fin clippings into small pieces, and treating the fragments with Proteinase K. The samples were passed through Qiagen DNAEZ extraction columns following the manufacturers instructions. The Polymerase Chain Reaction (PCR) was then performed to isolate the d-loop and the Cytochrome b (Cyt b) gene from the mtDNA. Primers (5'-TTGGGTTTCTCGTATGACCG-3') and (5'-AGAGCGTCGGTCTTGTAAACC-') were used to isolated the D-loop region, and primers (5'- GCCATAAATCGAAAAACCACCCA –3') and (5'-AAGTATCATTCGGGTTTGATATG –3') were used to isolate the Cyt b gene. DNA amplification was performed using the Gibco/BRL$^{\diamond}$ Platinum High Fidelity PCR supermix using 100 ng DNA-Template and 0.5 μM of each primer. Amplification occurred for 30 cycles (30 s at 95° C, 30 s at 50° C, 60 s at 72 C°). The PCR products were then purified using the Qiagen$^{\diamond}$ PCR purification kit. 600

ng of PCR product were then digested with either Rsa I (d-loop) or Alu I (Cyt b) overnight in a total volume of 30 µL. SSCP analysis was performed following Hongyo et al. (1993). Samples were loaded on to a 20.0 X 20.0 X 0.1 cm 0.5 X MDE® polyacrylamide gel ran at 10° C for six hours at 15 watt constant. The gel was stained with a 0.5 µg/ml ethidium bromide in 1 X TBE solution for 20 minutes, followed by destaining in distilled water for five minutes. Fragment size for each sample was determined by comparing results to a 123 bp DNA ladder and reporting migration values as relative base pairs (,bp). Samples determined to have the same migration patterns were then assigned a haplotype designation. Two of each haplotype identified was then sequence using the Beckman-Coulter CEQ2000® Capillary Sequencing system and aligned using the Omiga®1.1 Sequence Alignment program. AMOVA and Öst pairwise analysis was then performed to look for statistical differences between the two species using Arlequin statistical analysis program (Excoffier et al. 1992).

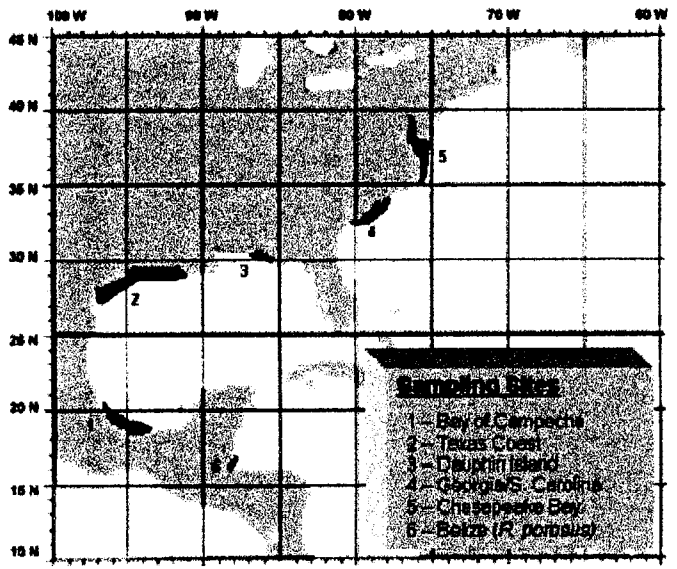

Figure 1. Location of sites for collection of the Atlantic sharpnose shark, *R. terraenovae*, and the Caribbean sharpnose shark, *R.porosus*.

RESULTS

Cyt b and the D-loop region of mtDNA were successfully amplified from both species and produced distinct bands per haplotype. A total of 11 haplotypes were identified in *R. terraenovae* (n = 69) and 3 haplotypes observed in *R. porosus* (n = 12) (Table 1). Both species never shared a common haplotype. The ability to discern between haplotypes was quite high. A typical gel illustrating the differences

between haplotype is shown (Figure 2). Haplotype diversity in the Atlantic sharpnose was high (h=0.8549 ± 0.053) compared to the Caribbean sharpnose (h=0.667 ± 0.091). AMOVA analysis was performed comparing the six samples sites grouped as two distinct populations (Table 2). Genetic variation observed between the two species was moderate (21.42%), and indicated that genetic material was not being shared between the two species ($\ddot{O}_{ST}$ = 0.113, p<0.001). The hypothesis that *R. terraenovae* and *R. porosus* are distinct and separate species is validated since it seems that both species are reproductively isolated. Further evidence supporting this conclusion was obtained using pairwise $\ddot{O}_{ST}$ analysis (Table 3). Comparision between individual populations within each group produced $\ddot{O}_{ST}$ values that were highly significant (p < 0.001) in all cases.

Table 1. Haplotypes designations and haplotype frequencies observed in mtDNA isolated from the Atlantic sharpnose shark, *R. terraenovae*, and the Caribbean sharpnose shark, *R. porosus*.

Haplotype	Northwestern Atlantic (28)	Northern Gulf of Mexico (31)	Bay of Campeche (13)	Caribbean (12)
AX	**12** 0.429	**13** 0.419	**2** 0.154	–
AY	**2** 0.071	**1** 0.032	–	–
BX	**1** 0.036	**4** 0.129	–	–
BY	**6** 0.214	**2** 0.065	**1** 0.077	–
BZ	**1** 0.036	–	**2** 0.154	–
CX	**2** 0.071	**6** 0.193	**2** 0.154	–
CY	–	**1** 0.032	**3** 0.231	–
CZ	**2** 0.071	**1** 0.032	**1** 0.077	–
DX	**1** 0.036	**2** 0.065	**1** 0.077	–
EX	**1** 0.036	**1** 0.032	–	–
FZ	–	–	**1** 0.077	–
GW	–	–	–	**4** 0.333
GV	–	–		**6** 0.500
HU	–	–	–	**2** 0.167
h	0.831 ± 0.053	0.811 ± 0.055	0.923 ± 0.050	0.667 ± 0.091

Bold number indicates number of individuals with observed haplotype at a site.
Lower number indicates frequency of the haplotype at a site.

Table 2. AMOVA design and results with significance tests based on 1023 permutations comparing differences between the Atlantic sharpnose shark, *R. terraenovae*, and the Caribbean sharpnose shark, *R. porosus*.

Source of Variation	d.f.	Sum of Squares	Variance Components	Percentage of Variation
Between Population of Species	1	2.845	0.1132 Va	21.42
Sample sites within Population of Species	2	1.169	0.0078 Vb	1.48
Between individuals at a sample site	80	41.457	0.4073 Vc	77.10
Total	83	36.595	0.5282	

V_c and Φ_{ST} : P (Random Value < Observed) = < 0.001
P (Random Value = Observed) = < 0.001
P (Random Value = Observed) = < 0.001

V_b and Φ_{SC} : P (Random Value > Observed) = 0.134
P (Random Value = Observed) = < 0.001
P (Random Value = Observed) = 0.135 ± 0.009

V_a and Φ_{CT} : P (Random Value > Observed) = < 0.001
P (Random Value = Observed) = 0.235
P (Random Value = Observed) = 0.235 ± 0.011

Table 3. Pairwise Φ_{st} analysis values and significance levels out of 110 permutations comparing difference between the Atlantic sharpnose shark, *R. terraenovae*, and the Caribbean sharpnose shark, *R. porosus*.

Sample Site	NW Atl	N. GoM	Campeche	Caribbean
NW Atl	0.000 -	-	-	-
N. GoM	-0.001 0.378 ± 0.04	0.000 -	-	-
Campeche	0.036 0.082 ± 0.03	0.036 0.982 ± 0.01	0.000 -	-
Caribbean	0.240 < 0.001*	0.250 < 0.001*	0.203 < 0.001*	0.000 -

* = Significant Difference

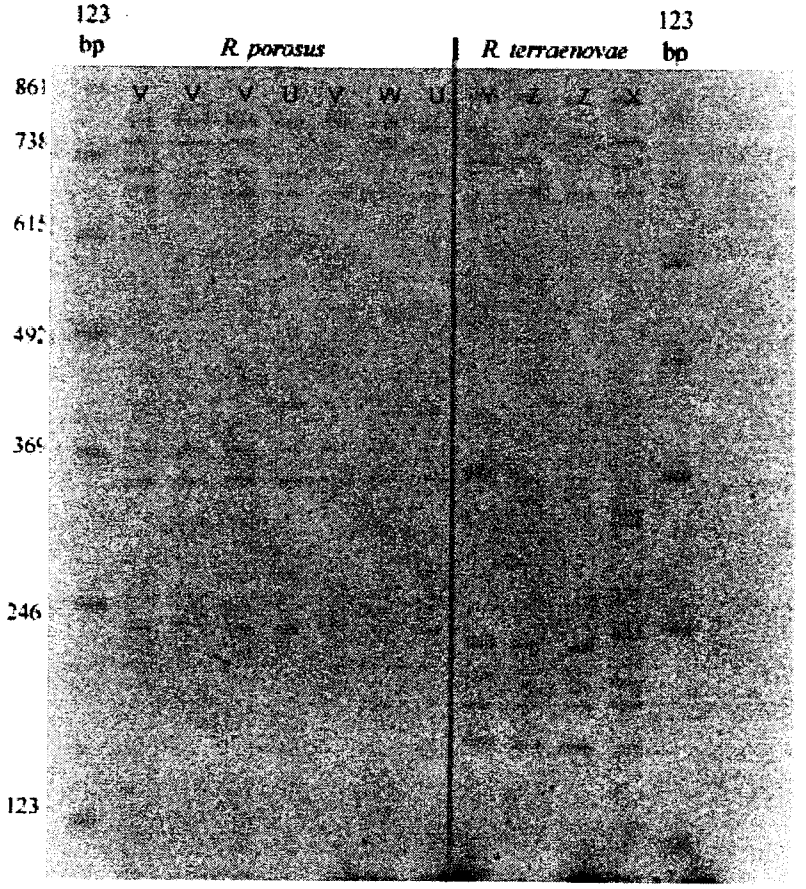

Figure 2. SSCP comparing Cyt b between *R. porosus* and *R. terraenovae* on a 0.5% MDE gel

Sequencing of each observed haplotype indicated that a relative low amount of nucleotide diversity between the two species existed. 729 bp of the D-loop region (Figure 3) and 650 bp of Cyt b (Figure 4) were successfully sequenced. 92 % of all nucleotide substitutions involved a transversion from a purine to a pyramidine residue. Fifteen nucleotides separated the most distantly related samples when comparing both genes between species, while five nucleotides separated the most closely related. This corresponded to a nucleotide divergence ranging from 0.36 % to 1.08 %. Phylogenetic inference based on parsimony analysis of the sequencing data was estimated where it was determined that 24 evolutionary steps were required for the observed haplotypes to have occurred (Felsenstein 1985)(Figure 5).

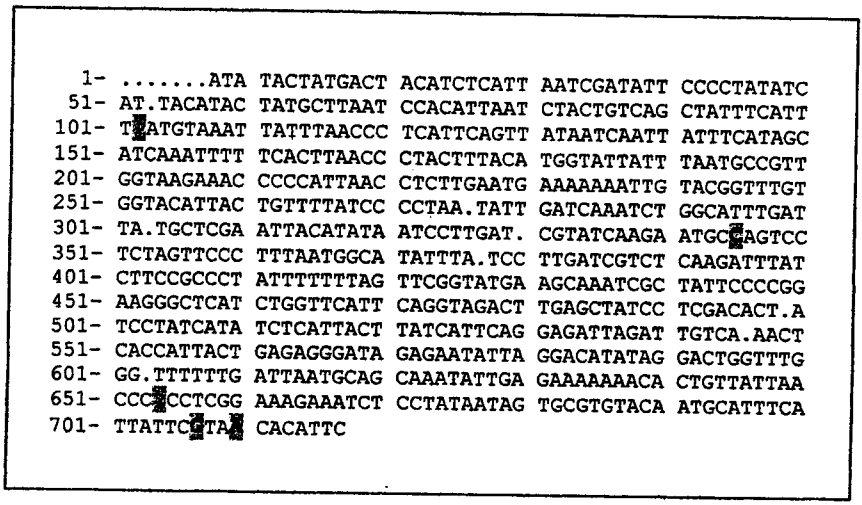

Figure 3. Nucleotide sequence of a 729 bp fragment of theD-loop region isolated from *R. terraenovae*. Highlighted nucleotide indicates a site where variability may occur in *R. porosus*.

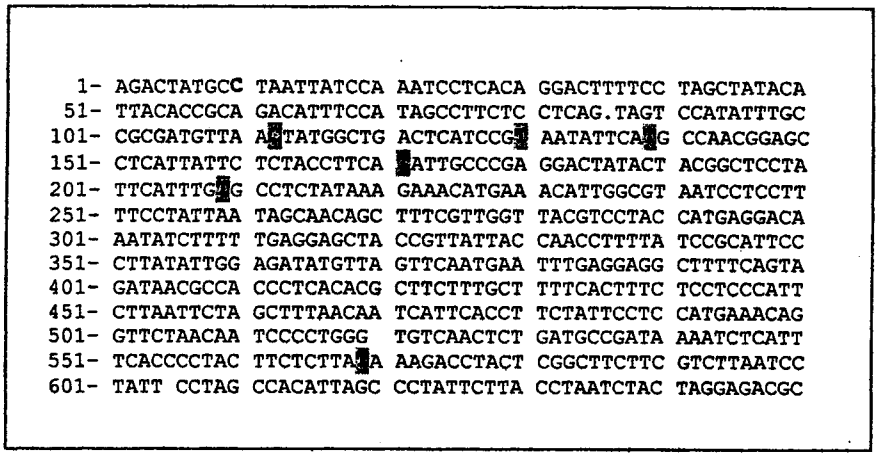

Figure 4. Nucleotide sequence of a 650 bp fragment of Cyt B isolated from *R. terraenovae*. Highlighted nucleotide indicates a site where variability may occur in *R. porosus*.

Figure 5. Phylogenetic inference based on parsimony analysis of the sequencing data using PHYLIP. Number at each node represents number of mutational steps required for haplotype to be observed.

DISCUSSION

The genus *Rhizoprionodon* currently exists on both coasts of North and South America. Roughly three million years before present (BP) the Plieocene rise of the Isthmus of Panama was completed (Bermingham et al. 1997). This event would have led to the geographical isolation of this Genus between the Atlantic and Pacific oceans. Thus, the ancestor of *R. terraenovae* and *R. porosus* would begin to change from its Pacific counterpart since it was now reproductively isolated. The behavior of organisms living in the region would also be affected due to ecological changes resulting from the differences in geography. This geological event caused northward projection of the equatorial current that now contributes to the formation of the Gulf Stream. Nursery ground, feeding grounds and possibly mating grounds would most

likely have been affected. Organisms in the area would begin to undergo speciation and radiate out along the new coastlines entering new niches. Further speciation probably could have occurred due to glacial-interglacial oscillations. Major glacial-interglacial oscillations tend to occur on a 100,000 year time scale. Evidence exists that at the peak of interglacial or glacial intervals, the enhanced changes in temperature from average levels affect the hydrologic cycles (McManus et al. 1999). One consequence suggests that as temperatures fall, the flow of the Gulf Stream would intensify. If this does occur, it may be possible that the current may be intense enough to cause a temporary barrier to be formed geographically isolating members of the same species. This may be the mechanism that caused speciation between the Atlantic sharpnose and the Caribbean sharpnose. Examination of the distribution between the two species seems to follow the boundaries of the Gulf Stream (Compagno 1984). A difference of five nucleotides separated samples of *R. porosus* collected from Belize with those of *R. terraenovae*. Intrinsic rates of mutations in shark mtDNA have been estimated to occur at a divergence rate of 2.3% per million years (Martin et al. 1992, Martin 1995). This suggests that divergence between the two species could have occurred in a period of 90,000 years. In contrast, the two samples collected from Brazil was high (1.08 %) compared to the Atlantic sharpnose and Caribbean sharpnose collected in Belize. However, the size of sample pool to represent this area is small. Further studies are needed to characterize the population structure of the Caribbean sharpnose.

A high amount of nucleotide diversity was observed in the Atlantic sharpnose covering throughout the range of this organism. A previous study performed by Heist (1994) identified a total of seven haplotypes using Restrictrion Fragment Length Polymorphisms (RFLP) after screening the entire mtDNA genome (~16.5 kb in length) of the Atlantic sharpnose shark in contrast to eleven haplotypes bing identified from just two genes (~1.6 kb in length). This indicates that SSCP has higher resolving power compared to RFLP. The frequencies of haplotypes tend to indicate a panmictic population may exist. This tends to support the finding of Heist (1994). However, nucleotide diversity in the Bay of Campeche tends to be lower compared to other sites. Nucleotide diversity in the Caribbean sharpnose was also low relative to populations in the Northern Gulf of Mexico and in the northwest Atlantic. In both cases, the low diversity may be the result of overfishing. Management plans are in effect off the coast of the United States that may help maintain the gene pool in the corresponding population. In contrast, many fish populations within other parts of the Gulf of Mexico and Caribbean do not benefit from a comprehensive fishery management plan. Further studies are required to ascertain the health of populations along coastal Gulf of Mexico to see if genetic bottlenecking is occurring at localized areas.

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Comparing Juvenile Catch Rates among Conventional Fish Traps and Traps Designed to Reduce Fishing Mortality on Juvenile Reef Fishes

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ABSTRACT

The trap fishery in Barbados, which targets nearshore coral reef species, are believed to be overexploited, particularly along the west and south coasts. In recognition of this, the recent Fisheries Management Regulations (1998) in Barbados set a minimum mesh size for fish traps at 3.18 cm (1¼"), and the Fisheries Management Plan (2001-2003) recommends that this be increased to 3.8 cm (1½") mesh over a two-year period to reduce the mortality of juvenile reef fishes. However, fishers have expressed concerns that not only will catch rates be significantly reduced by using a larger mesh, but that the 1½" mesh wire is too soft for trap construction, such that the fishable life of a trap will be much reduced.

Alternative designs to increasing the mesh size of the entire trap have been tested in previous studies, and have been partially successful in reducing mortality of immature fishes. These include the use of: vertical escape slits in conventional traps which reduce the mortality of immature, deep-bodied fishes; and a single large mesh (3.8 cm) panel incorporated into commercial traps which reduces the mortality of immature, round-bodied fishes. This study tests an alternative design (that includes both a vertical escape slit and a large mesh panel), and compares the juvenile catch rates, the size of juveniles captured, and the species composition of the juvenile catches with conventional small mesh (3.18 cm) traps and large mesh (3.8 cm) traps.

Experimental traps caught fewer juvenile reef fish than conventional traps, but significantly more than large mesh traps per haul. Weight of catch per haul also differed significantly among traps showing the same pattern as number of fish. Individual size of juveniles (by fork length, body depth and weight) also differed significantly among traps with mean size of fish becoming increasingly large from conventional to experimental to large mesh traps. All traps caught primarily deep-bodied juveniles and relative abundance of key species in the juvenile catches did not differ significantly among trap designs.

Both the alternative trap designs reduced juvenile catch rates and increased the mean size of juveniles caught, compared with the conventional traps. Experimental traps did not reduce catch rates as sharply as the large mesh traps and were

considered much stronger by fishers than the large mesh traps. As such they would seem to be a more acceptable alternative than the large mesh traps. However, unlike the large mesh traps, experimental traps failed to reduce the proportion of juveniles in the catch. Reduced juvenile catches were simply a result of reduced catches overall, with potentially high short-term economic impacts on fishers. Reducing gear efficiency does not adequately address the management goal of reduced levels of juvenile mortality with minimum impact on fishers.

KEY WORDS: Fish traps, juveniles, mesh size

Camparación de Tasas de Captura entre Trampas de Peces Convencionales y Trampas Diseñadas para Reducir la Mortalidad de Peces Juveniles

Se cree que la pesca de trampa en Barbados, la cual esta dirigida hacia las especies de coral de aguas costeras, sobre-explota ciertas poblaciones de peces de arrecife, especialmente en las costas del sur y oeste de la isla. Como consecuencia, las recientes Regulaciones de Gestión de Pesca (1998) de Barbados limitan el tamaño de la malla de las trampas a un mínimo de 3.18 cm (1¼"), y el Plan de Gestion de Pesca (2001-2003) recomienda que esta talla de malla sea aumentada a una 1½" en un plazo de dos años con vistas a reducir la mortalidad de peces de arrecife juveniles. Sin embargo, los pescadores han manifestado su preocupación de que no sólo la tasa de captura de peces se vera reducida significativamente debido al uso de esta malla mas grande, sino que tambien, el alambre de la malla de 1½" es demasiado blando para la construcción de trampas, disminuyendo por tanto la vida de estas.

Estudios anteriores has puesto a prueba varios diseños en busca de una alternativa al aumento de la talla de malla de toda la trampa, y han demostrado ciertos niveles de reducción de la mortalidad de peces inmaduros. Estos diseños incluyen el uso de: salidas de escape vertical en trampas convencionales que reducen la mortalidad de peces inmaduros de cuerpos profundos; un unico panel de malla de talla grande (1½ ") integrado en las trampas comerciales que reduce la mortalidad de peces inmaduros de cuerpos redondos. Este estudio pone a prueba un diseño alternativo que incluye una salida de escape vertical y un panel de malla de talla grande integrado en una trampa convencional, y compara las tasas de captura, la composición de las especies pescadas, y la proporción de especies juveniles pescadas con trampas convencionales (1¼") y trampas de malla de talla grande (1½"). Esta comparación es usada para evaluar la eficacia de los distintos diseños alternativos de trampas de peces con vistas a reducir la mortalidad de peces juveniles. Esta comparación tambien se extiende a la vida de los diseños de las trampas y al valor economico de las capturas para evaluar el impacto economico del diseño alternativo sobre el pescador.

PALABRAS CLAVES: Pesca de trampa, malla de las trampas, la tasa de captura

INTRODUCTION

Nearshore fishery resources of the Caribbean are of enormous social and economic importance to low-income coastal communities, and contribute significantly to food security in small island states. However, the widespread, largely unregulated use of fish traps has lead to the overexploitation of reef fish resources in many countries throughout the Caribbean (Munro 1983, FAO 1993, Mahon and Hunte 2001) especially around islands with narrow shelves (Appeldoorn et al. 1987). Over-fishing, where it has occurred, has been attributed to the combined effects of excess fishing effort and trap mesh sizes that are too small, resulting in high mortality of juveniles and a loss of long-term potential yield (Sary et al. 1997). Furthermore, reefs throughout the region are also suffering from habitat degradation and reef fish catches are now characterised by low yields, small mean size-classes, and a scarcity of larger species (Spalding et al. 2001). As such, the trap fisheries of the region are in urgent need of rehabilitation management (FAO 1993).

The trap fishery in Barbados is no exception. It provides a direct source of income and employment for an appreciable number of fishers and other persons in the coastal communities, and is an important source of protein, particularly during the pelagic fishing "off season" (July – October) (Barbados Fisheries Division 2001).

Management of Reef Fish Resources

Regulatory management approaches that deal with over-fishing of multi-species reef populations include: marine protected areas, that prevent fishing; fish size limits, considered unenforceable in most circumstances; effort limitation, an approach that may be politically untenable due to the open access nature of the resource; and trap mesh size regulation, which is considered to be the most feasible approach despite its limitations (Mahon and Drayton 1990). A minimum mesh size is indeed one of the most popular management measures for trap fisheries in the Caribbean (Mahon and Hunte 2001).

Studies on fish trap mesh selectivity show that mesh size is a determinant of catch rates and the size at which fish recruit to traps (Munro 1983, Robichaud et al. 1999). Comparative fishing studies indicate that increasing mesh size not only results in an overall reduction of catch per trap, but catches will consist of significantly bigger fish and a smaller proportion of juvenile fish than smaller mesh traps (Rosario and Sadovy 1991, Sary et al. 1997, Robichaud et al. 1999).

In recognition of this, the recent Fisheries Management Regulations (1998) in Barbados set a minimum mesh size for fish traps at 3.18 cm (1¼"), and the Fisheries Management Plan (2001-2003) recommends that this be increased to 3.8 cm (1½") mesh over a two-year period, to reduce the mortality of juvenile reef fishes. Implementation of an increase in mesh size has been delayed as fishers have expressed concerns that not only will catch rates be significantly reduced by using a larger mesh, but that the 3.8 cm mesh wire is too soft for trap construction, reducing the fishable life of a trap. As such, the Barbados Fisheries Division is interested in exploring alternative trap designs that will reduce growth over-fishing

by traps, while at the same time minimising the economic effects on fishers.

Alternative Designs

One possible alternative to increasing mesh size of the entire trap is the inclusion of a single large mesh panel within a conventional small mesh trap. This has recently been tested by Robichaud et al. (1999) and was successful in reducing the proportion of immature, round-bodied fish species retained by the trap. Another alternative is the inclusion of vertical escape slits in conventional small mesh fish traps. This has recently been tested in the British Virgin Islands and Jamaica, and was successful in reducing the proportion of immature deep-bodied fish caught (Munro et al. in press).

Study Objectives

In this study we investigated an alternative trap design that incorporates the two features previously tested separately. The new design included a single large mesh panel (after Robichaud et al. 1999) and a single vertical escape slit (after Munro et al. in press) built into a conventional small mesh trap. The rationale for this design was to reduce the proportion of immature fish of both deep- and round-bodied species, whilst retaining the strength and visual image of the conventional small mesh trap.

The primary objective of the study was to investigate whether this alternative experimental design is more effective than the currently recommended large mesh trap for achieving the management objective of reduced juvenile mortality. In judging 'effectiveness' of the trap designs, both the degree to which the capture of immature fish is reduced, and the degree of unnecessary hardship to fishers (through unintended reduction in catch rates of larger individuals or reduction in the fishable life of traps) will be considered. A secondary objective was to integrate the participation of the fishing stakeholders within the study.

METHODS

Public meetings coordinated by the Barbados National Union of Fisherfolk Organisations (BARNUFO) were held to inform, as well as encourage participation in this study.

Trap Design

Three trap designs and a total of 12 traps (four of each design) were used in the study. All traps were of the Antillean arrowhead type with a single horse-neck funnel (the most common type of trap used in Barbados) and were constructed with the assistance of a local fisher appointed by the Barbados Fisheries Division. All traps measured 0.61 m (2 ft) in height, 1.52 m (5 ft) in width, and 1.22 m (4 ft) in length, giving a total volume of 1.13 m^3. All traps were made of galvanised hexagonal mesh wire (chicken wire) supported by a frame of wooden sticks nailed and strapped together with wire. All traps were outfitted with a 15.24 x 27.94 cm (6 x 11") lead weighted escape door, fastened shut with biodegradable hemp string,

as required by the current 1998 Fisheries Management Regulations (Selliah et al. 2000). Traps differed from one another only in design details.

Conventional small mesh traps were constructed with 3.18 cm wire mesh with a maximum horizontal aperture of 4.2 cm. Large mesh traps were identical to the conventional traps, but were constructed with 3.8 cm wire mesh with a maximum horizontal aperture of 5.9 cm. Experimental traps were identical to conventional traps except that they were outfitted with both a single escape slit and a single large mesh panel (Figure 1). The escape slit dimensions (7 x 2.5 cm) were selected on the basis of available information on body depth at maturity for a variety of deep-bodied species targeted by the trap fishery in Barbados (Table 1). A vertical height of 7 cm was considered to be appropriate for most deep-bodied species (Table 1) such that a high proportion of immature fish could be expected to escape. All escape slits were rectangular in shape and cut into galvanised sheeting that was strapped onto a head panel of the trap with wire (Figure 1). The head panel was chosen based on the perception of fishers that fish would be most likely to find it at the head of the trap. The large mesh panel was 0.61 x 0.61 m (2 x 2 ft) and comprised 3.8 cm mesh oriented vertically (max. vertical aperture 5.9 cm) and placed in the adjacent head panel to the escape slit (Figure 1).

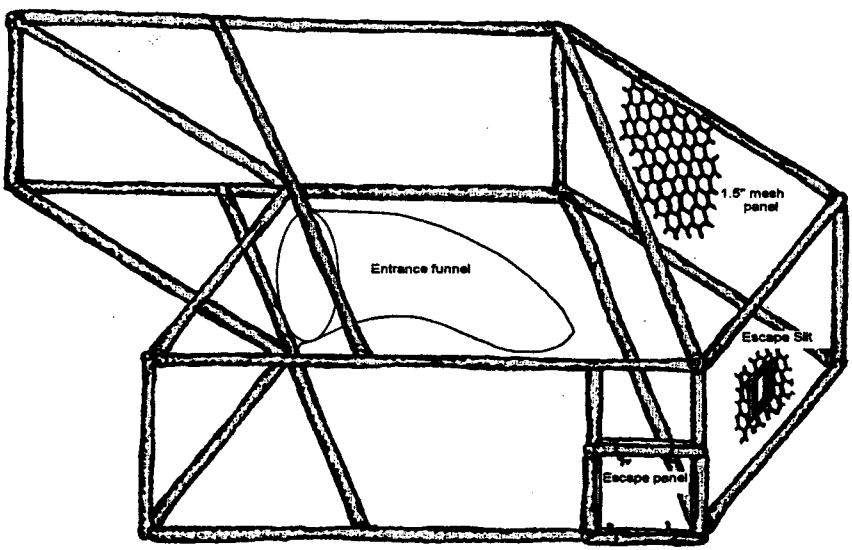

Figure 1. Diagram of the experimental trap design used in this study showing key features of both a single vertical escape slit (7 x 2.5 cm) and a single large 3.8 cm (1.5") mesh panel (0.61 x 0.61 m) on adjacent head panels of a conventional (3.18 cm) mesh Antillean arrowhead trap.

Sampling Design

All experimental fishing was undertaken in Oistins Bay, located on the south coast of Barbados, from July 2002 – September 2002. The fishing grounds in Oistins Bay are characterised by a coral-rich, relatively shallow (3 - 10 m), flat reef system, located within 1 km of the shore.

The twelve traps of standard dimensions, but differing in design, were fished simultaneously and continuously for three months. Traps were set and hauled in four sets of triplets. Each triplet comprised one trap of each design (i.e. a conventional small mesh trap, an experimental trap and a large mesh trap). Traps within a triplet were set randomly along the reef in similar depth and habitat, and in relatively close proximity to one another. The rationale for this sampling design was to control for the effects of variation in the availability of fish at different trap sites on catch rates. Each triplet was placed in a different location, but all traps were located within the Oistins Bay. Soak time (the time over which the trap was allowed to fish) was identical for all members of a triplet and was typically three days, but varied from 3-7 days for a total of 225 soaks conducted during the study. Traps were hauled on 19 occasions, and giving a sample size of 75 replicates per trap design. However, the data from the first two hauls of every trap were not used in the analyses of catch rate on advice from fishers that the traps were too new (had not "turned colour") and would therefore have reduced catch rates. Data from traps with a soak time in excess of four days were also not used in catch rate analyses. Sample size for catch rate analyses was therefore 55 hauls per trap design. A large number of replicates was included in the sample design in order to increase the statistical power of comparison testing, given the typically high level of variation in trap catch rates.

Data Collection

Traps were hauled and reset unbaited every three days in collaboration with another local fisher based at Oistins. If catch rates were considered low, the triplet of traps was moved to a new location on the same fishing ground. For each soak, the fishing location was recorded by GPS and the weather conditions, water depth, and substrate type were also noted for each triplet.

For each trap hauled, all fish caught (with the exception of pufferfish) were retained and stored in separately marked bags. All retained fish were subsequently measured onshore with technical assistance from staff of the Fisheries Division and UWI, and any interested fishers. The catch was identified to species, and each fish measured for fork length (FL) and body depth (BD) to the nearest 0.1 cm and wet weight to the nearest 1.0 g.

Data Handling and Analysis

All catch data were entered into EXCEL spreadsheets by day and trap number. Statistical analyses were done using the statistical programme SPSS version 10.0. All data sets were checked for normality using the Shapiro Wilk test, and homoscedasticity of variance using the Levene test. Standard data transformations

were used in an attempt to normalise and/or homogenise data that did not conform. Since at least one data set in every comparison showed a non-normal distribution and/or heteroscedasticity of variance even after transformation, non-parametric statistical tests were performed throughout.

The following parameters were compared among trap types: juvenile catch rates (as number and weight of juvenile fish caught per haul):

i) Percent of juveniles in the catch (per trap haul)
ii) Number of deep-bodied juveniles in the catch (per trap haul)
iii) Size of juveniles for all species (by fork length, body depth and weight)
iv) Body depth of juveniles for any species with an $n > 5$ in each trap design, and
v) Species composition of juvenile catches.

Catch rate and size comparisons were undertaken using non-parametric ANOVAs (Kruskal-Wallis test) and multiple comparison tests (Nemenyi test for equal sample sizes; Dunn test for unequal sample sizes; Zar 2000). Relative species composition among trap designs was compared using a multiple correlation technique (Kendall's concordance).

Fish were classified as juveniles if they were smaller than the mean size at first maturity (FL_m) given in Table 1. Since size at maturity data were not available for all species taken, only the most important species were classified as juvenile or mature. As such, nine species accounting for 83% of the total conventional trap catch (by number) were selected for analysis. These 'key' species (banded butterflyfish, blue tang, doctorfish, ocean surgeon, mahogany snapper, princess parrotfish, yellow goatfish) were classified as either deep-bodied if they had a mean body aspect ratio (FL/BD) of < 2.5, or round-bodied if they had an aspect ratio of > 3 (Table 1). Linear regressions for the body depth – fork length relationship were calculated for key species and body depth at maturity (BD_m) was recalculated using the literature value of fork length at maturity and our own relationship listed in Table 1.

RESULTS

Total Catch

During this study a total of 3,561 finfish from 19 families and 41 species were caught in 225 trap hauls over the three-month period. Of these, 2,078 fish from 38 species were caught in the conventional traps, 1,003 fish from 25 species were caught in experimental traps and 480 fish from 26 species were caught in large mesh traps (Table 2). For the nine key species selected, 1,543 juvenile finfish were captured, representing 52.8% of the catch of these species. Of these juveniles, 927 fish were caught in the conventional traps, 471 in experimental traps and 145 in large mesh traps (Table 3).

Table 1. Morphometric characteristics and size at first maturity for key species caught by fish traps in the Oistins Bay area in Barbados between July and September, 2002. All dimensions are in cm. FL_m = fork length at maturity; BD_m = body depth at maturity; a and b are constants in the body depth (BD) to fork length (FL) linear relationship (BD = a + bFL) and r^2 is the coefficient of determination for the regression line; AR = mean aspect ratio (FL/BD). The FL_m values are from Munro et al. (in press) or calculated from data given in Munro (1983). BD_m values are estimated from the FL_m values using the BD-FL linear regressions given in FishBase (2002), and also the BD-FL linear regressions derived in this study.

Family	Species	FL_m	BD_{m1}	BD_{m2}	a	b	r^2	AR
Acanthuridae	Blue tang	13	7.1	6.8	1.34	0.42	0.735	1.94
	Doctorfish	21	8.7	8.8	0.65	0.39	0.869	2.33
	Ocean surgeon	15.5	6	6.4	1.11	0.34	0.688	2.44
Chaetodontidae*	Banded butterflyfish	12	5.8	6.7	1.08	0.47	0.790	1.78
Haemulidae	French grunt	15.5	4.4	4.8	-0.43	0.34	0.630	3.21
Lutjanidae*	Mahogany snapper	20	-	5.5	0.87	0.23	0.691	3.67
Mullidae	Yellow goatfish	18	-	4.1	-0.03	0.23	0.666	4.33
Scaridae	Princess parrotfish	15.5	-	3.8	-0.71	0.29	0.704	3.85
	Redband parrotfish	15	-	4	0.35	0.27	0.487	3.46

* FLm data estimated from Munro (1983)

[1] conversions using BD-FL relationships from FishBase (2002)

[2] conversions using BD-FL relationships from this study

Table 2. Summary of finfish catch of conventional, experimental and large mesh traps over 75 hauls for each trap design, sampled at Oistins Bay, Barbados between July and September 2002.

Trap Design		Conventional					Experimental					Large mesh				
FAMILY	SPECIES	No. fish	% total no.	% juv.	Wt (kg)	% total Wt	No. fish	% total no.	% juv.	Wt (kg)	% total Wt.	No. fish	% total no.	% juv.	Wt (kg)	%
Acanthuridae	Blue tang	151	7.27	12.58	13.37	6.10	123	12.28	8.13	10.93	10.49	91	18.96	5.49	8.55	
	Doctorfish	139	6.69	97.12	12.16	5.55	69	6.88	97.10	5.70	5.47	44	9.17	88.63	5.47	
	Ocean surgeon	806	38.79	86.50	57.87	26.40	543	54.14	78.45	44.63	42.82	154	32.08	60.39	13.67	
Aulostomidae	Trumpetfish	1	0.05	-	N/A	N/A	-	-	-	-	-	-	-	-	-	
Carangidae	Bar jack	5	0.24	-	0.247	0.11	-	-	-	-	-	-	-	-	-	
	Horse eye jack	7	0.34	-	11.92	5.44	2	0.20	-	3.49	3.35	1	0.21	-	1.23	
Chaetodontidae	Banded butterflyfish	90	4.33	25.56	5.28	2.41	40	3.99	30.00	2.45	2.35	47	9.79	17.02	2.92	
	Foureye butterflyfish	4	0.19	-	0.12	0.05	-	-	-	-	-	-	-	-	-	
	Spotfin butterflyfish	-	-	-	-	-	-	-	-	-	-	2	0.42	-	0.18	
Dactylopteridae	Flying gurnard	-	-	-	-	-	-	-	-	-	-	1	0.21	-	N/A	
Ephippidae	Atlantic spadefish	1	0.05	-	0.44	0.20	-	-	-	-	-	-	-	-	-	
Grammistinae	Greater soapfish	8	0.38	-	1.96	0.89	-	-	-	-	-	3	0.63	-	1.06	
Haemulidae	Caesar grunt	50	2.41	-	5.16	2.35	6	0.60	-	0.75	0.72	13	2.71	-	2.3	
	French grunt	111	5.34	25.23	9.31	4.25	24	2.39	4.17	2.51	2.41	5	1.04	0.00	0.7	
	Smallmouth grunt	17	0.82	-	1.30	0.59	4	0.40	-	0.29	0.28	-	-	-	-	
	Tomtate	2	0.10	-	0.24	0.11	-	-	-	-	-	-	-	-	-	
Holocentridae	Blackbar soldierfish	5	0.24	-	0.50	0.23	8	0.80	-	0.9	0.86	-	-	-	-	
	Longspine squirrelfish	17	0.82	-	2.27	1.04	3	0.30	-	0.43	0.41	2	0.42	-	0.32	
	Squirrelfish	18	0.87	-	3.03	1.38	11	1.10	-	2.17	2.08	16	3.33	-	3.1	
Lutjanidae	Mahogany snapper	54	2.60	44.44	6.39	2.91	11	1.10	0.00	1.99	1.91	7	1.46	0.00	1.2	
Monocanthidae	Orangespotted filefish	73	3.51	-	6.08	2.77	25	2.49	-	2.33	2.24	15	3.13	-	1.52	
	Scrawled filefish	4	0.19	-	2.60	1.19	11	1.10	-	6.07	5.82	3	0.63	-	1.78	
	Whitespotted filefish	1	0.05	-	0.44	0.20	2	0.20	-	0.67	0.64	-	-	-	-	
Mullidae	Spotted goatfish	29	1.40	-	4.58	2.09	1	0.10	-	0.16	0.15	2	0.42	-	0.47	
	Yellow goatfish	81	3.90	0.00	15.12	6.90	1	0.10	0.00	0.29	0.28	4	0.83	-	0.89	
Ostraciidae	Honeycomb cowfish	4	0.19	-	0.216	0.10	14	1.40	-	2.52	2.42	8	1.67	-	1.62	
	Smooth trunkfish	30	1.44	-	2.15	0.98	18	1.79	-	1.12	1.07	11	2.29	-	0.84	
	Spotted trunkfish	1	0.05	-	0.17	0.08	-	-	-	-	-	-	-	-	-	
Pomacanthidae	French angelfish	18	0.87	-	2.50	1.14	15	1.50	-	3.93	3.77	13	2.71	-	2.01	
	Rock beauty	1	0.05	-	0.16	0.07	-	-	-	-	-	-	-	-	-	
Pomacentridae	Sergeant major	24	1.15	-	1.81	0.83	33	3.29	-	2.47	2.37	19	3.96	-	1.41	
Scaridae	Princess parrotfish	155	7.46	0.00	24.72	11.28	8	0.80	0.00	1.76	1.69	4	0.83	0.00	0.9	
	Queen parrotfish	3	0.14		1.27	0.58	-	-	-	-	-	-	-	-		
	Redband parrotfish	136	6.54	0.74	17.19	7.84	18	1.79	0.00	3.13	3.00	6	1.25	0.00	1.05	
	Stoplight parrotfish	1	0.05	-	0.08	0.03	-	-	-	-	-	-	-	-	-	
	Striped parrotfish	-	-	-	-	-	1	0.10	-	0.18	0.17	-	-	-	-	
Sciaenidae	Spotted drum	1	0.05	-	N/A	N/A	-	-	-	-	-	-	-	-	-	
Serranidae	Coney	4	0.19	-	1.40	0.64	-	-	-	-	-	1	0.21	-	0.36	
	Graysby	25	1.20	-	6.52	2.97	12	1.20	-	3.36	3.22	7	1.46	-	2.01	
	Red hind	-	-	-	-	-	-	-	-	-	-	1	0.21	-	0.23	
Sparidae	Saucereye porgy	1	0.05	-	0.62	0.28	-	-	-	-	-	-	-	-	-	
Totals	40	2078	100		219.16	100	1003	100		104.23	100	480	100		55.79	

Table 3. Comparison of fishing performance for juveniles of key fish species among conventional, experimental and large mesh traps at Oistins Bay, Barbados from July to September 2002

Characteristic	Trap Design			K-W test statistics		
	Conventional	Experimental	Large mesh	n	H	p-value
N (no. hauls examined)	55	55	55			
Total number of juveniles caught	927	471	145			
Total weight of juveniles caught (kg)	63.55	36.35	10.24			
Mean number juveniles/trap/haul	13.71	7.76	1.71	165	99.99	< 0.001
Mean weight juveniles/trap/haul (kg)	0.946	0.573	0.149	165	90.76	< 0.001
% by number of juveniles/trap/haul	57.41	57.16	30.24	165	32.62	< 0.001
Mean number of deep-bodied juveniles/trap/haul	13.33	7.75	1.73	165	97.59	< 0.001
Mean fork length of key species juveniles (cm)	14.07	14.30	14.95	1542	73.96	< 0.001
Mean weight of key species juveniles (kg)	0.069	0.074	0.086	1542	108.88	< 0.001
Mean body depth of key species juveniles (cm)	5.80	6.02	6.47	1542	163.75	< 0.001
Mean body depth of banded butterflyfish juveniles (cm)	5.84	6.45	6.61	42	9.85	0.007
Mean body depth of blue tang juveniles (cm)	6.25	6.34	6.56	35	1.91	0.385*
Mean body depth of doctorfish juveniles (cm)	6.39	6.43	6.96	241	22.32	< 0.001
Mean body depth of ocean surgeon juveniles (cm)	5.74	5.96	6.03	1171	90.77	< 0.001

* Indicates no significant differences among trap designs

Juvenile Catch Rates

Juvenile catch rates by number and by weight of fish per trap haul varied significantly among trap designs (Kruskal Wallis tests: for number of fish, $H = 99.99$, $n = 55, 55, 55$, $p < 0.001$; for weight of fish, $H = 90.76$, $n = 55,55,55$, $p = 0.001$). Post hoc multiple comparisons confirmed that catch rates by number and weight differed significantly between each trap design (Table 4). Experimental traps caught considerably fewer juveniles per trap haul (7.76 fish per haul) than conventional traps (13.71 fish per haul), but considerably more juveniles than large mesh traps (1.71 fish per haul) (Table 3). The weight of juveniles caught by experimental traps (0.573 kg per haul) was also much lower than for conventional traps (0.946 kg fish per haul), but much higher than for large mesh traps (0.149 kg fish per haul) (Table 3).

Catch rate comparisons among traps for deep-bodied species were similar to those for all species; differing significantly among traps (Kruskal-Wallis test: $H = 97.59$, $p < 0.001$) and between all trap designs (Nemenyi test: $p < 0.001$ in all cases; Table 4). The experimental and large mesh traps captured too few round-bodied juveniles to justify statistical comparison. It remains possible however, that the alternative trap designs may be selecting against round-bodied juveniles more effectively than conventional traps

Despite the clear difference in catch rates of juveniles among the different trap designs, the proportion of the catch comprising juveniles differed among traps (Kruskal-Wallis test: $H = 32.62$, $n = 55,55,55$, $p < 0.001$; Table 3) but not between all traps (Table 4). Experimental traps caught on average 57.2% of juvenile fish per trap haul, and this did not differ significantly from conventional traps (57.4% juveniles), although both experimental and conventional traps caught a significantly higher proportion of juveniles than the large mesh traps (30.2%) (Tables 3 and 4). This indicates that out of the alternative trap designs, only the large mesh trap was effective in selecting against juveniles in the catch. Experimental traps caught fewer juveniles than conventional traps only because they caught fewer fish in general.

Size of Juveniles

Juveniles differed significantly in size (by body depth, fork length, and weight) among trap designs (Kruskal-Wallis tests, $p < 0.001$ in all cases; Table 3). These differences were significant between each trap design (Dunn tests, $p < 0.001$ in all cases; Table 4). Juveniles caught by experimental traps were slightly larger (by body depth, fork length and weight) than those caught by conventional traps, and slightly smaller than those caught by large mesh traps (Table 3). This pattern also emerged for the BD of all four species examined separately (banded butterflyfish, doctorfish, ocean surgeon, blue tang) but was not significantly different among trap designs for blue tang (Tables 3 and 4).

Table 4. Post hoc non-parametric multiple comparison results for juvenile catch rates and sizes among conventional, experimental and large mesh trap designs in Oistins Bay, Barbados from July to September 2002.

Characteristic	Comparison	Statistical Test	Q_{cal}	$Q_{\alpha=0.05,3}$	Sign. difference
Number of juveniles / haul	conventional vs experimental	Nemenyi	44.51	2.394	yes
	conventional vs large mesh		111.10	2.394	yes
	experimental vs large mesh		66.59	2.394	yes
Weight juveniles / haul	conventional vs experimental	Nemenyi	41.50	2.394	yes
	conventional vs large mesh		105.78	2.394	yes
	experimental vs large mesh		64.28	2.394	yes
% juveniles / haul	conventional vs experimental	Nemenyi	0.79	2.394	no
	conventional vs large mesh		54.25	2.394	yes
	experimental vs large mesh		55.04	2.394	yes
Number of deep-bodied juveniles / haul	conventional vs experimental	Nemenyi	84.00	2.394	yes
	conventional vs large mesh		216.14	2.394	yes
	experimental vs large mesh		132.14	2.394	yes
Weight of juveniles	conventional vs experimental	Dunn	515.03	2.394	yes
	conventional vs large mesh		1140.76	2.394	yes
	experimental vs large mesh		625.73	2.394	yes
Fork length of juveniles	conventional vs experimental	Dunn	573.61	2.394	yes
	conventional vs large mesh		1189.18	2.394	yes
	experimental vs large mesh		615.58	2.394	yes
Body depth of juveniles	conventional vs experimental	Dunn	462.53	2.394	yes
	conventional vs large mesh		1084.78	2.394	yes
	experimental vs large mesh		622.25	2.394	yes
Body depth of banded butterflyfish juveniles	conventional vs experimental	Dunn	7.54	2.394	yes
	conventional vs large mesh		10.69	2.394	yes
	experimental vs large mesh		3.14	2.394	yes
Body depth of doctorfish juveniles	conventional vs experimental	Dunn	103.93	2.394	yes
	conventional vs large mesh		119.30	2.394	yes
	experimental vs large mesh		15.37	2.394	yes
Body depth of ocean surgeon juveniles	conventional vs experimental	Dunn	288.35	2.394	yes
	conventional vs large mesh		840.15	2.394	yes
	experimental vs large mesh		551.80	2.394	yes

Species Composition of Juvenile Catches

Species composition of the juvenile catch of key species indicated that the majority (96.5%) of species retained in all trap designs were deep-bodied and the predominant species caught were ocean surgeon and doctorfish in all cases (Table 5). All trap designs caught the same four deep-bodied species, but appeared to differ in the diversity of round-bodied species captured. Experimental traps caught one juvenile round-bodied species, whereas conventional traps caught fifty-three and large mesh traps caught none (Table 5). However, the relative abundance of key species within the catch was similar among trap designs (Kendall's concordance test: $W = 0.735$, $X^2 = 13.23$, $n = 3$, $p = 0.001$), indicating that key species composition of the juvenile catch is not affected by trap design.

DISCUSSION

The experimental trap design clearly caught fewer juvenile fish of all key species, fewer deep-bodied juveniles, and larger sized juveniles than the conventional small mesh trap design currently used by commercial reef fishers in Barbados. This is consistent with expectations based on previous studies using larger mesh in traps (e.g. Rosario and Sadovy 1991, Sary et al. 1997, Robichaud et al. 1999, Mahon and Hunte 2001) or escape slits (e.g. Munro et al. in press). On the face of it, therefore, this alternative trap design would seem to be achieving the management objective of reducing juvenile mortality, at least in the key species taken by the trap fishery. Furthermore, trap fishers involved in the study perceived that the fishable life of the experimental trap would be comparable to the conventional trap and would therefore be acceptable as an alternative. However, the experimental trap design did not reduce juvenile catch rates to the same extent as the large mesh trap design, nor was the mean size of juveniles as large as those retained in the large mesh traps. It would therefore be a less effective design (albeit longer-lasting) than the large mesh trap in reducing juvenile fish mortality, although the economic impacts on fishers in the short-term are likely to be less.

More importantly, the experimental trap design failed to reduce the proportion of juveniles in the catch compared with the conventional trap design, although the large mesh trap design was successful in this regard. This illustrates that the reduction in juvenile catch rates of experimental traps compared with conventional traps comes from a reduction in the overall catch rate of the trap, rather than an effective selection against the capture of juveniles. As such, the experimental trap design will be seen as an inefficient gear for the capture of reef fish, with potential negative economic impacts on fishers. It is therefore unlikely to be acceptable as a viable alternative for the purpose of managing a reduction in juvenile reef fish mortality.

Table 5. Key species composition of juvenile catches shown as numbers of fish and percent of total juveniles caught for conventional, experimental and large mesh trap designs in Oistins Bay, Barbados from July to September 2002

Body Type	Species	Conventional		Experimental		Large Mesh		All Traps	
		No. juv.	% total juv.	No. juv.	% total juv.	No. juv.	% total juv.	No. juv.	% total juv.
Deep-bodied	banded butterflyfish	23	2.48	11	2.34	8	5.52	42	2.82
	blue tang	20	2.05	10	2.12	5	3.45	35	2.35
	Doctorfish	135	14.56	67	14.23	39	26.90	241	16.19
	ocean surgeon	696	75.08	382	81.10	93	64.14	1171	78.64
Sub-total		874	94.17	470	99.79	145	100	1489	96.50
Round-bodied	french grunt	28	3.02	1	0.20	0	0	29	53.70
	mahogany snapper	24	2.59	0	0.00	0	0	24	44.44
	princess parrotfish	0	0.00	0	0.00	0	0	0	0
	redband parrotfish	1	0.11	0	0.00	0	0	1	1.85
	yellow goatfish	0	0.00	0	0.00	0	0	0	0
Sub-total		53	5.72	1	0.20	0	0	54	3.50
Total		927	100	471	100	145	100	1543	100

The low proportion of round-bodied juveniles of the key species taken by all the traps is interesting, particularly given that the maximum vertical aperture of the small mesh (3.18 cm) is less than that of the BD_m of all of the species (Table 1). This suggests that the fish are capable of squeezing through mesh slightly smaller than their maximum body depth (as suggested by Robichaud et al. 1999) and/or escaping by swimming out sideways, given that the maximum horizontal aperture is 4.2 cm. The larger BD_m of french grunt and mahogany snapper compared with the other round-bodied species (Table 1), probably explains why these two species were the most abundant of the round-bodied species in the juvenile catch (Table 5).

By contrast, more juveniles of the deep-bodied species were retained in the experimental trap design than was anticipated, given that the BD_m values for three of the four deep-bodied species were less than 7 cm (the height of the escape slit) (Table 1). This would suggest that they were not using the escape slit effectively. The lower proportion of juveniles in the catches of large mesh traps (compared with experimental and conventional designs) is largely explained by a reduction in the percentage of juvenile ocean surgeon, banded butterflyfish and doctorfish caught (Table 2). This is not easily explained by the BD_m values of these species, especially for doctorfish with a BD_m of 8.8 cm, which is considerably larger than the vertical aperture (3.8 cm) or maximum horizontal aperture (5.9 cm) of the large mesh. These results would suggest (contrary to the general findings of Robichaud et al. 1999) that ingress rates for these species are less in the large mesh traps.

The Barbados 2001-2003 Fisheries Management Plan states the importance of the reef fish resource as primarily for local consumption and employment (harvest use) and secondarily for tourism (non-harvest use), and emphasizes the need for reduced mortality of juveniles. The results of this study indicate that implementing a move to the large mesh fish trap design would effectively reduce catch rates of juvenile fish. However, the economic hardship associated with greatly reduced overall catches, and the need to replace traps more frequently than the stronger small mesh traps currently used by fishers is likely to be unacceptably high. The experimental design would pose less of an economic burden on fishers in terms of the reduction in catch rates and gear replacement costs, but their failure to select against the capture of juveniles negates their usefulness as a management option. In the absence of effort restrictions, fishers could simply fish more of the inefficient traps to maintain the current overall catch levels. Furthermore, reducing gear efficiency does not adequately address the management goal of reduced levels of juvenile mortality with minimum impact on fishers. An overall reduction in catch rates could be equally well achieved by more conventional methods such as limiting the number of traps used in the fishery, rather than reducing the fishing efficiency of the gear itself.

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Spatial and Temporal Recruitment Patterns of Juvenile Grunts (*Haemulon* spp.) in South Florida

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ABSTRACT

Grunts (Haemulidae) are important fisheries species and represent a major component of reef fish communities in the Greater Caribbean region. To date, little is known about their recruitment patterns. Data from more than 2,000 visual fish counts from multiple natural and artificial reef studies in Broward County, Florida, over a seven-year period, were examined to identify both spatial and temporal trends in recruitment of juvenile (*i.e.*, < 5cm TL) grunts of the genus *Haemulon*. In general, data from these studies indicate that juvenile *Haemulon* spp. recruitment increases in the spring and peaks in the early summer months (*i.e.*, June and July). Data from natural reef surveys revealed a predominantly nearshore preference for recruitment in water depths less than 8 m. However, on artificial reefs, recruitment commonly occurred at 20 m depths. The biotic and abiotic factors determining the settlement of grunts are not clear and will be examined in future studies.

KEY WORDS: Recruitment, Reef Fish, Visual Census

Patrones Espaciales y Temporales en el Reclutamiento de Juveniles de Roncos (*Haemulon* Spp.) en el Sur de Florida (Estados Unidos de América)

Los roncos (Haemulidae) son especies importantes en las industrias pesqueras del Caribe. Poco se sabe acerca de sus patrones de reclutamiento. Este estudio examinó los patrones espaciales y temporales en el reclutamiento de juveniles de *Haemulon* spp. (< 5cm TL) en el condado de Broward, Florida. Los datos indicaron que el reclutamiento máximo ocurrió durante el comienzo del verano (i.e., junio y julio). Los resultados también mostraron que en arrecifes naturales, el reclutamiento de *Haemulon* spp. ocurrió en densidades más altas en los sitios más cercanos a la orilla. En los arrecifes artificiales, el reclutamiento de *Haemulon* spp. también mostró una preferencia por las zonas poco profundas.

PALABRAS CLAVES: Reclutamiento, roncos, *Haemulon* spp.

INTRODUCTION

Grunts (Haemulidae) represent a substantial, and in some cases dominant, component of Greater Caribbean reef fish assemblages. Three genera comprise the family Haemulidae in the western Atlantic: *Haemulon*, *Anisotremus*, and *Orthopristes*. Of these, *Haemulon* is the most speciose genus with 15 western Atlantic species (Froese and Pauly 2002). This genus is also more frequently encountered in South Florida than the other two genera (Stark and Davis 1966). Although the ecology and behavior of adult *Haemulon* spp. have been documented, little is known about their settlement strategies.

Like other fishes that associate with coral reefs, *Haemulon* spp. have a pelagic larval stage, followed by demersal juvenile and adult stages. Pelagic larval duration is shorter compared to many other reef fish genera, with one species, the French grunt (*Haemulon flavolineatum*), settling 15 days after hatching (McFarland et al. 1985). Settlement for this genus has been recorded on a variety of habitats including mangroves, seagrass beds, patch reefs, wormrock, low relief nearshore hardbottom, and artificial reefs. After settlement, newly settled (< 2cm) juveniles often live within multicohort, congeneric schools feeding on plankton and trying to avoid the most common fate of mortality due to predation (McFarland 1980, Shulman and Ogden 1987). Newly settled *Haemulon* spp. are difficult to identify to species level because of similar pigmentation patterns (Lindeman 1986). If newly settled individuals survive the intense predation pressure, they will grow, enter the early juvenile stage (~2-5cm), and undergo an ontogenetic shift in habitat use and feeding behavior. Early juveniles no longer feed exclusively on plankton. They forage on infaunal and epifaunal invertebrates (though exceptions exists) and, presumably as a result, begin to develop adult coloration patterns (Lindeman 1986). It has also been suggested that this ontogenetic change in feeding behavior is associated with a relatively short migration to a different habitat (Lindeman 1986). Once adult pigmentation patterns begin to emerge, *Haemulon* spp. may migrate further offshore to deeper waters or continue to live as a member of the shallow reef community (McFarland and Wahl 1996).

This paper examines the temporal and spatial recruitment patterns of juvenile *Haemulon* spp. in Broward County, Florida. Data analyzed for this paper were compiled from data acquired in four previously published studies on both natural hardbottom and artificial reef modules. All four studies were designed to test specific hypotheses, which focused on total fish assemblages (including all species). These studies were not designed to examine species-specific differences amongst the haemulids. Due to the difficulty of identifying newly settled and early juveniles and the time constraints placed on observers using SCUBA, all species in the genus *Haemulon* were grouped together in these studies. The present work was designed as a preliminary examination of *Haemulon* spp. recruitment in general to gain insight for the design of a focused, hypothesis-directed investigation of the species-specific cross-shelf spatial patterns of *Haemulon* recruitment.

METHODS

Data from four separate studies in Broward County, Florida were used to examine the local spatial and temporal patterns of juvenile *Haemulon* spp. abundance. Because of the unique ontogenetic shift in habitat use and feeding behavior fishes of this genus undergo, data were analyzed, where applicable, in terms of two life stages: newly settled individuals (< 2cm TL) and early juveniles (2 - 5 cm TL). Of the four separate studies included in this analysis, three examined artificial concrete reef modules (Reefball®, Gilliam-Spieler [hereafter GS] modules, and Isolation studies) and one examined natural hardbottom. One study used replicate Reefball® molds to construct replicate patch reefs. For the present study, data collected monthly from ten Reefballs ("pallet balls", 1.3 m x 1 m) deployed on a sand flat at 21 m were compared to ten deployed at 7 m depth over 18 months from April 1995 to October 1996 (Sherman et al. 2002). No data were collected in October 1995 due to rough sea conditions. For the GS module (aka Fish Condo) study, replicate 1 m^3 modules were constructed using concrete block amalgamated with waste concrete and rebar. Ten GS modules deployed at 21 m and ten at 7 m depth were censused monthly from January to October 1996 (Gilliam 1999, Sherman 2000). The Isolation study, which examined the effects of reef isolation distance on the associated reef fish assemblage, also used GS modules as replicate patch reefs (Jordan 2002, Jordan et al. in prep.). Modules were positioned at the apices of four equilateral triangles with side lengths of: 0.33 m, 5 m, 15 m, and 25 m; each with two replicates. Two additional treatments were used here to examine the effects reef size (i.e., volume): a solitary module and two modules side by side. The Isolation study was performed at only one depth (7 m) and only used to examine temporal trends in *Haemulon* spp. abundance. In the three studies using artificial reef modules, data were collected by recording the abundance of every species present within one meter of the modules. Then, each fish was assigned into one of five size classes based on total length (TL): < 2 cm, 2 - 5 cm, 5 - 10 cm, 10 - 20 cm, and > 20 cm. For this paper only, *Haemulon* spp. from the smallest two size classes were extracted from the data sets.

Data from the fourth study were collected using a different visual census technique. The Natural Hardbottom study used the Bohnsack and Bannerot (1986) point-count method as the census technique. In this method a diver remains stationary at the center of a 15 m diameter cylinder that extends from the bottom to the surface. During the initial five minutes, all species present within the cylinder are recorded. When the five minutes have passed, the abundance of each species present in the cylinder is recorded and, for all species, a mean, minimum and maximum total length (cm TL) were assigned. For the purpose of the present study, only juvenile *Haemulon* spp. with a maximum size of 5cm TL were analyzed from 483 point-counts. The three reef tracts in Broward County, Florida, USA, run parallel to the coastline in sequentially deeper water separated by sand. The Inshore reef ranges from 3 m to 5 m depth while the Middle reef crests at 5 m and extends down to 20 m depth. The crest of the Offshore reef is at 15 m with the eastern edge reaching past 30 m depth. Point-counts were performed on the crest, eastern, and western

edges of each of the three reef tracts making a cross-shelf transect with nine point-counts each. Transects were separated by 0.463 km (0.25 nautical miles) (see Ettinger et al. 1999 for a full description of the study site). The Deep GS and Deep Reefball module sets were deployed in the sand flat separating the Middle and Offshore reef tracts while the Shallow GS, Shallow Reefball, and Isolation study modules were deployed in the sand flat between the Inshore and Middle reef tracts.

Due to the diverse methodologies among studies the data were not combined; data from each study were analyzed separately. Prior to ANOVA tests, abundance data were examined to see if they significantly differed from a normal distribution. If found to be non-normal, data were $\log_{10}(x+1)$ transformed to homogenize variances. A one-way parametric ANOVA was then performed. If significant differences ($\alpha = 0.05$) were found, a *post hoc* Newman-Keuls test was used to identify the differences among means. A T-test for dependent samples was performed to compare the abundances of newly settled individuals and early juveniles (Statistica v6, Softstat, Inc. 2001).

RESULTS

Spatial Distribution

Reefball Study — In this study (April 1995 - October 1996), comparison between Shallow (7m depth) and Deep (21 m depth) sets of modules showed the Shallow set had a significantly greater abundance of newly settled individuals (< 2 cm TL) than the Deep set of modules (Shallow: 10.39 ± 1.87, Deep: 3.35 ± 1.01 [mean ± 1SE]). However, when early juvenile (2 - 5 cm TL) abundance was compared between the same sets of modules, no significant differences arose (Shallow: 3.13 ± 1.06, Deep: 0.80 ± 0.25 [mean ± 1SE]).

Gilliam-Spieler (GS) Modules Study — This study (Jan-Oct 1996) compared fish assemblages at two depths, GS modules demonstrated no significant differences in abundance of newly settled *Haemulon* spp. when comparing sets of modules at 7m and 21 m depth (Shallow: 6.67 ± 1.78, Deep: 12.10 ± 6.01 [mean ± 1SE]). When the early juvenile abundance was compared among the same sets of modules at differing depths, the 7 m depth set had a significantly higher abundance than the modules at 21 m depth (Shallow: 20.85 ± 4.06, Deep: 16.17 ± 4.61 [mean ± 1SE]).

Natural Hardbottom Study — Analysis of juvenile *Haemulon* spp. (< 5cm TL) data from natural reef sites (Aug 1998 - May 2002) revealed a distinct spatial pattern. Juvenile *Haemulon* spp. abundance appeared to decrease away from shore. The Inshore reef tract had significantly more juvenile *Haemulon* spp. than both the Middle and Offshore reef tracts, which lacked significant difference from one another (Figure 1). With the three reef tracts separated into their respective census sites (i.e., western reef edge, reef crest and eastern reef edge), creating a more

detailed representation of the shelf profile, the apparent trend of decreasing *Haemulon* spp. abundance moving offshore was again present. The most nearshore site, the western edge of the Inshore reef (referred to as the Inshore West site), had significantly more juvenile *Haemulon* spp. than any other census site (Fig. 2). The other two Inshore reef census sites (Inshore Crest and Inshore East sites) had a significantly higher abundance than the remaining Middle and Offshore reef census sites, which lacked difference from one another. In fact, of the 320 censuses performed on the Middle and Offshore reef tracts, juvenile *Haemulon* spp. were recorded during only 11 counts: six times on the Middle West, three times on the Middle Crest, once on the Middle East and Offshore East, and never on the Offshore West and Offshore Crest census sites.

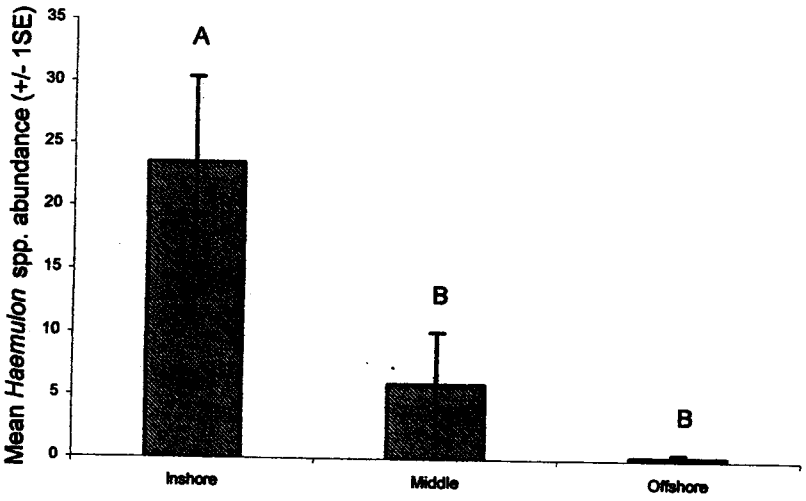

Figure 1. Mean abundance of juvenile (< 5 cm TL) *Haemulon* spp. on the three natural reef tracts when pooling all reef census sites. Newman-Keuls grouping letters that are the same are not significantly different ($p > 0.05$).

Temporal Distribution

Reefball Study — Both newly settled and early juvenile *Haemulon* spp. abundance appeared to be higher in the summer. Although significantly different, pooling data from Deep (21m depth) and Shallow (7m depth) sets of modules suggested that, with few exceptions, newly settled individuals were normally more abundant than early juveniles (Figure 3). This was substantiated by a T-test for dependent samples

($p < 0.05$). In fact, early juvenile abundance was qualitatively higher in only three of a possible 18 months: August 1995, March 1996, and October 1996. The opposite was found on the GS modules (see below). For the GS module study, early juvenile abundance was significantly higher than newly settled individual abundance (T-test for dependent samples).

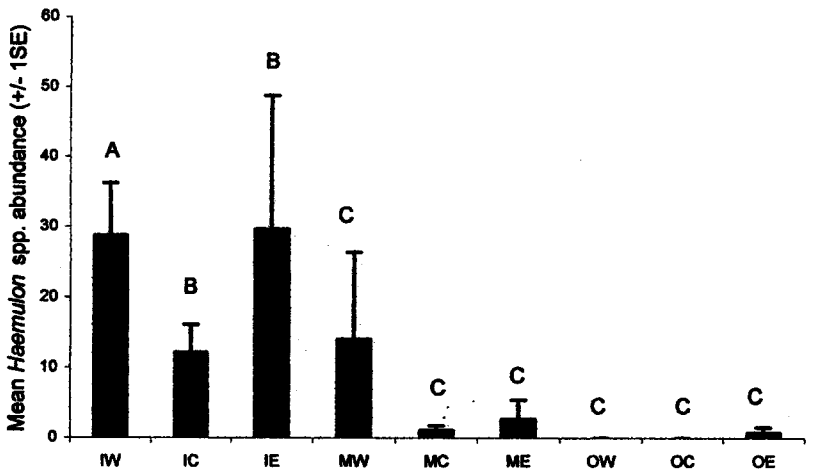

Figure 2. Mean abundance of *Haemulon* spp. juveniles (< 5 cm) on reef census sites: IW = western edge of Inshore reef, IC = crest of Inshore reef, IE = eastern edge of Inshore reef, MW = western edge of Middle reef, MC = crest of Middle reef, ME = eastern edge of Middle reef, OW = western edge of Offshore reef, OC = crest of Offshore reef, OE = eastern edge of Offshore reef. Newman-Keuls grouping letters that are the same are not significantly different ($p > 0.05$).

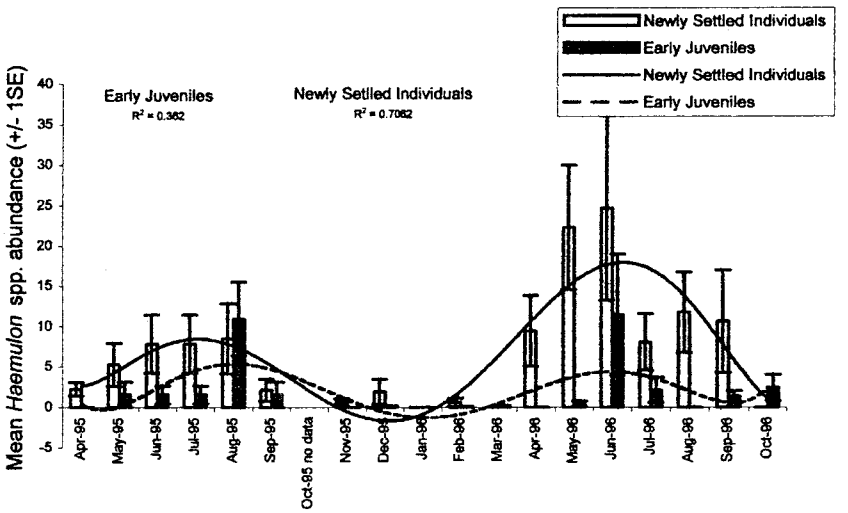

Figure 3. Monthly mean abundance of newly settled and early juvenile *Haemulon* spp. on Reefball modules pooling Deep (21 m) and Shallow (7 m) sites.

Gilliam-Spieler (GS) Module Study — As mentioned above, the abundance of newly settled individuals lacked significant differences between Deep and Shallow module sets. When pooling these data, the abundance of newly settled fishes exhibited a significantly smaller magnitude than early juveniles (T-test for dependent samples) and lacked significant differences among months (Figure 4). In contrast, early juvenile abundance exhibited significant differences between the module sets at differing depths. Nevertheless, when pooling these data, early juvenile *Haemulon* spp. abundance on the Deep set of modules appeared to exhibit a pattern similar to the Shallow set of modules, although the summer abundance increase was more precipitous (Figure 5). From May to June 1996, early juvenile abundance increased from means 0.10 to 81.00, respectively. After June, abundance gradually decreased.

Isolation Study — In Jordan and coauthors (in prep.), significant differences were found for the abundance of newly settled individuals but not for early juveniles among treatments with different amounts of isolation distance separating the three modules. However, when pooling all isolation treatments by month, significant differences occurred for both newly settled and early juvenile abundances. Using pooled data from different treatments likely increased the variability of the monthly means; nevertheless, temporal trends appeared to exist for both life history stages (Figure 6). During 1999, the abundance of newly settled individuals appeared to be higher from May to July. In 2000, abundance appeared to increase in late winter/early spring, peaking in March. At the end of this study, the abundance of newly settled individuals again increased from July to September, suggesting another

large settlement pulse. Early juveniles also appeared to exhibit a temporal trend in abundance. Although present for every monthly data collection, the abundance of early juveniles increased in the spring months, and peaked in the summer months (*i.e.*, June, July, August). Examination of 2000 data revealed an increase in early juveniles coinciding with a decrease in newly settled *Haemulon* spp. This apparent temporal lag between newly settled and early juveniles may be the result of transition of newly settled individuals into early juveniles. As newly settled individuals grew past 2 cm TL, they entered the early juvenile size category. However, this transition alone could not account for the abundance increase of early juveniles considering peak early juvenile abundance is substantially greater than the peak abundance of newly settled individuals.

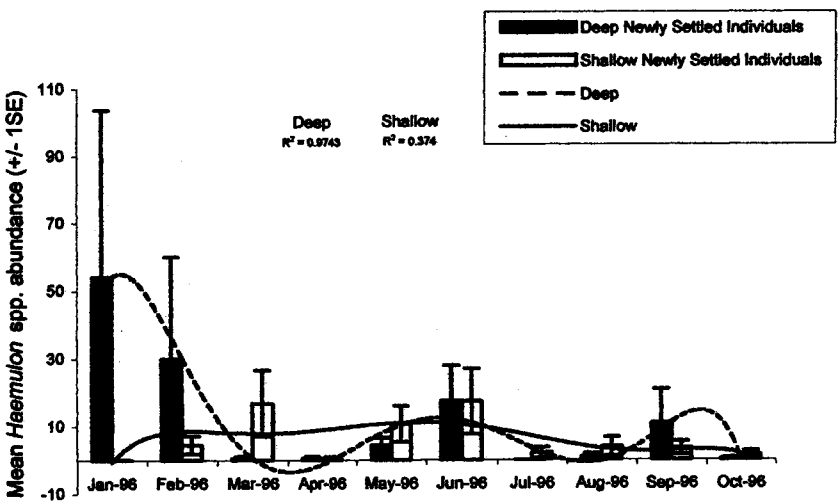

Figure 4. Monthly mean abundance of newly settled *Haemulon* spp. on Gilliam-Spieler modules deployed at Deep (21m) and Shallow (7m) sites.

Natural Hardbottom Study — Locating temporal trends in abundance of juvenile *Haemulon* spp.(< 5cm TL) is problematic in the Natural Hardbottom study data. The data were collected sporadically during the year with the majority taken during summer months, nor was sampling effort evenly divided among the three reef tracts throughout the year. Regardless of these obvious sources of error, juvenile *Haemulon* spp. abundance appeared to be lower in winter months and higher in spring and summer months (Figure 7). Although not substantiated by ANOVA, this temporal trend appears consistent with the findings from the other studies.

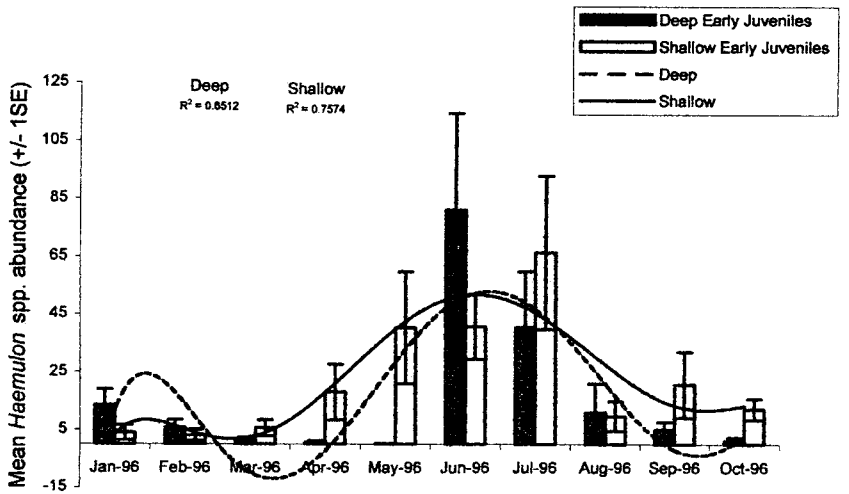

Figure 5. Monthly mean abundance of early juvenile *Haemulon* spp. on Gilliam-Spieler modules deployed at Deep (21m) and Shallow (7m) sites.

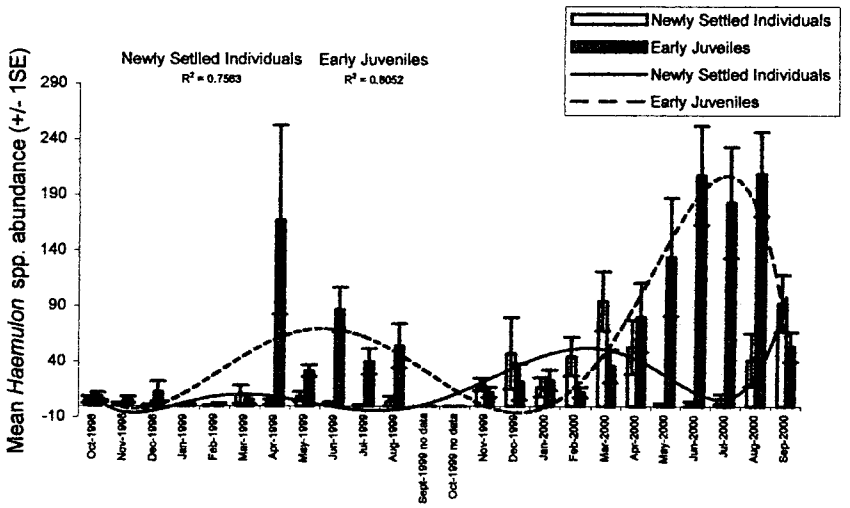

Figure 6. Monthly mean abundance of newly settled and early juvenile *Haemulon* spp. on Isolation study.

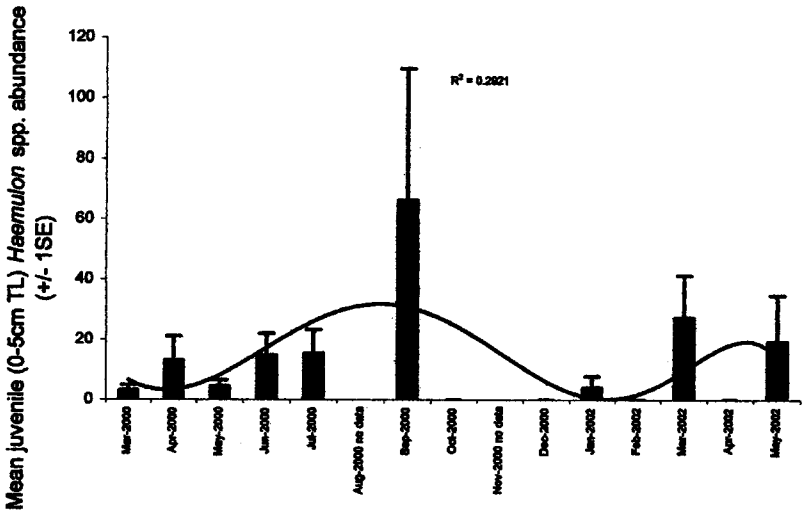

Figure 7. Monthly mean abundance of juvenile (<5cm TL) *Haemulon* spp. on Natural Hardbottom study.

DISCUSSION

Data from the four studies, over several different years, indicated a similar spatial (cross-shelf) and temporal pattern of juvenile *Haemulon* spp. abundance. The study examining fishes on the Natural Hardbottom revealed that juvenile *Haemulon* spp. may show preference for a shallow, nearshore habitat. On reef census sites deeper than approximately 10 m, juveniles were rarely recorded. These findings are consistent with the results of other studies. Lindeman and Snyder (1999) found that over 80% of fishes recorded on nearshore hardbottom sites offshore Jupiter, Florida were juveniles. In St. Croix, juvenile French grunts (*H. flavolineatum*) and white grunts (*H. plumieri*) commonly associated with shallow patch reefs with adjacent sea grass beds (Ogden and Ehrlich 1977). It is often postulated that juveniles of a variety of species use shallow water habitats as a nursery (Lindeman et al. 2000). Our data for the Natural Hardbottom portion of this study certainly suggest that this may be so, however, data from the Reefball and GS module studies are contradictory. Newly settled and early juveniles were commonly found at 21m depth on artificial reefs modules. Additionally, artificial reef modules deployed at both 7m or 21m depth had a more than an order of magnitude higher density of juvenile (< 5cm TL) *Haemulon* spp. than the nearshore-most hardbottom in Broward County, where juvenile abundance is normally highest (Sherman 2000, Baron and Spieler in review). Why? The obvious answer would appear to be refuge

from predators. Artificial reefs deployed in an area where essentially no natural refuge exists, such as a sand flat, allow fish to live where they normally would not. Because newly settled and early juvenile *Haemulon* spp. are capable of recruiting to and living at these depths, it is difficult to acknowledge the nearshore environment as *essential* fish habitat and provides a cautionary note to the assumption that abundance implies preference (Wilbur 2000). It may be that use of shallow water habitats by *Haemulon* spp. is not obligatory but simply recruitment to the best available habitat.

Gilliam (1999) found significant increases in newly settled and early juvenile *Haemulon* spp. abundance on modules enclosed with caging material that increased refuge from predators, verses uncaged controls. In another study, concrete block was added to the internal void space of Reefballs to create additional refugia. Again, the result was a significant increase in *Haemulon* spp. abundance when compared to the control treatment (no block) (Sherman 2000). Although these studies demonstrate the importance of refugia, the quantity/quality of refuge cannot be the only determinant for cross-shelf distributional patterns of juvenile *Haemulon* spp. Vertical profile and rugosity, topographical attributes thought to create shelter for fishes, are substantially higher on the Offshore and Middle reef tracts in Broward County, Florida (authors' unpub. data). Yet, the results of the Natural Hardbottom study indicate the Inshore reef tract has the highest abundance of juvenile *Haemulon* spp. If refugia are the sole determinant of distribution and refuge is in greater supply on the Offshore and Middle tracts, why are juveniles not regularly present there? We can only speculate. It is possible that predators are less abundant or efficient in the nearshore environment. There is also the possibility that residents (*e.g.*, territorial damselfishes [Pomacentridae]) already residing on the Middle and Offshore tracts competitively exclude juveniles. Differences in food supply and variety may also be responsible for the distributional patterns. Further experimentation is required before the determinant(s) of *Haemulon* spp. distributional patterns are found.

Lighty (1977) noted the presence of at least three relict coral ridges, in sequentially deeper waters, following the coastline of Dade, Broward and Palm Beach Counties; a product of reef development at differing sea-levels. At our current sea-level status, these ridges do not form leeward protected waters (lagoon). Therefore, patch reefs, by definition, are nonexistent and seagrass beds and mangroves are limited to the intracoastal waters leeward of the barrier island. In Curacao, Netherlands Antilles, juveniles of two grunt species (*H. parra* and *H. sciurus*) exhibited dependence for mangroves and seagrass beds (Nagelkerken et al. 2001). In Broward County, seawalls commonly border intracoastal waterways where mangroves once existed. In a study examining the differences in fish assemblages on natural and mitigated mangrove areas in Broward County, no juvenile *Haemulon* spp. were recorded (Roberts 1994 unpub. MS thesis). Although an extensive ichthyofaunal study of seagrass beds in our area has not been performed, data collected from our area suggest the most densely populated natural area of juvenile *Haemulon* spp. exists on the most inshore hardbottom habitat (Baron and Spieler in review). In Barbados, Tupper (1989) also found that juvenile

haemulids often settle onto reefs. Our results do not necessarily contradict the study conducted in Curacao because, in our area, the most abundant juvenile taxa are *H. aurolineatum* and *H. flavolineatum* (Bristol et al. in prep.). In Nagelkereken and coauthors (2001), *H. aurolineatum* was apparently not common enough to warrant analysis and *H. flavolineatum* exhibited only slight dependence to mangroves and seagrass beds. In contrast, to the Curacao study, early juvenile *H. parra* was one of the most abundant taxa found in a study examining nearshore hardbottom sites (Lindeman and Snyder 1999). This finding challenges the results of the Nagelkerken and coauthors (2001) study and implies a facultative rather than obligatory dependence for mangroves and seagrass beds for *H. parra* and probably other species.

While juvenile *Haemulon* spp. were present year-round in three of the four studies (all three used reef modules), summer months had the highest abundances in all studies, evidence of a possible settlement pulse associated with greater reproductive activity during certain months of the year (Munro et al. 1973). In contrast, most reef fishes appear to settle during a particular time of year (Williams and Sale 1981). Even though data from the present study indicate maximum abundance of juvenile *Haemulon* spp. occurs in summer months, it is unknown if this apparent seasonal peak is reflected by a broad time interval of recruitment for all (or most) species or if it is a composite signal of many species-specific uni- or multimodal recruitment peaks. Obviously, this information is critical for effective management.

With the caveat that it is risky to draw conclusions from small differences in length data derived from visual censuses (Sherman et al. 1999), one of the more interesting findings of the present study was the apparent difference in peak abundance between newly settled individuals and early juveniles. Two of the three studies that used artificial reef modules (*i.e.*, Reefball study, and Isolation study) showed the abundance of newly settled individuals increased and peaked a month or two before the abundance of early juveniles peaked (Figures 3 and 6). This lag in the abundance of early juveniles is likely due to a transition corresponding with growth of newly settled individuals. Based on growth curve data for *H. flavolineatum*, a newly settled individual could be promoted to an early juvenile at approximately 45 days after hatching (Brothers and McFarland 1981). Since settlement occurs at approximately 15 days, it would take about one month for a newly settled juvenile to enter the early juvenile stage. This was best shown in the Isolation study (Figure 6). The abundance of newly settled individuals peaked in late spring while early juvenile abundance peaked in the summer. At its peak, early juvenile abundance on the modules, however, more than doubled the peak of newly settled individuals. The logical explanation for this anomaly is emigration from other areas.

In conclusion, the results of this study suggest that, overall, newly settled individual *Haemulon* spp. primarily associate with the nearshore environment, exhibiting highest abundance in late spring/early summer. However, these fishes will settle on artificial reefs in deeper waters at higher densities than the natural

nearshore hardbottom. The determinant(s) for this occurrence are still unknown and it is our intention to examine a variety of post-settlement ecological processes including: predation, competition, and food quality/quantity in future studies. Without knowledge of what drives the cross-shelf patterns of settlement, successful management of haemulids will be guesswork, at best.

ACKNOWLEDGEMENTS

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Edad y Crecimiento de la Mojarra Rayada, *Eugerres plumieri* (Cuvier), en la Ciénaga Grande de Santa Marta, Colombia

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RESUMEN

La edad, crecimiento y mortalidad de la Mojarra rayada (*Eugerres plumieri*) en la Ciénaga Grande de Santa Marta (Colombia) y la información de capturas entre enero y diciembre 1997 fueron analizados para los sitios 1 y 2, respectivamente. Utilizando ELEFAN I, la longitud asintótica (L_∞) estimada osciló entre 40.8 y 40.6 cm de longitud total (LT) y la tasa de crecimiento (K) alcanzó valores de 0.78 y 0.79/años; mientras que con el método de Wetherall (L_∞) osciló entre 45.7 y 41.7 cm de LT. Aplicando la ecuación de Pauly, los valores para la mortalidad natural (M), por pesca (F) y total (Z) variaron de 1.439 a 1.453/años, 1.614 a 1.865/años y 3.053 a 3.318/años, respectivamente. La longitud de captura (Lc) fue de 20.5 cm LT y la tasa de explotación (E) fue de 0.53 y 0.57 para ambos sitios, estos valores confirman que hay sobrepesca sobre el recurso.

PALABRAS CLAVES: Edad y crecimiento, mojarra rayada, *Eugerres plumieri*, Colombia

Age and Growth of Striped Mojarra, *Eugerres plumieri* (Cuvier), in the Cienaga Grande De Santa Marta, Colombia

Age, growth and mortality of the Striped mojarra (*Eugerres plumieri*) from the Cienaga Grande de Santa Marta (Colombia) and the catch's information from january to december 1997 were analyzed for sites 1 and 2, respectively. By using the ELEFAN I, calculated asymptotic length (L_∞) ranged 40.8 and 40.6 cm total length (TL) and growth rate (K) ranged 0.78 and 0.79 y^{-1}. By using the Wetherall's method, L_∞ ranged 45.7 to 41.7 cm TL. Applying Pauly's equation, the values for natural (M), fishing (F) and total (Z) mortalities ranged 1.439 to 1.453 y^{-1}, 1.614 to 1.865 y^{-1} and 3.053 to 3.318 y^{-1} respectively. The length at capture (Lc) was 20.5 cm TL and the exploitation rates (E) were 0.53 and 0.57 and for both sites; this values confirm over fishing of resource.

KEY WORDS: Age and growth, striped mojarra, *Eugerres plumieri*, Colombia

INTRODUCCION

La Ciénaga Grande de Santa Marta (CGSM) (Figura 1) es la mayor laguna costera de características estuarinas de Colombia. Hace parte del plano deltaico del Río Magdalena, ubicada al noroeste del Departamento del Magdalena en el Caribe colombiano, con una extensión de 452 km^2 (IGAC 1973). El grupo de peces más frecuente y más distribuido son las mojarras (familia Gerreidae). La mojarra rayada (*Eugerres plumieri*) presenta ejemplares casi todos los meses del año en ambientes con evidente influencia marina, en la boca de los ríos y en el interior de la laguna, con mayor proporción de hembras en las capturas (Arenas-Granados y Acero 1993). Tiene dos áreas de alimentación: los arrecifes de guijarros y conchas y los fondos de arena y arena-fango (Arenas-Granados 1990), es la principal especie ocupando un lugar destacado en las capturas y tiene el mayor valor comercial (Gallo 1988, Arenas-Granados y Acero 1993, INPA, 1993). Además, la problemática pesquera y ambiental que ha atravesado la ciénaga durante años ha introducido cambios en el desarrollo de su pesquería.

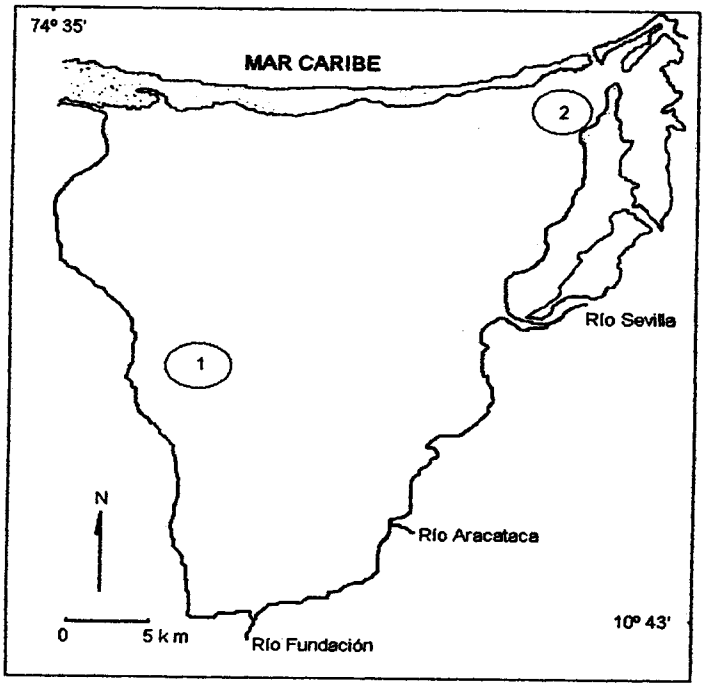

Figura 1. Ubicación de los sitios de muestreo en la Ciénaga Grande de Santa Marta

Por tanto, los objetivos de este trabajo son estimar los parámetros de edad, crecimiento y mortalidad de la mojarra rayada mediante el análisis de la frecuencia de tallas, observando las especificaciones y características técnicas de las artes y métodos de pesca empleados en el área de estudio para identificar los puntos críticos de la pesquería y poder delinear correctivos que permitan una mejor explotación y regulación de su captura.

MATERIALES Y METODOS

Aplicando ELEFAN I (Gayanilo et al. 1988) a la distribución de frecuencia de tallas (longitud total) se estimó la longitud asintótica (L_∞) y tasa de crecimiento (K) de la ecuación de crecimiento de Von Bertalanffy (1938), la cual se expresa así: $L_t = L_\infty \{1-e^{[-K(t-to)]}\}$, en donde: L_t es la longitud media a la edad t, L_∞ es la longitud asintótica, K es la constante a la cual se alcanza L_∞ y to es la "edad" a la longitud cero. t_0 se obtuvo con la ecuación empírica de Pauly (1980): $\text{Log}_{10}(-to) = -0.3922 - 0.2752 \text{Log}_{10} L_\infty - 1.038 \text{Log}_{10} K$. Las mediciones se tomaron en longitud total (LT) hasta el milímetro más cercano y el intervalo de clase utilizado fue de 1 cm. Para comparar las estimaciones de los parámetros de crecimiento, se calculó el Indice de desempeño del crecimiento (ϕ') = $\text{Log}_{10} K + 2 \text{Log}_{10}(L_\infty)$ (Pauly and Munro 1984). La tasa instantánea de mortalidad total (Z) se estimó con el método de tallas convertidas en curvas de captura de Ricker (1975) y Pauly (1983). La tasa instantánea de mortalidad natural (M) se estimó con la ecuación de Pauly (1980): $\text{Log}_{10} M = -0.0066 - 0.279 \text{Log}_{10} L_\infty + 0.6543 \text{Log}_{10} K + 0.4634 \text{Log}_{10} T$, en donde: T es la temperatura media anual del agua en °C. La tasa instantánea de mortalidad por captura (F) se calculó con F= Z-M, la tasa de explotación se obtuvo con la relación (E=F/Z), la talla con que entra a la pesquería y el patrón anual de reclutamiento se obtuvieron con los métodos de Pauly (1987, 1982, respectivamente), los cuales son rutinas de ELEFAN II (Gayanilo et al. 1988). Para caracterizar la pesquería se observaron las artes y métodos de pesca y se consultó toda la información posible para identificar los puntos críticos y plantear algunas medidas que permitan una mejor explotación de la mojarra rayada, apuntando hacia una regulación de su captura y del ordenamiento pesquero en la CGSM.

RESULTADOS

Frecuencia de Tallas

La Figura 2 presenta la distribución para cada sitio de muestreo.

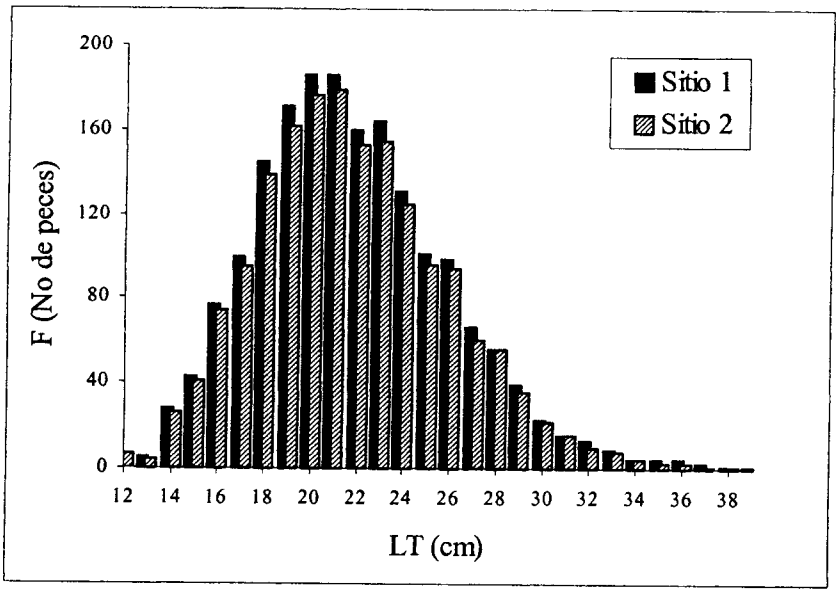

Figura 2. Distribución de frecuencia de tallas para la mojarra rayada.

Parámetros de Crecimiento

Los valores estimados para L_∞, K (Tabla 1) y t_0 fueron 40.8 (± 0.2) cm LT, 0.78 (± 0.01) año^{-1} y 0.734 (± 0.006) años; 40.6 (± 0.2) cm LT, 0.79 (± 0.01)/año y 0.728 (± 0.006) años, para los sitios 1 y 2, respectivamente, con temperatura media anual de 30°C y 95 % de confianza. El valor de t_0 es bajo y no significativamente diferente de cero, asumiéndose como tal. Con los valores anteriores se obtuvo el Indice de desempeño del crecimiento (ϕ'), el cual arrojó valores de 3.113 y 3.115 para los sitios 1 y 2, respectivamente (Tabla 2).

Tabla 1. Parámetros de crecimiento y mortalidad estimados para la mojarra rayada (*Eugerres plumieri*) con ELEFAN 1 y el método de Wetherall.

Metodo	L_∞ (cm)	K (/años)	Z (/años)	M (/años)	F (/años)
ELEFAN					
Sitio 1	40.8	0.78	3.053	1.439	1.614
Sitio 2	40.6	0.79	3.318	1.453	1.865
Weatherall					
Sitio 1	45.7	0.78	4.515		
Sitio 2	41.7	0.79	3.761		

Parámetros de mortalidad

Las tallas convertidas en curvas de captura y sus correspondientes regresiones se observan en la Figura 3. La tasa instantánea de mortalidad total (Z) fue estimada en 3.053 (± 0.2)/año y en 3.318 (± 0.3)/año (con 95 % de confianza) para los sitios 1 y 2. El valor de Z estimado con el método de Wetherall (1986), con K igual a 0.78 y 0.79, fue de 4.515/año y 3.761/año para los sitios 1 y 2, respectivamente (Tabla 1). La mortalidad natural (M) se estimó en 1.439/año y 1.453/año. La mortalidad por captura (F) se calculó con F= Z - M, en 1.614año y 1.865/año, para cada sitio respectivamente (Tabla 1). La tasa de explotación (E = F/Z) estimada fue de 0.53 y 0.57 para los sitios 1 y 2.

Patrón de Selección y Reclutamiento

La Figura 4 muestra la curva de selección de captura de acuerdo con el tamaño de malla del arte utilizado en las faenas de pesca. Allí se observa que la talla con que la mojarra rayada es reclutada a la pesquería es de 12.0 cm de longitud total, mientras que la talla media de captura (Lt_{50}) es de 21.8 y 21.7 cm de longitud total para los sitios 1 y 2, respectivamente. En cuanto al patrón anual de reclutamiento, se nota que la especie recluta durante todo el año, con dos grandes pulsos y superposición entre ellos.

Caracterización de la Pesquería

Las artes y/o métodos de pesca utilizados en la CGSM presentan una complejidad de tipo artesanal y, con excepción del método del boliche, proceden de una utilización generacional con diferencias en la longitud y el tamaño de malla. El uso de la red de enmalle "parada" está relacionado con el efecto que ocasiona en áreas especiales donde no es posible su operación. El impacto del bolicheo y el zangarreo se basa en la selectividad y su operación en áreas con poca profundidad, por lo que el INPA los prohibió. La actividad pesquera es soportada principalmente por la captura de mojarra rayada, abasteciendo un mercado importante del norte del país y el distrito capital.

Tabla 2. Comparación de parámetros de crecimiento y mortalidad para la mojarra rayada (*Eugerres plumieri*) con los obtenidos por otros autores. Las longitudes asintóticas (L_∞) han sido transformadas en LT, L/F = Frecuencia de tallas, C = Cleitrum, E = ELEFAN y W = Wetherall.

Area (Sexo)	Metodo	L_∞ (cm)	K (/años)	Z (/años)	M (/años)	F (/años)	(ϕ')	Fuente
Colombia	L/F							Rubio, 1975b
Machos		43.9	0.211	0.692	-	-	2.609	
Hembras		47.5	0.329	0.863	-	-	2.871	
Venezuela	C							Romero y González, 1984
Machos		26.7	0.300	-	-	-	2.330	
Hembras		32.0	0.190	-	-	-	2.289	
Colombia								Este estudio
Muestra 1	E	40.8	0.87	3.053	1.439	1.614	3.113	
	W	45.7	0.78	4.515	-	-	-	
Muestra 2	E	40.6	0.79	3.318	1.453	1.865	3.115	
	W	41.7	0.79	3.761	-	-	-	

El número de pescadores es 3,215 (Mancera y Botero 1993), la atarraya es el arte de pesca más usado con 2,342 unidades (35 %), seguida por el trasmallo con 1,993 unidades (30 %) (Viloria y Santos-Martínez 1997) y el esfuerzo pesquero lo concentran el boliche (77.5 %) y la atarraya (20.5 %). Según información reciente, la producción se estimó en 1,227 t (23 %) entre nov./93-oct./94, 1,010 t (24.0 %) para nov./94 - oct./95 y 931 t (23 %) entre nov./95 - oct./96 del total de captura comercial entre 48 especies de peces reportadas por las estadísticas pesqueras en la CGSM (Viloria y Santos-Martínez 1997).

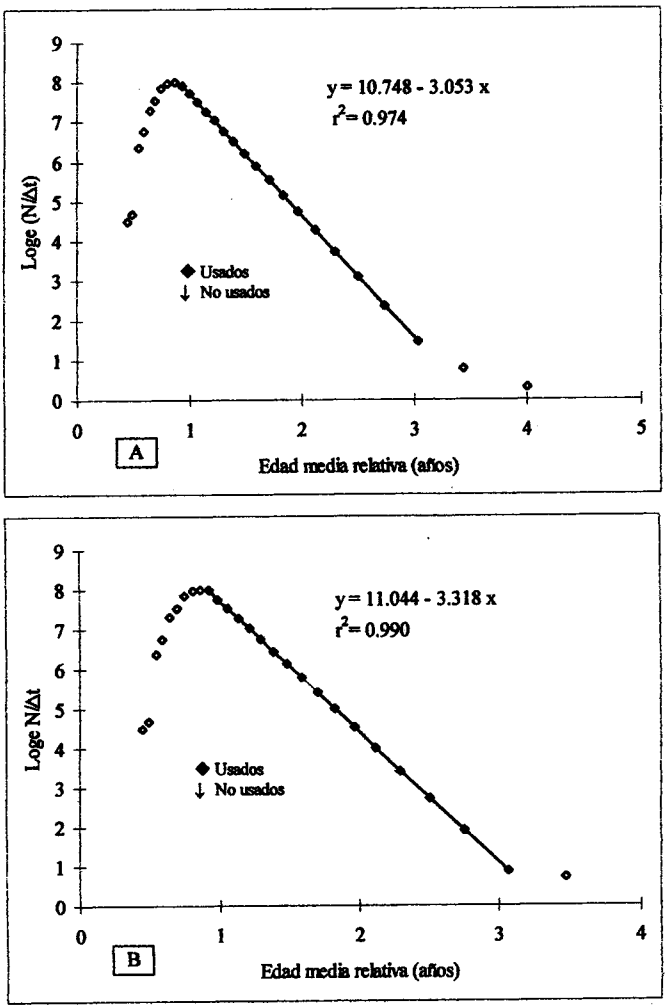

Figura 3. Tallas convertidas en curva de captura para *E. plumieri*. Sitios 1 (A) y 2 (B).

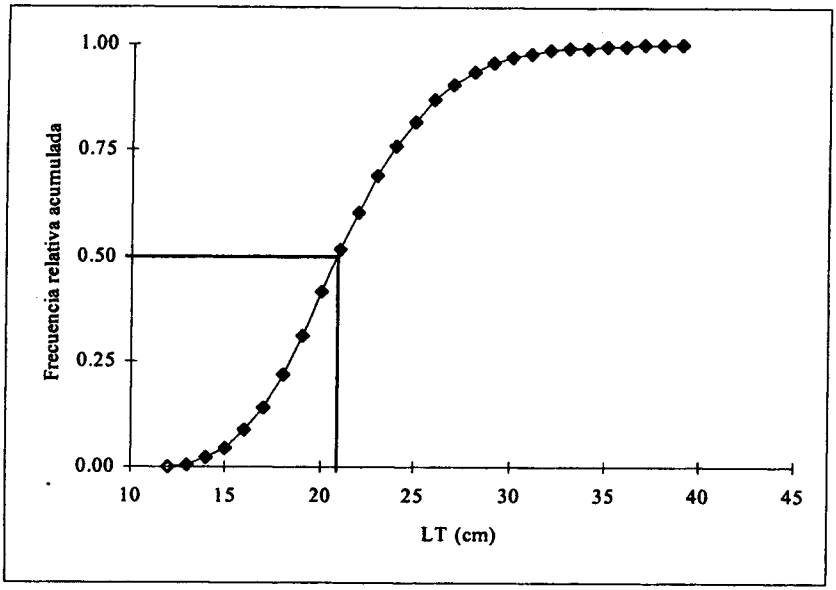

Figura 4. Curva de selección de captura de la mojarra rayada.

DISCUSION

De acuerdo con los pocos estudios realizados sobre la mojarra rayada (*Eugerres plumieri*) se infiere que en un pez de vida y crecimiento medios y bajas tasas de mortalidad natural. Analizando la Tabla 2, los valores de L_∞ (40.8 y 40.6 cm LT) son similares a la talla máxima reportada por Cervigón et al. (1992), mayores a las de Romero y González (1982) y menores a la estimada por Rubio (1975b), para machos, hembras y sexos combinados.

Hay notables diferencias entre las tasas de crecimiento y mortalidad total estimadas en este trabajo con las de Rubio (1975b). Estas tasas pueden variar de acuerdo con cambios en temperaturas y tallas que se presenten, especialmente si se comparan tasas para cada sexo vs sexos combinados. Además, de acuerdo con el régimen de pesca que se aplique, la población puede sufrir cambios mayores o menores en el número y biomasa total de sus integrantes, en su estructura de edad o de talla, en su velocidad de crecimiento e inclusive en su capacidad de reproducción (Csirke 1980); con lo arriba citado se infiere que al reducir la edad promedio de los individuos de la población de mojarra rayada se hace que ésta crezca más rápidamente, lo que no significa que su tamaño aumente; sino, que por

el contrario, el tamaño o biomasa total disminuya a consecuencia de la mayor mortalidad que se presenta.

Lo anterior también es sustentado por los valores estimados para la tasa de explotación (E), pues los obtenidos aquí permiten inferir que la especie está siendo sobrepescada actualmente y desde hace mucho tiempo, teniendo en cuenta que el tamaño de malla del arte de pesca disminuyó hasta 1/2 y 2 pulgadas. Actualmente oscila entre 1 y $2^3/_4$ pulgadas según el Plan de Ordenamiento Pesquero concertado con las comunidades de pescadores en 1996. Este plan se está cumpliendo en parte, y es posible que la mojarra rayada no haya desacelerado aún su tasa de crecimiento a la fecha de los muestreos para adaptarse a nuevas condiciones.

El índice de desempeño del crecimiento estimado en este trabajo muestra valores relativamente mayores (Sitio1 = 3.113, Sitio 2= 3.115) que los estimados por otros autores, lo cual puede estar asociado con la productividad de la CGSM, estimada en 1,690 g C/m^3/años (Hernández y Gocke 1990). La talla de entrada a la pesquería de la mojarra rayada (12.0 cm LT) es menor que las reportadas por Rubio (1975b), quien estimó valores de 19.6 cm, 20.8 cm y 20.2 cm de LT para machos, hembras y sexos combinados, respectivamente. Sin embargo, y extrañamente, es similar a la informada por Gallo (1988); lo anterior puede deberse a que entre 1988 y 1997 Lc continuó bajando para luego ascender como respuesta a los cambios introducidos en el ordenamiento de su pesquería.

Con la talla media de captura (21.8 y 21.7 cm LT) también se aprecian notables diferencias con Rubio (1975b) quien estimó valores de 25.2 cm, 28.1 cm y 26.7 cm de LT para machos, hembras y sexos combinados, respectivamente. Comparándola con la talla media de captura (20.1 cm LT) estimada por Gallo (1988) se puede inferir que a pesar que el ordenamiento pesquero no marcha de forma óptima, sí se evidencian signos de recuperación de la pesquería de la mojarra rayada en lo que a esto se refiere.

En cuanto al reclutamiento, analizando la producción pesquera a partir de la información parcial que se tiene desde 1970 hasta 1994, se puede inferir que el nivel de captura es afectado por este proceso. Aunque según diferentes autores, la mojarra rayada presenta desoves parciales durante el año con pulsos intensos en abril-junio (Rubio 1975a) o desove prolongado entre mayo-agosto (Arango y Rodas 1978), el hecho de que esto ocurra en el Mar Caribe, lugar diferente a su residencia, le agrega más incertidumbre al reclutamiento mismo porque éste depende entonces de muchas más variables a que si ocurriera en la CGSM, lo que puede traducirse en fluctuaciones de la producción con respecto al tiempo.

Observando la problemática presente en el área de estudio, ProCiénaga impulsa un Plan de Ordenamiento Pesquero, basado en un soporte técnico (Acosta et al. 1996) que identificó los puntos críticos de la pesquería, delineó los correctivos para una mejor explotación de la especie, apuntando hacia una regulación de su captura en la búsqueda del ordenamiento pesquero de la CGSM. Por tanto, se recomienda mantener abiertos los caños que interconectan el Río Magdalena y el Delta Estuarino Exterior del Río Magdalena con la ciénaga para permitir la circulación de agua y de los peces, sin que haya interrupción de los procesos alimenticios y reproductivos, los

ríos Frío, Sevilla, Aracataca y Fundación, la Boca de la Barra por ser la interconexión más importante entre la ciénaga y el Mar Caribe. Se deben reglamentar las capturas de la mojarra rayada, y se recomienda un tamaño de malla extendido de 3 pulgadas (7.62 cm) que permita la captura de individuos con talla mínima de 22.5 cm de longitud total.

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Caracterización del Ictioplancton a través del Canal de la Mona con énfasis en Familias Arrecifales

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RESUMEN

Se estudió el patrón de distribución de larvas de peces a través de un gradiente horizontal desde la plataforma insular de Puerto Rico hasta la plataforma de Isla de Mona con muestras colectadas durante un crucero de 3 días en octubre del 2000. Se muestrearon 15 estaciones usando un sistema de arrastre Tuker provisto con tres redes de 202 µm. Se identificó un total de 4.246 larvas pertenecientes a 70 grupos taxonómicos. Se observó un aumento en la abundancia de larvas de peces en dirección a ambas plataformas relacionado con concentraciones máximas de clorofila *a*. Las larvas de peces arrecifales de huevos pelágicos fueron más abundantes en las estaciones oceánicas a 13 y 26 km de la plataforma de Puerto Rico y disminuyeron significativamente a 39 km. La corriente media a través del Canal de La Mona fue de 10.08 cm/seg en dirección sur-oeste. El área de mayor probabilidad de enriquecimiento por dispersión larval es la plataforma insular de Puerto Rico en su costado oeste favoreciendo el auto-reclutamiento.

PALABRAS CLAVE: Dispersión, Ictioplancton, Larvas de peces.

Characterization of the Icthyoplankton Across the Mona Channel with an Emphasis on Reef Fish Families

The distribution pattern of fish larvae across a horizontal gradient from the insular shelf of Puerto Rico to the shelf of Mona Island was studied from samples collected during a three days cruise in October 2000. A total of 15 stations were sampled using a Tucker-trawl system fitted with three nets of 202 µm. A total of 4.246 fish larvae belonging to 70 taxonomic groups were identified. An increment of fish larvae abundance was observed in direction to both shelves, which was related to maximum chlorophyll-a concentrations. Reef fish larvae from pelagic eggs were more abundant in the oceanic stations at 13 and 26 km from the Puerto Rico shelf and decreased significantly at 39 km. Mean current across the Mona Channel was 10.08 cm/sec in a southwest direction. The most favorable area for larval enrichment by dispersion was the west side of the insular shelf of Puerto Rico, favoring self-recruitment.

KEY WORDS: Dispersión, Fish larvae, Ichthyoplankton.

INTRODUCCIÓN

Las poblaciones de peces se encuentran directamente relacionadas con las interacciones de fenómenos físicos, químicos y biológicos que determinan su abundancia y distribución espacio-temporal. Al respecto, es importante considerar las etapas pelágica y nectónica que caracterizan sus ciclos de vida. La influencia de dichos fenómenos es mayor y determinante durante estadios larvales (Leis 1991) debido a la alta tasa de mortalidad natural (Hempel 1979), afectando así los patrones de reclutamiento de las poblaciones adultas. Dado que los peces adultos se consideran principalmente sedentarios (Sale 1980), es el período pelágico de desarrollo larval, la fase más probable para que ocurra la dispersión (Leis 1986). Sobre la distribución de peces arrecifales estudios han reportado la presencia de larvas a grandes distancias de la costa (Leis 1982, Richards 1984, Victor 1987), lo que ha llevado a proponer que las poblaciones de estos son abiertas (Doherty 1991, Sale 1980).

Para la región del Caribe Norte en particular, Roberts (1997) propuso un modelo de dispersión inter-regional mediante el cual los patrones de reabastecimiento de las poblaciones de peces arrecifales en cada isla dependen de fuentes externas a favor de la corriente dominante. Sin embargo, investigaciones recientes como Cowen et al. (2000) aducen a procesos hidrográficos (corrientes) influenciados por la batimetría local la retención de larvas de peces cerca de la isla de Barbados en el Caribe y sugieren que el efecto de la mortalidad natural y la difusión exponencial limita el potencial de dispersión inter-regional como principal mecanismo de reabastecimiento de las poblaciones de peces arrecifales. Varias las investigaciones que consideran que existen procesos de retención local que son de gran importancia en el mantenimiento de las poblaciones de peces arrecifales (Steves et al. 1999, Jones et al. 1999, Limouzy-Paris et al. 1997). Ramírez- Mella y García-Sais (en prensa) evidencian la reducción exponencial de las larvas de peces arrecifales en un gradiente nerítico – oceánico al sur de Puerto Rico, lo que tiende a apoyar la aplicabilidad del modelo propuesto por Cowen et al. (2000).

El presente trabajo fue realizado en la sección este del Canal de la Mona entre Puerto Rico e Isla de Mona, el cual es un importante umbral del Mar Caribe. La presencia, abundancia y estado de desarrollo de larvas de peces arrecifales en el transecto entre la plataforma insular de Puerto Rico e Isla de Mona a través del Canal de Mona, en conjunto con el estudio del régimen de corrientes en la capa mixta, podrían indicar que éstas poblaciones están siendo reabastecidas por procesos locales. Además, se apoya la hipótesis de que el canal de Mona actúa como barrera de dispersión y que en caso de existir enriquecimiento por dispersión larval, es la plataforma insular de Puerto Rico en su costado Oeste el área más probable de reclutamiento.

MATERIALES Y MÉTODOS

El Canal de la Mona comunica el Mar Caribe con el Atlántico Norte, con un ancho de 65 km y una profundidad promedio de 390 m constituye un importante umbral de la región. Recientes trabajos en el área muestran a este Canal como uno de los principales pasos de aguas del Atlántico al Caribe, con un volumen estimado entre 1.85 Sv +/- 0.25 Sv (Sv = $10^6 m^3$/sec - svendrups) (Segura-Torres 2000). El presente trabajo fue realizado en la sección este, entre Isla de Mona y Mayagüez (Puerto Rico). Isla de Mona se encuentra localizada entre los 18°10' y 18° 00' latitud Norte y 68° y 67° 50' longitud Oeste, a 68 km de Punta Higuero - Puerto Rico y a 60 km al Este de Punta Espada, Republica icana.

En un crucero del 9 al 11 de octubre del 2000 se establecieron 19 estaciones a través de un transecto entre La Parguera e Isla de Mona: tres en la plataforma insular de Puerto Rico (B6-N, B4-N, 5N3-N), tres en el borde externo de la plataforma (B6-BP, B4-BP, 5N3-BP), tres en el canal de Mona (una cada 13 km O-1,O-2,O-3), tres en la plataforma insular de Isla Mona (N-1, N-2, N-3), tres en el borde externo de la plataforma de Isla Mona (BP-1, BP-2, BP-3), dos estaciones oceánicas al Oeste (O-6, O-7) y dos al Noreste de Isla Mona (O-4,O-5) a 3.7 km y 7.4 km respectivamente (Figura 1). Se realizaron arrastres oblicuos escalonados entre 0 – 60 m en estaciones oceánicas y entre 0 – 20 m para las estaciones sobre la plataforma insular (neríticas). Las muestras fueron obtenidas en triplicados usando un sistema Tucker de tres redes con maya de 202 µm. Los arrastres se realizaron a una velocidad de dos nudos filtrando un volumen promedio de 350 m^3. El volumen agua filtrado se estimó con flujómetros. Las muestras fueron preservadas en formalina al 4 % identificación. Los datos de abundancia por estación se reportan como Ind/100m^3.

Los datos oceanográficos fisicoquímicos se obtuvieron usando un CTD (SBE 19 de Sea-Bird Electronics, Inc.) con un fluorómetro integrado para establecer los perfiles de salinidad, temperatura, sigma t y clorofila – *a*. Se utilizó un metro de corrientes acústico ADCP (Acustic Doppler Current Profiler - Broadband Blue Water - RD Instruments – 75 Khz) para medir dirección y velocidad. El metro de corrientes estuvo instalado por 4 meses (mayo 24 a octubre 11/2000) en la estación ADCP 1 localizada en los 18° 17.390 de latitud norte y 67° 48.033 de longitud oeste a una profundidad de 460m, registró 5029 datos de la velocidad de las corrientes presente entre 44 y 444 m de profundidad. El estudio de corrientes se centró a 44 m.

Los datos de abundancia por familia se normalizaron con transformación al logaritmo natural (ln (x+1)). Para establecer si existían diferencias en abundancia de cada familia por estación y del estado de desarrollo se realizaron Análisis de Varianza (ANOVA) con replicados (Sokal y Rohlf 1995) y pruebas de diferencia significativa para comparaciones múltiples de promedios de Student Newman Keuls del programa estadístico Sigma-Stat software versión 1.0 (1992 - 1994).

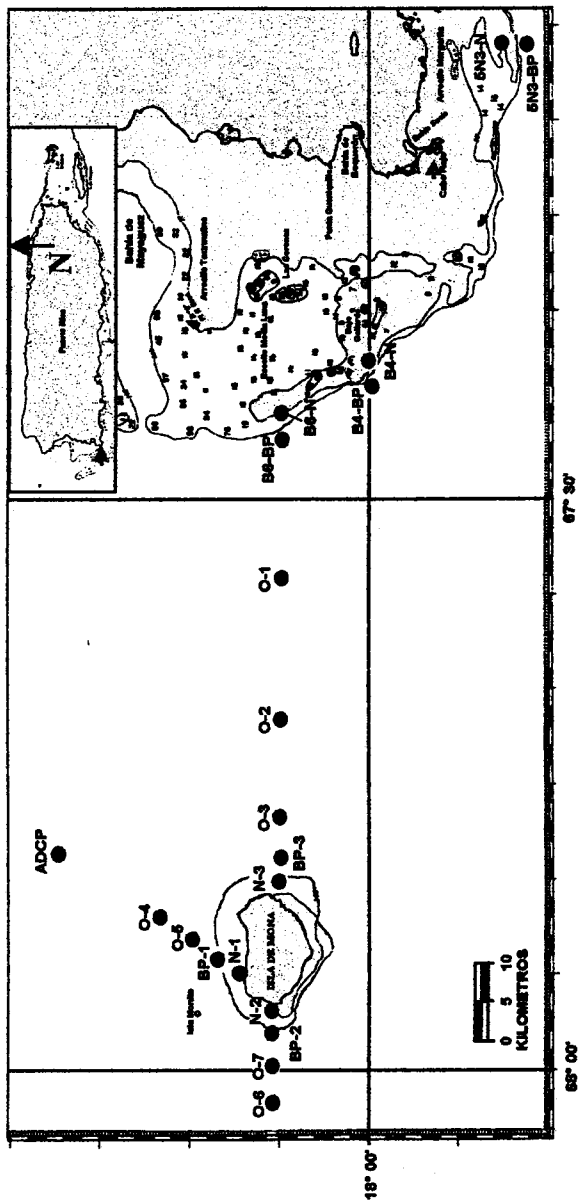

Figura 1. Mapa de estaciones del crucero Mona Challenge. Octubre 9 - 11, 2000

RESULTADOS

Datos Hidrográficos

La salinidad varió entre 33.6 y 36.8 ups presentando las valores mínimos en superficie en las estaciones sobre la plataforma de Puerto Rico. La variación se estableció para los primeros 50 m. Las isohalinas presentaron una mayor estabilidad hasta los 100 m. Los valores superficiales para las estaciones sobre la plataforma de Isla de Mona fueron de 34.6 ups, siendo en una unidad mayor a los registrados en la plataforma de Puerto Rico. El comportamiento de la temperatura en la columna hasta los 100 m es consistente con los perfiles típicos de aguas oceánicas para esta sección del Caribe, registradas en la estacion Cats (Caribbean Time Series) (Corredor y Morell 2001). La densidad de la columna se presenta fuertemente influenciada por la salinidad presentando el mismo patrón. Las variaciones de sigma –t a través de las estaciones de muestreo se encontraron entre los 21.0 y 24.8, mostrando los mínimos valores en los primeros 50 m de la columna después de los cuales se observó estabilización de las isopignas.

Los valores de clorofila- a variaron entre 2.2 y 0.6 µg/L. Las mayores concentraciones se localizaron en los primeros 30 m de la columna de agua, en las estaciones de la plataforma y borde de la plataforma de Puerto Rico. En las estaciones oceánicas, se observaron los máximos de clorofila entre los 70 y 90 m, con una concentración de 1.7 µg/L. Las aguas superficiales de las estaciones al oeste y las del borde de la plataforma de Isla de Mona presentaron los valores mínimos, en los primeros 40 m de la columna (0.6 µg/L). En la plataforma de Isla de Mona se incrementó la concentración a 1.2 µg/L. El aumento en la concentración de clorofila en Isla de Mona con relación a las estaciones oceánicas, pudiera estar relacionada al efecto de "efecto de masas" (Rissik et al. 1997).

Los datos de velocidad de corrientes fueron tomados en sus componentes U (este - oeste) y V (norte - sur) a 44 m. La estadística descriptiva del registro desde el 25 de mayo hasta el 11 de octubre del 2000 se presenta en la Tabla 1. La trayectoria por vectores progresivos para el registro completo de datos se presenta en la Figura 2. De las trayectorias obtenidas a partir de vectores progresivos para los 44 m se establece que en la mayoría de las ocasiones, una partícula inerte se desplazaría en el canal saliendo del mismo por el límite sur. El flujo medio a 44 m de profundidad en el Canal de La Mona durante el periodo de estudio fue predominantemente hacia el sureste. Cabe notar que en el borde y sobre la plataforma oeste de Puerto Rico el flujo es en dirección norte con lo que se puede favorecer el reclutamiento de peces en toda la costa oeste de larvas provenientes de huevos pelágicos.

Tabla 1. Datos estadísticos del metro de corrientes ADCP. Mayo 25 (14:00) -Octubre 11 (6:00). Nivel superficial 44 m.

	Componentes	
	U (Este - Oeste	V (Norte - Sur)
Promedio	9.00767994	-4.52564144
Varianza	470.99472	640.178955
Desviación standar	21.7024136	25.3017578

Dirección promedio	
Velocidad escalar promedio	31.03417
Velocidad vectorial promedio	10.08066
Número de datos	5029

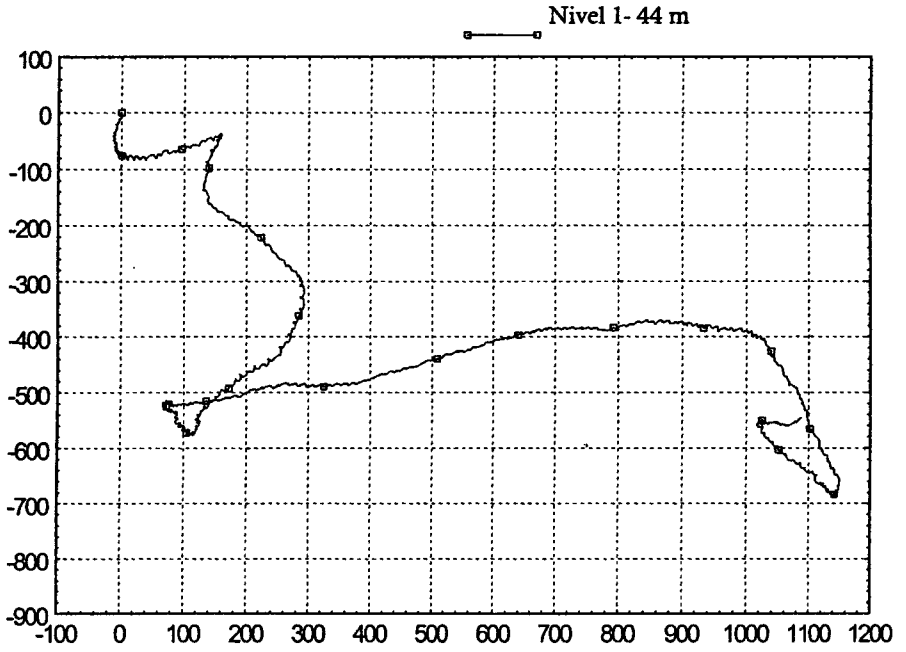

Figura 2. Vectores progresivos para 44 m desde el 25 de mayo hasta el 10 octubre del 2000

Datos Biológicos

El ictioplancton del crucero fue clasificado en 70 taxones, que incluyeron 4 ordenes y 66 familias (Tabla 2). Se capturaron un total de 6, 244 larvas de las que se identifico el 68 %. El 18 % de la captura total correspondió a larvas en estado postflexión, las cuales fueron identificadas en su totalidad. Las familias más abundantes a través del transecto fueron Mycthophidae (20 %), Gobiidae (6 %), Scaridae (6 %), Photichtyidae (3 %) Lutjanidae (3 %) y Clupeiformes (3 %), representando el 41 % de la captura. Las clasificaciones: Labridae, Scombridae, Carangidae, Perciformes y Blennidae con un 2 % cada una, se representan el 51 % de la abundancia total y el 49 % restante estuvo conformado por 59 taxones.

Para visualizar el comportamiento larval a través del transecto los taxones identificados fueron agrupados en 4 categorías de acuerdo a su hábitat y al tipo de desove (Leis y Miller 1976): Grupo 1 - Familias pelágicas de bahía y neríticas, la mayoría con desoves pelágicos (PB N-DP), Grupo 2 - Familias de arrecife costeras con huevos no pelágicos (AC -HNP), Grupo 3 - Familias de arrecife con huevos pelágicos (A-HP) y Grupo 4 - Familias oceánicas y bénticas profundas con desoves presumiblemente de huevos pelágicos (O-HP) (Tabla 3). Las clasificaciones en nivel de Orden como Clupeiformes, Perciformes, Pleuronectiformes, así como las familias que no representaron más del 0.2 % de la captura total no fueron incluidas en el análisis.

En el análisis de la abundancia para las larvas del grupo1 se observaron diferencias significativas entre estaciones para las larvas preflexión (ANOVA, $p < 0.05$). La prueba de comparación múltiple de promedios Student Newman Keuls reflejó diferencias significativas ($p < 0.05$) entre la estación NP – Nerítica Puerto Rico y las demás estaciones. También para la estación O-1 con las estaciones O-4, B-3 y N-2; y la estación N-1 con B-3. Se establecen diferencias en la estación N1 – Nerítica de Isla de Mona (ANOVA, $p < 0.05$).

El comportamiento de las larvas peces del grupo 2 (AC -HNP) preflexión y postflexión fue inverso entre plataformas, la estación de máxima abundancia preflexión NP se cuantificó en 20.4 Ind/100 m^3 y para las larvas postflexión en la estación nerítica N1 3 Ind/100 m^3. Los valores de abundancia del grupo 2 en el estado preflexión presentaron diferencias significativas (ANOVA, $p < 0.05$) entre la estación NP – Nerítica de Puerto Rico y las estaciones de borde de plataforma B1,B2,B3 y las oceánicas O4, O5 y O7. También entre la estación B-2 y O-2. En estado postflexión (ANOVA, $p = 0.4437$), se observó una distribución relativamente homogénea a través del transecto.

Tabla 2. Distribución taxonómica y abundancia (Ind/100m^3) de larvas de peces.

FAMILIAS	O-1	O-2	O-3	O-4	O-5	O-6	O-7	BP 1	BP 2	BP 3	NP	BP	N 1	N 2	N 3	TOT	%
Elopidae	0.0	0.0	0.0	0.4	0.0	0.0	0.3	0.7	0.4	0.0	0.0	0.0	0.0	0.0	0.0	1.7	0.1
Albulidae	0.0	0.0	1.8	0.0	0.4	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	2.6	0.1
Anguilliformes	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.4	0.0
Muraenidae	0.0	0.0	0.4	0.4	0.4	0.0	0.0	0.0	0.0	1.2	0.0	0.4	0.0	0.3	0.0	3.1	0.1
Ophichthidae	0.0	0.0	0.0	0.4	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0
Clupeiformes	0.9	1.9	1.4	0.0	2.1	1.5	0.0	2.2	0.0	0.0	23.7	1.2	1.5	0.6	0.5	37.6	1.4
Clupeidae	0.0	0.9	0.0	0.4	1.0	0.0	0.0	7.2	0.0	1.1	1.1	0.4	1.0	0.3	0.0	13.4	0.5
Engraulidae	0.0	0.7	0.0	1.7	4.8	0.0	0.0	10.2	0.0	0.0	0.4	0.6	0.0	0.0	0.0	18.4	0.7
Gonostomatidae	5.0	3.0	2.0	4.7	0.5	0.0	0.0	0.0	0.2	2.7	0.0	0.0	0.0	0.0	1.0	19.1	0.7
Photichthyidae	10.4	3.8	8.4	10.9	3.6	1.3	2.4	2.0	1.1	13.6	4.4	1.8	4.3	1.2	6.3	75.5	2.8
Melanostomiidae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.4	0.0	0.0	0.0	0.0	0.0	0.8	0.0
Notosudidae	1.2	1.7	0.7	0.0	0.0	0.0	0.3	0.0	0.0	2.4	0.0	0.0	0.0	0.0	0.0	6.3	0.2
Synodontidae	0.4	0.6	0.7	0.4	0.9	0.0	0.0	0.3	0.0	0.8	6.5	0.0	1.0	0.0	0.0	11.6	0.4
Paralepididae	1.8	1.2	2.4	5.3	3.1	1.2	1.2	1.4	0.0	5.2	0.0	0.7	0.5	2.2	0.5	26.8	1.0
Evermannellidae	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.6	0.5	1.9	0.1
Myctophidae	40.7	30.9	54.7	62.2	52.7	12.5	19.2	59.8	16.3	46.4	38.1	37.5	23.9	27.5	8.2	530.7	19.9
Bregmacerotidae	1.3	0.0	0.0	0.4	0.0	0.0	0.3	0.0	0.0	0.0	0.0	2.7	0.9	1.6	0.0	7.3	0.3
Ophidiidae	0.4	0.0	0.0	0.4	0.5	0.0	0.0	1.1	0.2	0.0	0.0	0.6	0.5	0.0	1.0	4.8	0.2
Carapidae	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0
Bythitidae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.4	0.0	0.0	0.0	1.5	0.1
Gobiesocidae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	1.0	4.0	0.2
Atherinidae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2	0.0	0.0	1.6	0.0	3.8	0.1
Hemiramphidae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.4	0.0	0.0	0.0	0.0	0.8	0.0
Exocoetidae	0.0	0.3	0.4	0.0	0.0	0.0	0.0	0.8	3.5	0.0	2.2	0.8	0.0	0.0	2.9	10.7	0.4
Stylephoridae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.5	0.0
Miriapinnidae	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.8	0.0
Holocentridae	0.0	3.7	1.0	0.4	0.0	0.0	1.9	1.2	0.2	0.0	1.1	0.9	0.9	0.3	0.6	12.4	0.5
Aulostomidae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2	0.0	0.0	0.5	0.0	2.7	0.1
Fistularidae	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0
Syngnathidae	0.0	0.0	0.4	0.0	0.0	0.0	0.7	0.7	0.0	0.0	10.9	1.3	1.0	0.0	0.0	14.9	0.6
Scorpaenidae	0.0	0.3	0.4	0.9	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	2.9	0.1
Perciformes	0.0	0.0	1.5	0.0	8.1	0.0	1.2	8.1	7.7	2.4	6.5	0.0	0.0	15.2	0.0	50.6	1.9
Serranidae	0.4	0.3	0.7	0.0	1.2	0.3	0.0	0.0	0.0	0.4	0.0	0.0	0.9	2.5	0.0	6.8	0.3
Symphysanodontidae	0.0	0.0	0.4	0.4	1.5	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.5	0.5	4.1	0.2
Priacanthidae	0.0	0.3	0.0	0.0	0.4	0.0	0.0	1.1	0.0	0.8	0.0	0.0	5.4	0.3	0.0	8.3	0.3
Caproidae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.5	1.0	0.0
Apogonidae	0.4	0.0	0.4	2.5	0.8	0.3	0.0	5.0	2.6	0.4	0.4	0.9	1.0	0.0	0.0	14.7	0.6
Carangidae	0.4	1.3	3.8	2.8	4.2	2.1	0.3	5.2	1.3	5.1	2.0	1.1	7.7	2.3	1.1	40.8	1.5
Coryphaenidae	0.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	2.2	0.0	0.0	0.0	0.0	4.6	0.2
Bramidae	0.0	0.0	1.3	0.8	0.7	0.6	0.0	0.0	0.2	0.0	0.0	0.4	0.0	0.0	0.0	4.1	0.2
Lutjanidae	0.4	7.8	4.1	2.5	4.3	1.8	1.4	5.3	4.4	2.2	11.2	4.9	10.1	10.3	5.4	76.2	2.9
Gerreidae	0.4	0.0	0.4	0.4	0.0	0.3	0.0	2.0	0.0	0.8	21.1	0.3	1.5	0.0	0.0	27.2	1.0
Haemulidae	0.4	1.7	1.7	0.8	4.0	0.0	0.0	1.0	0.0	0.0	0.8	1.1	12.1	5.1	1.8	30.5	1.1
Mullidae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	0.0	0.0	0.0	0.0	0.0	0.0	1.8	0.1
Kyphosidae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.7	0.0	0.0	0.9	0.0	0.0	0.0	2.0	0.1
Ephippidae	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0
Chaetodontidae	0.0	0.0	0.4	0.0	0.4	0.8	0.4	0.0	0.0	0.4	0.0	0.0	0.5	0.0	0.0	2.5	0.1
Pomacanthidae	0.0	2.3	3.7	3.2	1.5	0.9	1.3	0.3	2.4	2.4	0.0	2.2	1.0	3.8	3.8	26.8	1.1
Pomacentridae	0.0	0.0	0.0	0.8	0.4	0.0	0.0	1.7	0.0	0.0	0.0	0.0	0.5	0.0	0.5	3.9	0.1
Opistognathidae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.6	0.0	23.6	6.9	2.7	41.8	1.6
Labridae	2.4	7.2	5.2	4.4	0.8	3.1	0.7	3.9	1.8	2.4	4.3	7.9	9.0	10.8	0.0	64.0	2.4
Scaridae	3.8	26.8	14.4	12.1	1.5	3.8	1.0	25.0	2.1	13.7	2.2	24.9	3.1	13.6	0.0	147.4	5.5
Tripterygiidae	0.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.3	0.0	0.0	0.0	0.0	5.5	0.2
Labriosomidae	0.0	0.0	0.0	0.0	2.7	2.2	0.0	0.0	0.0	0.4	8.8	0.0	0.0	0.0	0.0	14.2	0.5
Blennidae	1.1	2.0	6.9	0.8	2.7	1.2	0.9	1.0	2.9	7.7	19.2	3.0	2.0	2.1	1.2	54.6	2.0
Callionymidae	0.4	1.3	0.0	1.3	0.4	0.3	3.5	0.4	0.4	0.0	0.0	1.3	0.0	1.6	0.0	10.7	0.4
Gobiidae	6.5	4.9	6.9	4.1	5.6	7.1	5.9	9.1	5.4	5.8	31.1	16.5	17.5	29.1	7.6	167.1	6.3
Microdesmidae	0.0	0.0	0.7	0.0	1.2	0.3	0.7	2.0	0.2	0.0	0.0	1.7	1.0	0.0	1.2	9.0	0.3
Acanthuridae	0.7	3.2	3.2	0.0	0.0	0.3	1.0	0.3	1.1	1.2	0.0	1.9	1.5	0.0	0.0	14.5	0.5
Sphyraenidae	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	1.2	0.0
Gempylidae	0.4	1.3	0.0	0.0	0.9	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.6	5.8	0.2
Scombridae	1.5	6.3	10.9	5.9	2.5	4.0	1.8	9.7	3.2	9.2	0.4	2.8	4.0	2.7	0.5	65.0	2.4
Nomeidae	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.8	0.0
Ariommatidae	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0
Pleuronectiformes	0.0	0.3	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	1.2	0.0
Paralichthyidae	0.0	0.0	0.0	0.4	0.5	0.5	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0	2.7	0.1
Bothidae	0.0	0.0	0.3	0.4	0.4	0.6	0.7	0.7	0.2	0.8	0.0	1.9	0.5	0.5	0.0	7.1	0.3
Cynoglossidae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.6	0.0
Monacanthidae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.5	0.0
Ostraciidae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.5	0.0
Unidentified	67.0	47.4	62.5	41.3	62.2	23.3	22.6	39.7	56.5	50.3	167.7	37.3	119.6	86.5	23.4	846.8	31.7
TOTAL	147.8	166.4	229.6	174.5	181.1	72.6	70.0	209.7	117.7	181.1	386.2	165.2	263.9	231.2	74.3	2671.2	100

Tabla 3. Composición de Familias de larvas de peces coleccionadas por Grupo. Grupo 1 (Pelágico-estuarinas – huevos pelágicos); Grupo 2 (Costeras – huevos no pelágicos); Grupo 3 (Arrecifales – huevos pelágicos); Grupo 4 (Oceánicas – huevos pelágicos)

Grupo1	Grupo 2	Grupo3	Grupo 4
Elopidae	Atherinidae	Ophichthidae	Caproidae
Albulidae	Pomacentridae	Sphyraenidae	Evermannellidae
Gobiesocidae	Tripterygiidae	Bythitidae	Bramidae
Ophidiidae	Labriosomidae	Mullidae	Symphysanodontidae
Clupeidae	Apogonidae	Kyphosidae	Coryphaenidae
Engraulidae	Syngnathidae	Chaetodontidae	Gempylidae
Gerreidae	Blenniidae	Paralichthyidae	Notosudidae
Clupeiformes	Gobiidae	Aulostomidae	Bregmacerotidae
Carangidae		Scorpaenidae	Exocoetidae
		Muraenidae	Gonostomatidae
		Serranidae	Paralepididae
		Bothidae	Scombridae
		Priacanthidae	Photichthyidae
		Microdesmidae	Myctophidae
		Callionymidae	
		Synodontidae	
		Holocentridae	
		Acanthuridae	
		Pomacanthidae	
		Haemulidae	
		Opistognathidae	
		Labridae	
		Lutjanidae	
		Scaridae	

El grupo3 (A-HP) se observa como grupo dominante sobre el 40 % de abundancia total en las estaciones del borde de la plataforma de Puerto Rico, en las estaciones nerítica de Isla de Mona y en la estación oceánica O-2 a 26 Km de Puerto Rico. Este grupo es de especial interés dada la fase pelágica que le caracteriza y su asociación con el hábitat arrecifal, tema central de este estudio. En la plataforma de Puerto Rico la abundancia fue 14.4 Ind/100 m^3 (20 %), siendo mayor el porcentaje de individuos preflexión. Para Isla de Mona se encontró una mayor abundancia sobre las estaciones neríticas 11.5 Ind/100 m^3 (40 %) que sobre las del borde de la plataforma 4.1 Ind/100 m^3 (25 %). La estación oceánica O-2 fue particularmente abundante en larvas del grupo 3 (A-HP) con un valor promedio de 11.3 Ind/100 m^3 (45 %). Las larvas preflexión mostraron la mayor abundancia en las estaciones oceánicas O1 (12.1 Ind/100 m^3) y O-2 (6.4 Ind/100 m^3) a 13 y 26 km de la plataforma de Puerto Rico, respectivamente. Las larvas postflexión presentaron sus picos de abundancia en las plataformas tanto de Puerto Rico (8.3 Ind/100 m^3) como de Isla de Mona (8.5 Ind/100 m^3), así como en la estación O-5 (10.13 Ind/100 m^3). Las larvas preflexión del grupo 3 mostró diferencias

significativas (ANOVA, $p < 0.05$) en la estación oceánica O –1. Para el estado postflexión las diferencias fueron significativas entre la estación NP – Nerítica Puerto Rico y las estaciones oceánicas O-3, O-4, O-5 y nerítica N2 (ANOVA, $p < 0.05$) Tabla 3. La estación oceánica O-3 se muestra como diferente a la mayoría de las estaciones como consecuencia del bajo valor de abundancia (0.2 Ind/100 m^3), el menor observado. Esta estación se localiza a 39 km de la plataforma de Puerto Rico, y a aproximadamente 7 km de la plataforma de Isla de Mona.

El grupo 4 (O-HP) fue dominante en las estaciones oceánicas O-6 (27.3 Ind/100 m^3), O-7 (30.3 Ind/100 m^3) y en la nerítica de Mona N1 (26.3 Ind/100 m^3). Se observó una disminución hacia las plataformas de Puerto Rico, Isla de Mona y en las estaciones de borde de plataforma de Puerto Rico. En el análisis de abundancia para este grupo en estado preflexión no se establecen diferencias (ANOVA , $p = 0.0698$). Las larvas postflexión presentan diferencias ($p < 0.05$) para la estación nerítica N3 (8.9 Ind/100 m^3).

DISCUSIÓN

La abundancia de la comunidad de larvas de peces en el transecto Puerto Rico - Isla de Mona presenta un patrón de aumento sobre las plataformas insulares consistente con los resultados de Ramírez-Mella (2000) para la costa suroeste en La Parguera. Al respecto, encontramos dos consideraciones importantes:

i) Las plataformas insulares de Puerto Rico e Isla de Mona se muestran como áreas de desoves, a juzgar por la elevada relación de larvas preflexión a postflexión (15:1). En las estaciones de borde de plataforma esta relación fue de 4:1 y en las oceánicas de 5:1 y

ii) Los incrementos en la concentración de clorofila *a*, como indicativo de la productividad de las aguas muestran mayores concentraciones en las dos plataformas., pero en Isla de Mona fue relativamente menor, posiblemente debido a que los aportes de nutrientes por escorrentías son mínimos. Consistente a este patrón, la abundancia de ictioplancton fue significativamente mayor sobre la plataforma de Puerto Rico, con relación a las estaciones oceánicas al oeste de Isla de Mona.

En el componente postflexión se establecen diferencias significativas entre las estaciones neríticas y las de borde de plataforma, en donde se observan las mayores concentraciones. Este patrón es también similar al reportado por Ramírez-Mella (2000) para las estaciones del borde de la plataforma en La Parguera . El borde de la plataforma parece ser un hábitat altamente favorable para estas larvas en avanzado estado de desarrollo ya que las mantiene en áreas de alta productividad comparado a las zonas oceánicas, con la ventaja de la ausencia de depredadores asociados a la plataforma insular.

Del análisis de categorías ecológicas en cuanto a tipo de desove y hábitat, el grupo 1 (PBN-DP) se presentó como un componente importante en la plataforma de Puerto Rico, representado el 24 % de la abundancia total. En el análisis de la abundancia para larvas preflexión se observaron diferencias entre la estación NP –

Nerítica Puerto Rico y las demás estaciones. Este esquema estuvo influenciado por el grupo de los Clupeiformes, constituido por las familias Engraulidae y Clupeidae. Estas familias son típicas de áreas costeras estuarinas y de hábitos planctívoros (Watson 1996). Su distribución es indicativa de la presencia de áreas de desoves asociadas a la plataforma de Puerto Rico. García (1994) y García et al. (1996) reportan a los Clupeiformes como el componente taxonómico más abundante de las zonas costeras en Puerto Rico con ciclos completos de desarrollo larval principalmente neríticos. Para las larvas postflexión se establecen diferencias significativas en la estación N1 – Nerítica de Isla de Mona. Este patrón estuvo influenciado por la alta abundancia de la familia Carangidae, que representó un 17 % de la abundancia total de la estación junto con otros taxones con conocidos ciclos larvales neríticos (p.e. Engraulidae, Clupeidae, Gerreidae).

El grupo 2 (AC-HNP) se identifica como el grupo dominante (40 %) en las estaciones neríticas de Puerto Rico. Este grupo está representado principalmente por la familias Gobiidae, Bleniidae, Apogonidae y Labriosomidae. El máximo valor de larvas preflexión de este grupo está asociado al borde de la plataforma de Puerto Rico. Steves et al. (1999) observaron que la mayoría de taxones que completan su ciclo de vida en áreas de plataforma proviene de huevos no pelágicos. El grupo 2 presentó diferencias en el estado preflexión significativamente mayores entre la estación NP – Nerítica de Puerto Rico y estaciones de borde de plataforma y oceánicas.

El grupo3 (A-HP) fue numéricamente dominante en las estaciones del borde de la plataforma de Puerto Rico, en las estaciones neríticas de Isla de Mona y en la estación oceánica O-2 a 26 km de Puerto Rico. Este grupo se encuentra principalmente representado por las familias Scaridae, Lutjanidae, Labridae y Opistognatidae. La alta abundancia de este grupo en el borde de la plataforma de Puerto Rico es consistente con los estudios de García et al. (1996) y Ramírez-Mella (2000). La relativamente alta abundancia de larvas de peces de arrecife con huevos pelágicos (grupo 3) en las estaciones nerítcas de Isla de Mona refleja posiblemente la limitada extensión de la plataforma insular y una dinámica fuerte de interacción entre las poblaciones costeras y las oceánicas.

La observación de alta abundancia de larvas de peces del grupo 3 en la estación oceánica O-2 es de particular relevancia. Las corrientes de deriva a través del Canal de la Mona han sido estimadas para períodos cortos en 8.5 cm/seg (7.3 km/día) hacia el oeste (Metcalf et al. 1977). Asumiendo el desove de especies de arrecife en la plataforma de Puerto Rico con las corrientes superficiales de deriva, se calcula la posición de las larvas con saco vitelino (entre 24 y 48 horas después del desove) a una distancia entre 7 y 14 km de la costa. El flujo superficial se considera el factor de principal influencia en la localización final de las larvas dado que determina la dirección y magnitud de su desplazamiento horizontal (Capella et al., 1992). La estación oceánica O2 se encuentra a 26 km de la plataforma de Puerto Rico y el fuerte componente de larvas preflexión en esta estación puede explicarse como consecuencia del transporte de huevos desde los límites de la plataforma hacia mar abierto.

Es importante anotar que el patrón observado para el grupo 3 esta influenciado por las familias Scaridae y Lutjanidae dada su abundancia, pero el esquema de aumento en la estación O2 es reflejo de aumento de abundancia de 13 de las 24 familias que lo constituyen. Ramírez-Mella (2000) observó un pico de abundancia para este componente a 29 km. El marcado descenso de este grupo para la estación oceánica O3 a 39 km de la plataforma de Puerto Rico parece delimitar el rango de dispersión de este componente a partir de las plataformas de producción. Un resultado similar se desprende del estudio de Ramírez-Mella y García-Sais (en prensa) quienes encontrarón un marcado descenso en la abundancia de las familias arrecifales a los 46 km fuera de la plataforma.

El grupo 4 (O-HP) fue dominante en las estaciones oceánicas y en las de borde externo de la plataforma de Isla de Mona (45 % y 67 %). Se observó una disminución hacia las plataformas de Puerto Rico (24 %) e Isla de Mona (32 %) y en las estaciones de borde de plataforma de Puerto Rico (34 %). Nuevamente, la alta abundancia de este grupo en una estación nerítica denota una fuerte influencia oceánica en la costa este de Isla de Mona. La variación en este grupo estuvo influenciada por un gradiente costero – oceánico, el cual ha sido documentado por Leis y Miller (1976) y Ramírez-Mella (2000). Este grupo estuvo integrado principalmente por las familias Myctophidae, Photichthyidae, Scombridae y Paralepididae.

Este estudio muestra la existencia de procesos físicos que pueden explicar la distribución de larvas de peces de arrecife con huevos pelágicos a través del transecto Puerto Rico - Isla de Mona. El flujo y dirección de las corrientes en la capa mixta proveen un mecanismo potencialmente efectivo para el retorno a las áreas de producción. Una vez las larvas eclosionan (24 – 48 h) y cambian su profundidad en la columna de agua como consecuencia de cambios de densidad, se desplazan de la sección superficial afectada por la corriente de deriva (8.5 cm/seg hacia el oeste) y encuentran en un flujo de 10.1 cm/seg hacia el sur–este, favoreciendo el transporte y reclutamiento de larvas en el área oeste de la plataforma de Puerto Rico. Los resultados de este estudio muestran que el Canal de La Mona actúa como una barrera para la dispersión larval favoreciendo el reclutamiento local en la plataforma oeste de Puerto Rico.

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Estructura de la Comunidad de Peces Juveniles en la Laguna Yalahau, Quintana Roo, México (Época de Lluvias)

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RESUMEN

El número de especies asociadas a los ecosistemas costeros varia en función de la complejidad estructural y de la disponibilidad de alimento de cada hábitat. Las camas de pastos marinos se encuentran entre los sistemas costeros más complejos. El presente estudio permite determinar la estructura de la comunidad de peces asociadas a las praderas de pastos de *Thalassia testudinum* en la Laguna Yalahau, para lo cual se realizaron muestreos quincenales durante los meses de junio y julio del 2001 considerando las fases de luna nueva y llena. Se colectaron un total de 41 especies durante los dos meses sobre praderas de *T. testudinum* por medio de una red de barra Renfro. Las familias más representativas fueron Syngnathidae y Haemulidae. *Lagodon rhomboides* representó la especie más dominante tanto en abundancia como en biomasa para ambos meses (30.2 %), por su parte *Lucania parva* representó la segunda especie dominante en ambas lunas del mes de julio. La mayor riqueza de especies se presentó en luna llena de junio con 28 especies, disminuyendo a 26 durante la luna nueva, mientras que para el mes de julio se observó una disminución a 18 y 16 especies en luna llena y nueva, respectivamente. La mayor diversidad se obtuvo en la luna nueva de junio mientras que la mayor equidad se presentó en luna nueva de julio. La comunidad de peces de las camas de pastos marinos en Yalahau es muy similar a las reportadas por otros autores en ecosistemas similares. Finalmente, el ecosistema de pastos funcionó como área de alimentación, protección y crianza de especimenes de talla pequeña y juveniles de especies de diferente origen ecológico. Este conocimiento es importante para evaluar la importancia biológica y ecológica que representan las camas de pastos marinos en la laguna de Yalahau.

PALABRAS CLAVES: Peces juveniles, estructura de la comunidad, Quintana Roo, México

Structure of the community of juvenile fish in the lagoon Yalahau, Quintana Roo, Mexico during the "Time of Rains"

The number of coastal species associated with coastal ecosystems varies based on the structural complexity and the of availability of food of each habitat. The beds of marine grass are found among the most complexes coastal systems. The present study allows as to determine the structure of the community of fish associated with the beds of turtlegrass (*Thalassia testudinum*) in the lagoon of Yalahau, for which

biweekly samplings were made during the months of June and July 2001 considering the phases of New Moon and Full Moon. A total of 41 species were collected during both months on beds of turtlegrass with a "Renfro" net. The most representative families were Syngnathidae and Haemulidae. *Lagodon rhomboides* represented the most dominant species in abundance as in biomass for both months (30.2 %), *Lucania parva* represented the second species dominant in both moons of the month of July. The greater number of species appear in Full Moon of June with 28 species, reduced to 26 for New Moon, whereas for the month of July a decrease 18 and 16 species is observed in Full Moon and New Moon respectively. The greater diversity was obtained in the New Moon of June whereas the evenness appeared in New Moon of July. The community of fish of the beds of turtlegrass in Yalahau is very similar to the reported ones by other authors in similar ecosystems. The ecosystem of turtlegrass functions as an area of feeding, protection and raising of small and juvenile specimens of small size of species of different ecological origin. This knowledge is important to evaluate the biological and ecological importance that the beds of turtlegrass in the lagoon of Yalahau represent.

KEY WORDS: Juvenile fish, community structure, Quintana Roo, Mexico

INTRODUCCIÓN

Los ecosistemas costeros tropicales y subtropicales como son el arrecifal, pastos marinos y bosques de manglar, se caracterizan por la diversidad de productores primarios y de microhábitats que determinan la presencia de comunidades biológicas diversas, tramas tróficas complejas con un alto grado de interacción entre la columna de agua y el fondo, un gran número de especies generalistas tróficos, y altas tasas de intercambio de materia orgánica y organismos tanto internamente como con ecosistemas vecinos (Day et al.,1989). Estos ecosistemas presentan diversas características ambientales que influyen en la estructura de la comunidad (Álvarez et al. 1990). La verdadera importancia que estos sistemas tienen para la comunidad de peces, se basa en la diversidad de especies que aprovechan la variedad de hábitats que encuentran en los mismos; así como, la enorme producción de recursos que junto con los factores dinámicos determinan una variación espacio-temporal en las poblaciones nectónicas del propio sistema, compuestas en su mayoría por larvas y juveniles (Thayer et al. 1987, Yánez-Arancibia y Nugent 1988, Yánez-Arancibia et al. 1993).

A pequeña escala factores como la disponibilidad de alimento y el refugio contra la predación, constituyen elementos esenciales en la variación de la estructura de la comunidad de peces (Nagelkerken et al. 2000 y 2000a). Dentro de este contexto de sistemas con una gran complejidad estructural y una alta disponibilidad de alimento se encuentran las praderas de pastos marinos. Por lo que estos sistemas son utilizados como áreas de alimentación y crianza por parte de varias especies ícticas especialmente en etapas juveniles (Pollard 1984, Parrish 1989, Robertson y Blaber 1992, Nagelkerken et al. 2000, 2000a, 2001). Se han propuesto varias teorías para

explicar la alta abundancia de peces juveniles en estos sistemas, las cuales se basan en la alta disponibilidad de alimento y la alta complejidad estructural presente que les confiere una mejor protección contra los predadores (Parrish 1989, Robertson y Blaber 1992, Nagelkerken et al. 2000, 2000[a], 2001).

El estudio de la estructura de la comunidad de peces en etapas juveniles permitirá comprender mejor la relación existente entre estos organismos y el sistema de praderas de *Thalassia testudinum*.

MATERIAL Y METODOS

Área de estudio. La Laguna de Yalahau también conocida como laguna Conil se localiza en la parte noreste de la Península de Yucatán, en el Estado de Quintana Roo, México, entre los paralelos 21° 26' y 21° 36' de latitud Norte y los 87° 08' y 87° 29' de longitud Oeste (Figura 1). El sistema lagunar de Yalahau, se caracteriza por presentar áreas someras con praderas de macrófitas, dominadas principalmente por *Thalassia testudinum* tanto en la parte interna como en su boca (Espinoza-Avalos 1996).

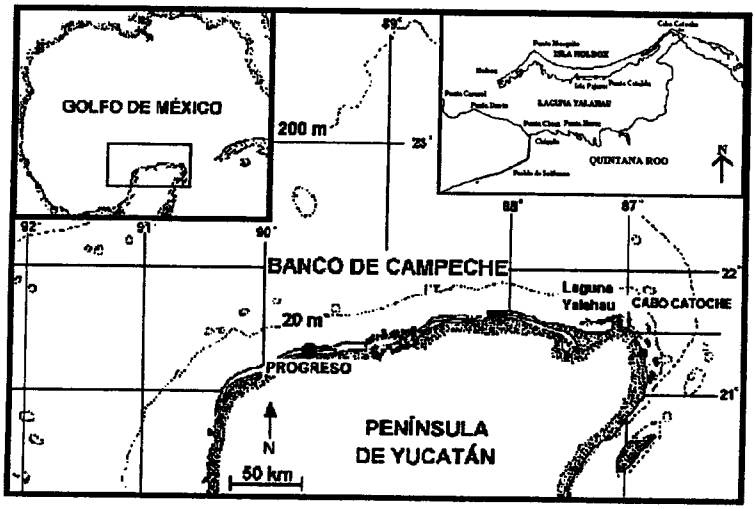

Figura 1. Ubicación del área de estudio. Laguna Yalahau, Península de Yucatán, México

En cada sitio de colecta se registraron los parámetros fisicoquímicos de salinidad en unidades ups y temperatura en °C, mediante un multisensor YSI 85/SOFT (±0.01). Para la recolecta se realizaron muestreos nocturnos considerando las fases de luna llena y luna nueva durante los meses de junio y julio del 2001, que corresponden a la época de lluvias en la región basándose en la estacionalidad hidrológica de la temperatura y salinidad (Valdés et al. 1988). Se realizaron

arrastres horizontales de 30 m sobre praderas de pasto de las tortugas con una red de barra tipo Renfro de 1.60 x 0.5 m de boca y una luz de malla de 1.00 mm. Las muestras obtenidas se fijaron en formaldehído diluido con agua de mar al 10 %. Los organismos colectados se identificaron a nivel de especie, cada organismo se peso (gr) y se midió en su longitud estándar (cm). Con los datos obtenidos se estimaron las fluctuaciones promedio de la abundancia y biomasa, además la estructura de la comunidad de juveniles se analizó a partir de sus principales descriptores: riqueza de especies, diversidad, equidad y dominancia (Ludwing y Reynolds 1988).

RESULTADOS

La temperatura promedio fue de 29.35°C presentándose un incremento gradual a través del tiempo, por lo cual la temperatura mínima se presentó durante la luna llena de junio y la máxima durante la luna nueva de julio. Por su parte la salinidad promedio durante los muestreos fue de 39.98 con un valor mínimo en luna llena de junio y el valor más alto reportado para este parámetro fue en la luna llena de julio (Figura 2).

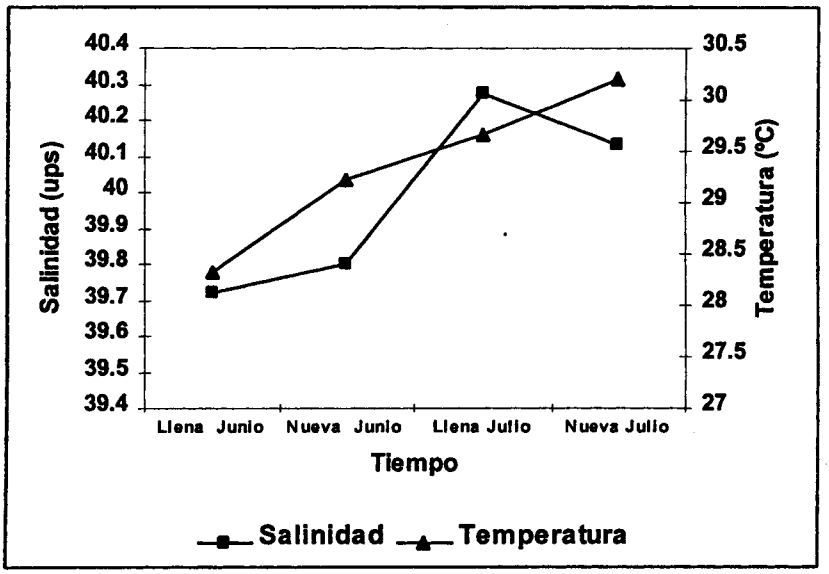

Figura 2. Variación temporal de la salinidad y temperatura durante las fases lunares de junio y julio del 2001

Se capturaron un total de 1050 individuos representados por 41 especies pertenecientes a 23 familias durante los meses de junio y julio del 2001, aportando en conjunto una biomasa total de 2930.3 gr. La captura promedio fue de 263 individuos con una biomasa de 732.6 gr para cada muestreo.

De las 41 especies reportadas el 53.7 % son eurihalinas y el 36.6 % son estenohalinas ambas del componente marino, solo el 9.7 % son residentes permanentes (Figura 3).

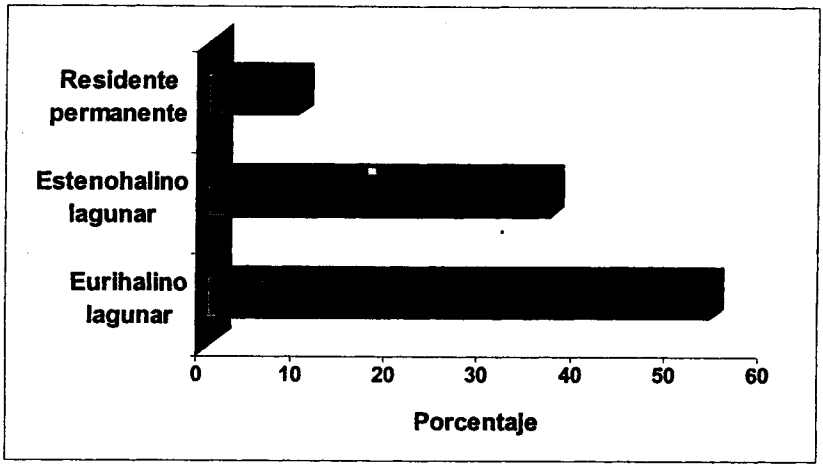

Figura 3. Categorías ecológicas de la ictiofauna juvenil registrada en Laguna Yalahau, Quintana Roo, México, de acuerdo a Castro-Aguirre et al (1999).

La mayor abundancia se presento durante la luna llena de julio y la menor en la luna nueva del mismo mes, mientras que la mayor biomasa se obtuvo en la luna nueva de junio disminuyendo a en la luna llena de julio (Tabla 1).

Tabla 1. Parámetros ecológicos registrados de la comunidad de peces juveniles en la Laguna Yalahau durante las fases lunares de junio y julio del 2001.

Parámetro	Llena Junio	Nueva Junio	Llena Julio	Nueva Julio
Abundancia (Nº de ind)	254	247	306	243
Biomasa (gr)	681.7	1120.6	480.5	647.5
Riqueza (S)	28	26	18	16
Familias	17	16	11	10
Diversidad (ind,/bits)	3.267	6.016	4.254	4.147
Equidad	0.092	0.168	0.210	0.227

La familia Syngnathidae fue la más representativa con un total de 10 especies, seguida de la Familia Haemulidae con solo 3 especies que en conjunto representan el 29.3 % de las especies reportadas en este estudio (Figura 4). En la tabla 1 se observó que la riqueza de especies presentó una variación temporal siendo la mayor durante la luna llena de junio (S = 28) diminuyendo gradualmente hasta la luna nueva de julio (S =16.). El valor más alto de diversidad se reporto para la luna nueva de junio y el menor en la luna llena de este mes, por su parte la mayor equidad se reporto para la luna nueva de julio y la menor en la luna llena de junio. La figura 5 representa a las especies más dominantes dentro de los juveniles, teniendo que *Lagodon rhomboides* fue la especie más dominante durante el muestreo tanto por su abundancia como por su biomasa, seguida en este sentido por *Lucania parva* que en conjunto representaron el 42.3 y 41.8 % de la abundancia y biomasa respectivamente. En conjunto las 7 especies más dominantes en el sistema de camas de *T. testudinum* aportan el 72 y 71.8 % de la abundancia y biomasa totales para toda la captura de juveniles en este sistema.

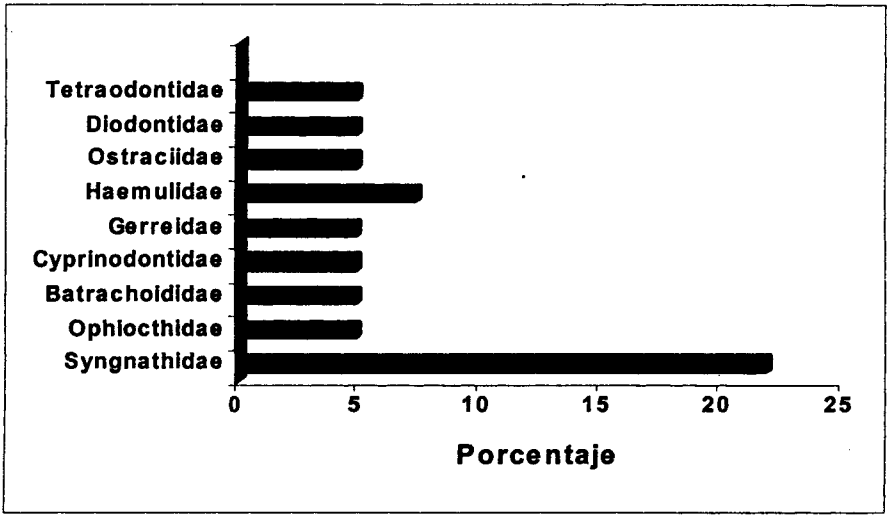

Figura 4. Abundancia relativa de las familias representativas en la comunidad juvenil en Laguna Yalahau durante las fases lunares de junio y julio del 2001

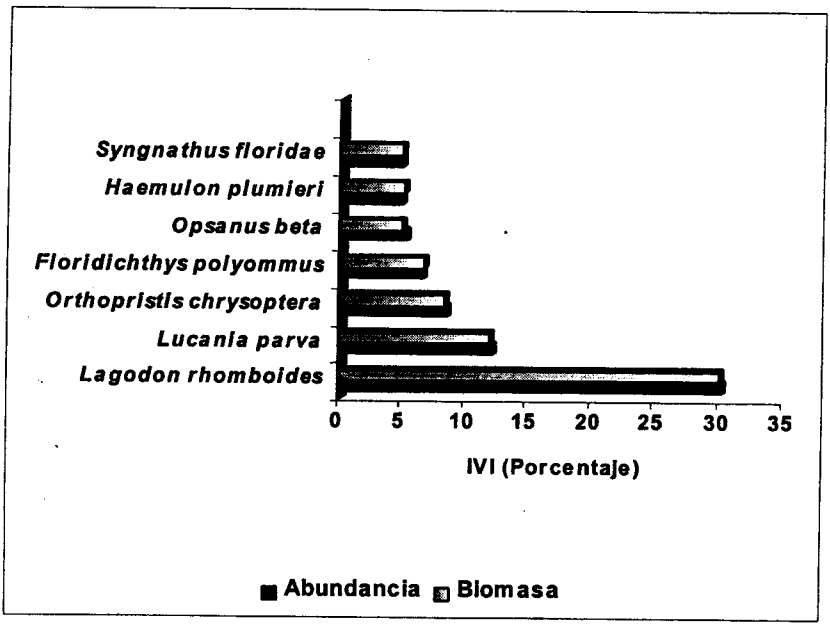

Figura 5. Especies dominantes en laguna Yalahau mediante el Índice de Valor de Importancia durante las fases lunares de junio y julio del 2001.

Por último la figura 6 presentó la tala promedio de captura para cada uno de los muestreos, donde se observó que la menor talla se presentó durante la luna llena de julio y la talla promedio máxima se registro en la luna nueva de junio, teniendo en promedio una talla de captura de los organismos durante todo el muestreo de 5.8 cm.

DISCUSIÓN

La salinidad experimentó un aumento durante el mes de julio, debido a una disminución en la precipitación pluvial, aunado a que esta laguna no presenta aportes de agua dulce por parte de ríos o manantiales. Al igual que el parámetro anterior la temperatura presento un ligero aumento durante el mes de julio, Valdés et al. (1988), señalan que la temperatura aumenta durante el periodo de lluvias, por efecto de la poca profundidad que junto con los niveles de radiación solar provocan un rápido calentamiento de la columna de agua.

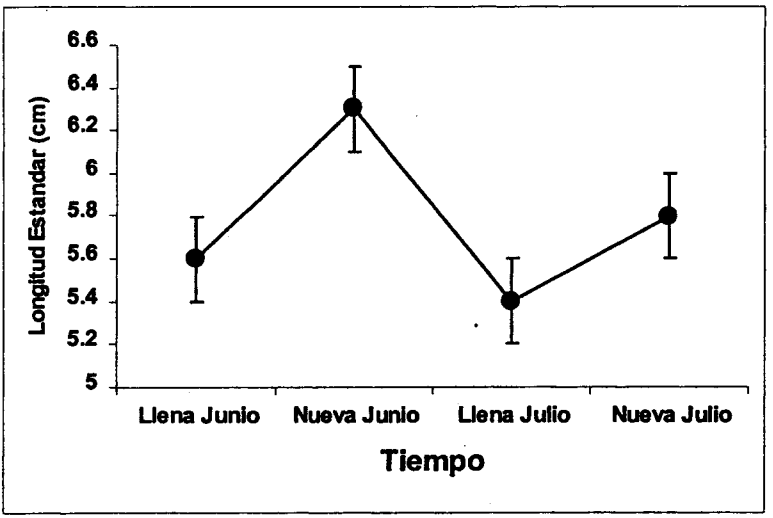

Figura 6. Variación temporal promedio de la talla de captura de la ictiofauna juvenil en Laguna Yalahau durante las fases lunares de junio y julio del 2001.

Las praderas de pastos de las tortugas en la Laguna Yalahau albergan una amplia variedad de especies de origen ecológico diverso. La constancia en la presencia de ciertas especies refleja la capacidad eurihalina de la ictiofauna de estas praderas, permitiéndoles soportar fluctuaciones en las condiciones ambientales (Kinne 1967). En el caso de este ecosistema se reportan en su mayoría especies eurihalinas y estenohalinas del componente marino en fase juvenil, una vez que han incrementado su talla y peso corporal migran a su hábitat de adulto fuera de la laguna alcanzando su madurez sexual y completando su ciclo de vida (Gunter 1961). Muchas de las especies reportadas en este estudio son individuos que en su fase adulta habitan en el arrecife adyacente a la laguna, mientras que su fase juvenil indicada por la talla promedio de los individuos capturados, utilizan a las praderas de *T. testudinum* como áreas de crianza, alimentación y protección que es proporcionada por la complejidad estructural que presentan este tipo de sistemas. Nagelkerken et al. (2000, 2000a y 2001) y García (2001), reportan comportamientos similares en la comunidad de peces de una laguna de la Isla de Curacao y Laguna Pajarera Central en Isla Contoy.

La comunidad de peces juveniles en este sistema guarda una característica en común con otras comunidades y es que se encuentra conformada por especies dominantes que residen en ella todo o gran parte del año y por especies que entran en ella en ciertos periodos de su ciclo de vida sobre todo en estadios juveniles (Yánez-Arancibia et al. 1980, González 1995, Vega 1998, y García, 2001). De acuerdo a Yánez-Arancibia *et al.* (1988), las especies dominantes son importantes

se ciclo de vida a las condiciones ambientales de su hábitat, así como por la conducta trófica y biológica de cada individuo.

La mayor abundancia durante la luna llena de julio se debe al incremento en el número de individuos capturados de especies forrajeras como *F. polyommus* y *L. parva*, siendo individuos juveniles de especies con una alta tasa reproductiva y de bajos niveles tróficos con altas eficiencia ecológicas, siendo importantes por el papel ecológico que realizan en la transformación y transporte de energía dentro del ecosistema, al ser alimento disponible para especies de niveles tróficos superiores (Vega 1998). El aumento en la biomas se debió a la presencia de organismos de mayor talla pero todavía en estadio juvenil de especies como *L. rhomboides* y *Orthopristis chrysoptera*, las cuales son especies generalistas que se alimentan de pequeños peces, crustáceos, poliquetos, nematodos que habitan sobre las praderas de pastos. Vega et al. (1992) reportan en un estudio prospectivo en esta misma laguna a estas especies como abundantes pero no especifican el substrato sobre el cual fueron capturados. Las especies que se presentaron en grandes abundancias son las que aprovechan más eficientemente los recursos presentes en el sistema, resultando dominantes en las capturas durante la época de lluvias (Yánez-Arancibia et al. 1988), resultados similares han sido reportados por González (1995) y Vega (1998) para la laguna de Celestún y para laguna Pajarera central por García (2001)

En conclusión el ecosistema de praderas de pastos de las tortugas en Laguna Yalahau funciona como área de alimentación, protección y crianza para individuos juveniles de diferente origen ecológico. Este tipo de estudios permiten determinar la importancia ecológica y biológica que representa el ecosistema de pastos para los peces juveniles dentro de sistemas más complejos como son las lagunas costeras del norte de la Península de Yucatán.

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Studies in Conservation Genetics of Tarpon (*Megalops atlanticus*) - IV. Population Structure among Gulf of Mexico Collection Sites Inferred from Variation in Restriction Site Polymorphisms of Tarpon Mitochondrial DNA

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ABSTRACT

Tarpon once supported valuable recreational fisheries in Texas waters. Beginning in the late 1940s catch rates began to decline, leading to reductions in tarpon-related activities including abandonment of lucrative tournaments. Desires to restore these valuable fisheries in Texas waters have prompted proposals for management interventions, including culture and stocking of hatchery-reared tarpon. Texas Parks and Wildlife Department Coastal Fisheries Division policies require examinations of the genetic consequences of enhancement programs prior to implementation of any stockings. In order to determine stock structure and estimate gene flow in the Gulf of Mexico, tarpon were collected from sites distributed between the Bay of Campeche in the southern Gulf and the Florida Keys in the eastern Gulf. Four mitochondrial DNA (mtDNA) fragments were amplified using the polymerase chain reaction. Each fragment was then digested with a suite of restriction enzymes and the resulting fragment patterns (RFLPs) were analyzed to infer population structure and gene flow.

KEY WORDS: *Megalops atlanticus,* conservation genetics, mitochondrial DNA

Estructura de los Sitios de la Colección en el Golfo de México deducidos por la Variación en Polimorfismos del Ditio de la Restricción de la DNA Mitochondrial de Sábalo

El Sábalo mantuvo una pesquería recreativa de mucho valor económico en las aguas de Texas. A inicios de los años 40 la tasa de captura declino, provocando que las actividades relacionadas con la pesca del sábalo se redujeran incluyendo el

abandono total de los torneos deportivos. El deseo de restaurar esa valiosa pesquería en aguas de Texas ha motivado plantear medidas de manejo, que incluyen el cultivo y la reintroducción de sábalos provenientes de poblaciones artificiales. El Departamento de Parques y Vida Silvestre, División de Pesquerías Costeras requiere conocer las consecuencias genéticas de los programas de mejoramiento antes de implementar cualquier actividad de reintroducción. Para determinar la estructura genética y estimar el flujo genético en el Golfo de México, se colectó sábalos de diferentes localidades distribuidas entre la Bahía de Campeche en el Sur del Golfo hasta Florida al Este del Golfo. Cuatro fragmentos de ADN mitocondrial (ADNm) fueron amplificados usando la Reacción en Cadena de la Polimerasa (PCR). Cada fragmento fue digerido con enzimas de restricción y los patrones de restricción (RFLPs) fueron analizados para inferir la estructura y el flujo genético.

PALABRAS CLAVES: *Megalops atlanticus,* genética , ADN mitochondrial DNA

INTRODUCTION

The tarpon (*Megalops atlanticus*) was historically one of the premier game fishes of the Texas coast, supporting a valuable recreational and tournament fishery. However, the Texas tarpon fishery collapsed near the middle of the 20th Century, resulting in a loss of recreational opportunity and an economic hardship on Texas' coastal communities. The Texas recreational fishery now focuses on estuarine species such as red drum (*Sciaenops ocellatus*) and spotted seatrout (*Cynoscion nebulosus*) and offshore species such as red snapper (*Lutjanus campechanus*). The recreational fishery represents a considerable economic asset for coastal communities, having recovered from overfishing in the 1970s (McEachron and Daniels 1995). The success of this recovery has renewed interest in attempts to effect recovery of the tarpon fishery. Proposals have centered on research to better understand the biology of tarpon and to determine the causes of the tarpon's decline in the northwestern Gulf of Mexico. In addition, the use of hatchery-spawned tarpon juveniles to enhance the natural population has been proposed as a possible management tool to facilitate the recovery of tarpon in Texas waters.

Marine stockings are considered to be an important component of the recovery and maintenance of Texas's recreational fishery (McEachron et al. 1995). Well designed enhancement programs may serve as valuable tools in the management of exploited organisms (Botsford and Hobbs 1984, Daley 1993), however poorly designed or poorly executed stocking programs represent a threat to the community structure (Courtenay and Moyle 1992), genetic diversity (Allendorf and Ryman 1987, Harada 1992) and stock structure (Nelson and Soulé 1987, Evans and Willox 1991) of natural populations. Protecting the genetic integrity of a native population impacted by a stocking program requires an understanding of within-population genetic diversity and among-population genetic divergence of the target species. In

recognition of the importance of protecting the genetic integrity of managed populations, the Coastal Fisheries Division of Texas Parks and Wildlife Department (TPWD) has established a policy requiring a thorough investigation of the genetic structure of a species prior to the implementation of a stocking program. This research provides the information necessary to implement sound protocols and safeguards to ensure the protection of the genetic resources of the species.

A series of investigations into the population genetics of tarpon have been conducted by TPWD biologists and their collaborators. The present paper describes variation observed in the mitochondrial DNA (mtDNA) of tarpon collected in the Gulf of Mexico. Variation in mtDNA across the distribution of tarpon has been reported (Blandon 2002), with samples from most regions characterized as highly diverse genetically. Population structure was limited, with tarpon from the western Atlantic, the Caribbean, and the Gulf of Mexico composing a single population. Tarpon from the Bay of Guinea and from the Pacific Ocean of Panama were genetically divergent and less diverse than conspecifics inhabiting the nonperipheral part of the species' range. A separate analysis (Garcia de Leon 2002) reached a different conclusion. This study, which examined variation in allozymes and 12S mtDNA RFLP data among tarpon from the western Gulf of Mexico, found evidence of distinct genetic differentiation between tarpon collected above Matagorda Bay, Texas and those collected from Matagorda Bay south to Veracruz. The present analysis attempts to specifically examine the Gulf of Mexico data contained in Blandon et al. in greater detail with the goal of resolving the differences between the earlier analyses.

METHODS

The strategy followed in this study was that of Chow et al. (1993). Targeted regions of the mtDNA genome were PCR amplified (Saiki et al. 1988) using conserved primers (Kocher et al. 1989), then digested with restriction endonucleases to produce fragments whose number and size depended upon the presence or absence of recognition sites. PCR allows analysis of small amounts of tissue collected by minimally invasive techniques (Whitmore et al. 1992) a characteristic especially important in tarpon, which are often accessed during recreational captures requiring minimal handling and release of fish. Samples were primarily scales obtained from a variety of sampling sites (Figure 1). Most Texas samples were obtained by TPWD personnel during routine resource sampling or opportunistically following fish kills. Recreational fishermen and guides from across the distribution of the species were enlisted to collect scales from catch-and-release captures. Several samples were obtained from tournaments in Mexico, Texas, Louisiana, and Florida and from fish markets in Mexico. For perspective, a sample from Chetumal, on the Mexican Caribbean Coast, was included in some analyses. Scales were placed in 100% ethanol (diluted to 70% with DI water), refrigerated for 24 hours, then stored at room temperature until shipment to the Perry R. Bass Marine Fisheries Research Station.

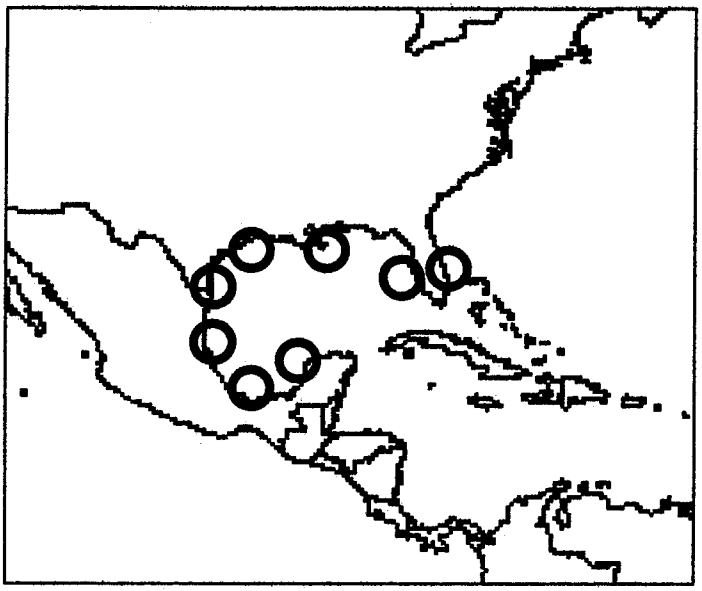

Figure 1. Tarpon collection localities in the Gulf of Mexico and Atlantic Ocean

Table 1. Genotypic diversity and percent mean nucleotide sequence diversities for seven tarpon (*Megalops atlanticus*) sampling localities

Locality	Number of individuals	Number of haplotypes	Nucleon diversity (mean +/- SD)
Florida	21	8	0.723+/-0.101
Louisiana	20	10	0.758+/-0.101
Texas – Upper	28	11	0.807+/-0.060
Texas – Lower	25	14	0.890+/-0.052
Tampico	27	12	0.849+/-0.059
Veracruz	53	17	0.731+/-0.064
Campeche	3	2	0.667+/-0.314
Total	177	43	0.776+/-0.001

Genomic DNA was recovered from scales using the Puregene DNA isolation kit (Gentra Systems, Minneapolis, MN). Four mtDNA fragments were PCR amplified using primers designed for broad application among teleost fishes (Table 1). Reactions employed Ready-To-Go PCR beads (Amersham Pharmacia Biotech, Piscataway, NJ) in 25 µl reactions containing 1.0 µl of template DNA and 1µl of each member of the primer pair. Amplifications were performed using Techne

Genius thermalcyclers (Techne Inc., Princeton, NJ) programmed for the following profile: 35 cycles at 95°C (60 s), 48 °C (75 s), 72 °C (90 s), followed by 72 °C for 7 min, then a 4 °C hold.

A sub-set of amplification products were digested with 26 restriction endonucleases: *AciI, AluI, BfaI, BsaJI, BslI, BsoFI, BstUI, Cac8I, DdeI, Fnu4HI, HaeIII, HhaI, HinfI, MaeIII, MboI, MnlI, MseI, MspI, MwoI, NlaIII, NlaIV, RsaI, Sau96I, ScrFI, TaqI,* and *Tsp509I.* Digestion protocols provided by restriction enzyme suppliers were followed. Results were screened for polymorphism and quality of digest. Polymorphic RFLP patterns were confirmed through repeat digestions separated on 2% agarose gels. Fragment sizes were determined by comparison with pGEM molecular weight DNA markers (Promega Corporation, Madison, WI) and analyzed using the Gene Profiler 1-D Gel Analysis and Databasing Program (Scanalytics, Inc., Fairfax, VA).

Nucleotide sequence diversity within samples and divergence among sampling sites were estimated using the software package REAP (McElroy et al. 1992). Phylogeographic relationships of composite haplotypes were examined using minimum-length parsimony networks. Composite haplotypes were connected based on similarity of inferred restriction site sequences. Changes in restriction site sequence were assumed to reflect single nucleotide gain, loss, or point mutation. Exact tests were used to examine pair-wise differences in haplotype frequency (Raymond and Rousset 1995a, Goudet et al. 1996) using the statistical program ARLEQUIN (Schneider et al. 1999). Significance of exact test probabilities was estimated by resampling 1000 times. Population subdivision was estimated using the statistical program GENEPOP (Raymond and Rousset 1995b) which calculated θ (Weir and Cockerham 1984). ARLEQUIN was used to perform an analysis of molecular variance (AMOVA) generating estimates of genetic variance components (Excoffier et al. 1992). The program TREEVIEW (Page 1996) was used to generate a neighbor-joining tree generated from the matrix of interpopulational (mtDNA) nucleotide sequence divergence.

RESULTS

Intrapopulational mtDNA nucleotide-sequence diversities (Table 1) ranged from 0.667 (SD = 0.314) at Campeche to 0.890 (SD = 0.052) on the lower coast of Texas, with a value of 0.776 (SD = 0.001) for the combined samples. Campeche, with a limited sample (n = 3), had three observed composite haplotypes and Veracruz was observed to have 17 composite haplotypes. Forty-three composite haplotypes were observed across the Gulf of Mexico. The diversity of encountered nucleotide sequences is reflected in the minimum-length parsimony network (Figure 2). The composite haplotypes (H, M, N, and AL) observed to be most divergent differed from the most common composite haplotype (A) by a minimum of 3 base-pair (bp) changes. Three secondary hubs (E, F, and L; in the sense of Gold et al. 1997) were found, each related to composite haplotype A by a minimum of 1 bp. There is little apparent biogeographic correspondence among haplotype lineages.

Louisiana and Veracruz had representatives of each of the secondary hubs. The only apparent biogeographic structuring involved the absence of hub L from Tampico and the lower coast of Texas and the rarity of that hub in the upper Texas coast and in Louisiana.

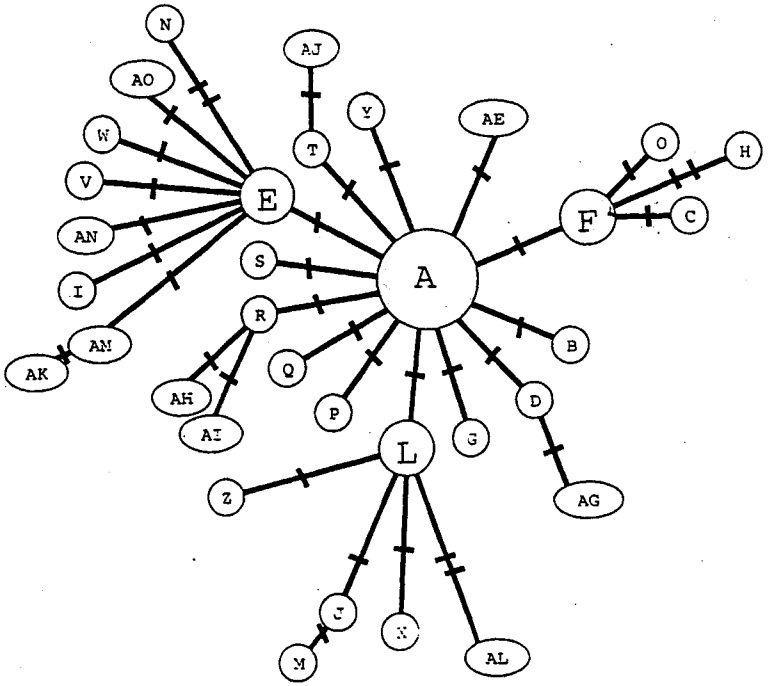

Figure 2. Minimum length parsimony network for composite haplotypes of tarpon collected in the Gulf of Mexico. Missing letters represent composite haplotypes not observed in the Gulf of Mexico

Nucleotide divergence among populations was low (Table 2). The combination of high within-region genetic diversity and low among-regions genetic divergence is reflected in the results of the AMOVA (Table 3) which found a strong preponderance of the observed variance to be attributable to within sample diversity. Estimation of a θ value of 0.007 (p = 0.665) suggests absence of biologically significant population structuring among collection regions in the Gulf of Mexico. However, pairwise examinations of among-sampling region genetic differentiation (Table 2) found differences between the northwestern Gulf of Mexico (Tampico and the Texas collections) and the southern and eastern Gulf of Mexico. Though the structure was not pronounced, a neighbor-joining tree generated from interpopulational mtDNA nucleotide sequence divergence values (Figure 3) also differentiated between the northwestern Gulf of Mexico and eastern and southern reaches of the Gulf, however distances among nodes were minimal.

Table 2. Above diagonal, nucleotide sequence divergence among sampling regions. Below diagonal, probability values (*p*) associated with pairwise exact tests of population differentiation among sampling regions. Second value represents the confidence in the probability value estimated using 1,000 resamplings.

	Florida Gulf	Louisiana	Texas Upper	Texas Lower	Tampico	Veracruz	Campeche
Florida Gulf	-	-0.0005	-0.0001	-0.0001	0.0002	-0.0003	-0.0015
Louisiana	0.892 ±0.003	-	-0.0003	-0.0002	-0.0004	-0.0003	-0.0013
Texas Upper	0.017 ±0.004	0.377 ±0.011	-	-0.0002	-0.0001	-0.0001	<0.0001
Texas Lower	0.029 ±0.005	0.438 ±0.016	0.139 ±0.010	-	0.0005	0.0005	0.0003
Tampico	0.051 ±0.009	0.918 ±0.009	0.007 ±0.003	0.026 ±0.007	-	0.0002	-0.0003
Veracruz	0.992 ±0.013	0.687 ±0.013	0.044 ±0.006	0.033 ±0.007	0.070 ±0.007	-	-0.0015
Campeche	0.284 ±0.016	0.316 ±0.012	0.037 ±0.004	0.284 ±0.010	0.162 ±0.015	0.401 ±0.021	-

Table 3. Analysis of molecular variation (AMOVA) among composite mtDNA haplotypes of tarpon from the Gulf of Mexico.

Variance component	Observed partition	
	Variance	% total
Among regions	-0.00980	-0.68
Within regions	1.45715	100.68
Total	1.44735	100.00

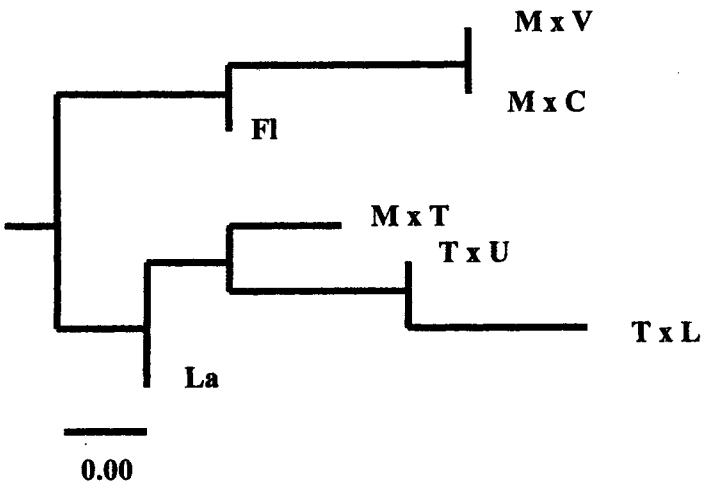

Figure 3. Neighbor-joining tree generated from matrix of interpopulational (mtDNA nucleotide sequence divergence. Bar scale below tree represents relative distance units

DISCUSSION

Gulf of Mexico tarpon are characterized by extensive within-region genetic variability and by reduced among-region genetic differentiation. The exception to the latter is the northwester Gulf, where tarpon appear to exhibit some degree of differentiation. This divergence is reminiscent of the conclusions drawn by García De León et al. (2002) which suggested a break in the frequencies of allozyme allelic distributions between the upper and lower coasts of Texas. This discontinuity is further west in the Gulf of Mexico than any differences detected in the present study, but that may be a function of different evolutionary histories of the allozyme loci

(nuclear) studied by García De León and the mtDNA fragments examined in the present study.

If tarpon from the northwestern Gulf of Mexico are genetically distinct from conspecifics in the southern and eastern Gulf some mechanism must be found to account for this differentiation. Tarpon spawn in deep offshore waters, have eggs and larvae with an extended pelagic phase, and adults are highly migratory (Zale and Merrifield 1989). This suite of life history traits would predict little or no population structuring in the absence of physical barriers to gene flow (Gyllensten 1985). It's possible the observed differentiation is attributable to chance geographic variation in a panmictic gene pool or to sampling error. The geographic cohesion of the cluster of genetically differentiated sampling regions argues against this interpretation.

If tarpon of the northwestern Gulf of Mexico are genetically differentiated, stocking strategies will have to be developed that take this structuring into account. Broodfish will need to be collected from the same region into which their offspring will be stocked. Optimally, broodfish should be collected from Texas, with possible contributions from Louisiana or northern Mexico. Certainly tarpon derived from broodfish collected in Florida or from south of Tampico should not be released in Texas. The high levels of within-sample genetic variation noted in Gulf of Mexico tarpon require that the numbers of broodfish be extensive and that broodfish turnover be frequent. It will also be necessary to insure an equal contribution from each female broodfish and an approximately equal number of male and female broodfish.

The reduced population of wild tarpon targeted for enhancement makes care in the design and implementation of culture and stocking strategies critical. The smaller the effective size of the target population the greater the potential impact, both positively and negatively, an enhancement program will have if that program is effective.

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Trophic Analysis of the Fish Community Taken as Bycatch of Shrimp Trawls off the Coast of Alvarado, Mexico

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ABSTRACT

In the southern Gulf of Mexico, there is an important shrimp fishery industry with no recent works on the fish assemblage ecology coming from the trawling bycatch. The objective of this work was to seasonally analyze the trophic spectrum and niche parameters of the most important fish coming from the shrimp bycatch. During 1991 to 1994, 21 two hour trawls were done in the southern Gulf of Mexico off Veracruz, Mexico at a mean depth of 20 m. The importance value of the food items, identified to the finest level possible, was used to calculate: the Levins niche breadth for each species; a cluster analysis, and the Rekonen index for niche overlap between species for three seasons. During the dry season, 26 fish species were analyzed which grouped into four clusters based on 24 food items. The highest Rekonen value (> 53%) was for species feeding on benthic or zooplankton items. For the rainy season, 26 species were grouped into three clusters, of which the benthic feeders presented the highest niche overlap (> 47%) and the least number of species. The northerly winds season was the richest in species (43), which were assembled in three groups according to their food items. One group was formed by two anchovies with a high (> 80%) niche overlap. Thirty-six species formed a single group feeding on a variety of items (mainly benthic) with a niche overlap > 50%. The high number of species feeding on similar items during the northerly winds season may be due to a higher productivity in the region produced by the river runoff. In contrast to the other seasons, the amount of food items are restricted, thus diminishing the number of possible prey and increasing the niche overlap between trophic groups.

KEY WORDS: Fish ecology, resource partitioning, shrimp bycatch

Análisis Trófico de la Comunidad de Peces Provenientes de la Pesca Incidental Camaronera de la Costa de Alvarado, México.

El objetivo de este trabajo fue el de analizar estacionalmente el espectro trófico y los parámetros del nicho de las especies de peces más importantes provenientes de la pesca incidental del camarón. Durante 1991 a 1994 se realizaron 21 viajes en el sur del Golfo de México haciendo arrastres de 2 horas a una profundidad media de 20 m. El valor medio de los tipos alimenticios, identificados al nivel más fino posible, fue usado para calcular: el índice de amplitud de nicho de Levins; un análisis de clasificación y el índice de Rekonen para el solapamiento de nicho entre las especies durante las tres temporadas del año. Para la temporada de secas 26 especies fueron analizadas que se agruparon en cuatro grupos de acuerdo a los 24 tipos alimenticios ingeridos. El mayor valor de Rekonen (>53%) fue para las especies que se alimentan de bentos o zooplancton. Para la temporada de lluvias 26 especies fueron analizadas agrupadas en tres grupos, de los cuales las que se alimentaron del bentos presentaron el mayor valor de Rekonen (>47%) y el menor número de especies. La temporada de nortes fue la de mayor riqueza específica (43 especies) quienes se dividieron en solo tres grupos. Uno de los grupos formado por las anchoas y un solapamiento mayor al 80%. Otro de los grupos se formó por 36 especies que se alimentan de una variedad de organismos (principalmente bénticos) con un solapamiento de nicho del 50%. La alimentación de la gran cantidad de especies en la temporada de nortes tan similar puede deberse a una mayor productividad en la región producida por el escurrimiento de los ríos adyacentes. En contraste la cantidad de tipos alimenticios de las otras temporadas es menor disminuyendo el número de presas e incrementando el solapamiento entre los grupos tróficos.

PALABRAS CLAVES: Captura incidental, ecología de peces, repartición de recursos

INTRODUCTION

Demersal fish community structure has been studied in different ways at different locations of the world. For instance, there have been studies dealing with their diversity (Stobutzki et al. 2001), seasonal biomass trends (Blanchard, 2001), and relation to estuarine areas (Yañez-Arancibia et al. 1985). However, along the Mexican coasts, there are few studies relating to the demersal fish community, with the exception of Yañez-Arancibia and Sánchez-Gil (1988), and Franco et al. (in revision). The former work analyzes the effects on demersal fish from shrimp trawling at the Campeche Bank, and Franco et al. (in revision) analyzes the community structure and seasonal trends in biomass and abundance. Considering the importance that the demersal fish community has on the ecology of the ecosystem, in addition to its importance as an exploited resource, the aim of the present work was to analyze the trophic relationship of the most abundant species during three seasons over a four-year period.

METHODS

All biological material was collected on board the research vessel CET-Mar Alvarado within the commercial area for shrimp capture and in front of the opening of the Alvarado Lagoon. The sampling area was located between 18° 45" and 19° 00" N and 95° 40" and 85° 57" W (Figure 1). Twenty-one trips between May 1991 and November 1994 were performed using a Japanese-type trawl 20 m long, mouth opening of 2 m and mesh size of 1.75 inches. The trawl was fished for 2 h at a depth of 25 meters. All the sampling dates were divided into the three seasons occurring in the area; rainy (n = 6), dry (n = 6) and north winds (nortes; n = 9).

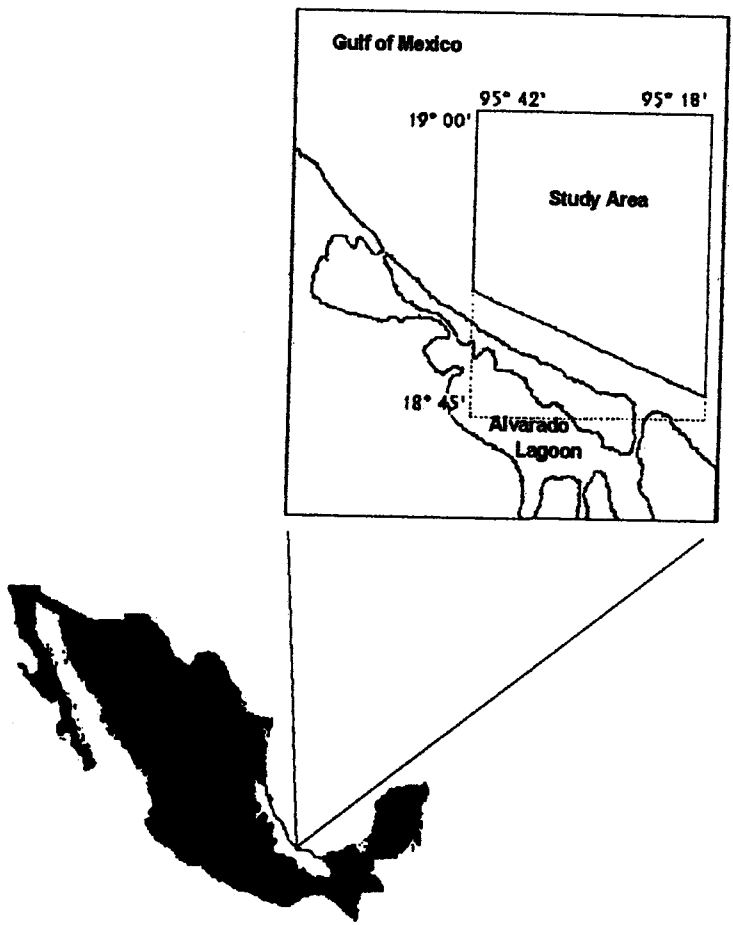

Figure 1. Study area location and its relation with the coastal lagoon of Alvarado and the Gulf of Mexico.

Ten percent of the total fish capture was randomly selected, stored in plastic bags with 10% formaldehyde, and transported to the laboratory. Fishes were identified to species, weighed (g), and measured (standard length; SL; mm). The stomach contents were identified to the highest possible taxonomic level using a stereoscopic microscope. Food items were weighed to the nearest 0.1 mg, and an importance value was assigned to each item, based on the gravimetric and volumetric methods (Bagenal 1978).

Although 159 fish species have been reported for this area (Franco-López et al. in revision), only the species with a biomass greater than 2 kg and an abundance of more than 100 individuals combined for all sampling dates per season were analyzed in this report. The stomach analysis for the fish were pooled for each season. A cluster analysis using Euclidean Distance was performed on the stomach content data in order to identify species guilds for each season. Food niche width was also calculated for each species at each season using the Levins Index (Marshall and Elliot 1997). The trophic niche overlap was computed using the Renkonen Index.

RESULTS

Dry Season

During the dry season, 26 species, representing 3,331 fish containing 24 different food items were analyzed. Trophic niche width, as measured by the Levins Index ranged from 1 to 4.7, with *Micropogonias furnieri*, *Cynoscion arenarius* and *Sphyraena guachancho* presenting values greater than 4, and *Anchoa rostralis* and *Menticirrhus littoralis* values of 1 (Table 1). After the cluster analysis, the dendrogram was divided into four groups according to their food items (Figure 2). The first group, formed by species like *Chloroscombrus chrysurus*, was a guild of species feeding on planktonic organisms. The Levins niche width ranged from 1 to 4.7 with a mean value of 1.74, and presented a mean Rekonen value for niche overlap of 54.17 %. Ten species feeding primarily on benthic items (polychaets, stomatopds, and fish) composed the second trophic guild. The mean Levins niche width was 2.13 (range 1 to 3.9), and the guild was composed of species such as *Haemulos aurolineatum* and *Harengula jaguana*. The Rekonen mean niche overlap for this guild was 53.71 %. Carnivorous species, such as *C. arenarius* and *Synodus foetens*, represented the third group with a mean Levins value of 3.46, (range 2.19 to 4.73) and a mean Rekonen niche overlap of 29.3 %. The last group, represented by six strict carnivorous species feeding on items such as shrimp, crabs, fish, and squid had a mean Levins value of 2.73 (range 1.8 to 3.5) and a mean Rekonen overlap value of 39.4 %.

Rainy Season

During the rainy season, 26 species, representing 3,023 fish were sampled. The Levins niche width index varied between 1 (*Diplectrum bivittatum*, *Saurida brassiliensis* and *Scorphaena plumeri*) and 4.5 (*C. arenarius* and *S. foetens*; Table

2). The dendrogram was divided into three guilds (Figure 3). The first guild contained seven species using 16 different food items such as *A. rostralis*, crabs, and squid, and had a mean Levins index of 3.52 (range 2.5 to 4.5) and a mean Rekonen overlap value of 22.62 %. The second guild represented 11 species feeding on 18 different food items, mainly benthic. The mean Levins index value was 2.5 (range 1 to 3.5), and the mean Rekonen overlap value was 47.7 %. The third guild was composed of five species using planktonic organisms as their main food. Species such as *Harengula clupeola* and *C. chrysurus* were part of this guild, which had a mean Levins value of 2.75 (range 1.9 to 3.9), and a mean Rekonen overlap value of 39.75 %.

Table 1. List of fish species for the dry season and the Levins index for niche width

Species	Levins index	Species	Levins index
Achirus lineatus	3.51	*Lepophidium graelisi*	1.92
Anchoa mitchilli	1.83	*Menticirrhus littoralis*	1.00
Anchovia rostralis	1.00	*Micropogonias fumieri*	4.74
Citharinchthys spilopterus	2.82	*Porichthys porosissimus*	1.89
Chloroscombrus chrysurus	2.00	*Sardinella aurita*	1.88
Conodon nobilis	3.93	*Saurida brassiliensis*	2.63
Cynoscion arenarius	4.73	*Selar crumenophthalmus*	2.34
Cynoscion nothus	2.73	*Selene vomer*	1.36
Diapterus auratus	2.20	*Sphyraena guachancho*	4.22
Engyophrys senta	2.17	*Synodus foetens*	2.25
Haemulon aureolineatum	1.83	*Trachurus lathami*	2.19
Harengula jaguana	1.37	*Trichiurus lepturus*	3.32
Hoplunnis macrura	1.83	*Upeneus parvus*	377

North Winds Season

The highest number of species (43) and individuals (4,378) were captured during the north winds season. The Levins values varied between 1 and 5.9 (Table 3). The resulting dendrogram from the food items analysis was divided into three groups (Figure 4). The first group was composed by two planktivorous species, *Anchoa hepsetus* and *A. mitchilli*, with a mean Levins niche width of 1.38 (ranging from 1 to 5.9), and a mean Rekonen overlap value of 82.7 %. The second group was formed by a carnivorous guild of four species including *Diplectrum formosum* and *S.guachancho*. The mean Levins value for this guild was 1.29 (range 1 to 1.9), and the mean Rekonen overlap value was 69.7 %. The third group had the highest number of species (36), and the greatest number of food items (23), making this group one of the most diverse. The mean Levins width index was 3.04 (range 1 to 5.9), and the mean Rekonen niche overlap value was 53.24 %. This group is a mixture of species feeding on different items, but predominating the benthophagous.

Table 2. List of fish species for the rainy season and the Levins Index for niche width

Species	Levins Index	Species	Levins Index
Cetengraulis edentulus	1.28	*Porichthys porosissimus*	2.62
Chloroscombrus chrysurus	3.92	*Pristipomoides aquilonaris*	3.46
Conodon nobilis	3.70	*Saurida brassiliensis*	1.00
Cyclopsetta chittendeni	3.51	*Scorphaena plumeri*	1.00
Cynoscion arenarius	4.55	*Selene setapinnis*	1.92
Cynoscion nothus	2.53	*Selene spixii*	2.38
Diapterus auratus	2.21	*Sphyraena guachancho*	2.94
Diplectrum bivittatum	1.00	*Stellifer lanceolatus*	4.17
Engyophrys senta	2.06	*Syacium gunteri*	2.94
Haemulon aureolineatum	2.79	*Synodus foetens*	4.44
Harengula clupeola	1.81	*Trinectes maculatus*	1.10
Harengula jaguana	3.09	*Umbrina coroides*	3.63
Micropogonias furnieri	3.08	*Upeneus parvus*	333

Table 3. List of fish species for the north winds season and the Levins Index for niche width

Species	Levins Index	Species	Levins Index
Achirus lineatus	3.58	*Mirophys puntatus*	2.94
Anchoa hepsetus	1.54	*Ophidion welshi*	2.00
Anchoa mitchilli	1.22	*Polydactilus octonemus*	3.41
Caranx hippos	1.00	*Porichthys porosissimus*	4.03
Chloroscombrus chrysurus	3.59	*Prionotus rubio*	2.88
Conodon nobilis	5.88	*Pristipomoides aquilonaris*	2.24
Cyclopsetta chittendeni	1.95	*Sardinella aurita*	1.00
Cynoscion arenarius	2.52	*Scorpaena plumeri*	3.77
Cynoscion nothus	2.99	*Selar crumenophthalmus*	2.00
Diapterus auratus	1.93	*Selene spixii*	2.38
Diapterus rhombeus	1.74	*Sphyraena guachancho*	1.00
Diplectrum bivittatum	1.54	*Stellifer lanceolatus*	3.77
Diplectrum formosun	1.92	*Stenotomus caprinus*	3.43
Egyophyrys senta	2.40	*Syacium gunteri*	3.75
Eucinostomus melanopterus	4.17	*Syacium papillosum*	2.78
Gymnotorax nigromarginatus	2.29	*Symphurus plagiusa*	4.44
Harengula clupeola	4.03	*Synodus foetens*	2.93
Harengula jaguana	5.09	*Trachurus lathami*	1.80
Lepophidium graellsi	2.90	*Trichiurus lepturus*	3.06
Lobotes surinamensis	1.24	*Umbrina coroides*	5.49
Lutjanus campechanus	1.75	*Upeneus parvus*	3.57
Micropogonias furnieri	2.52		

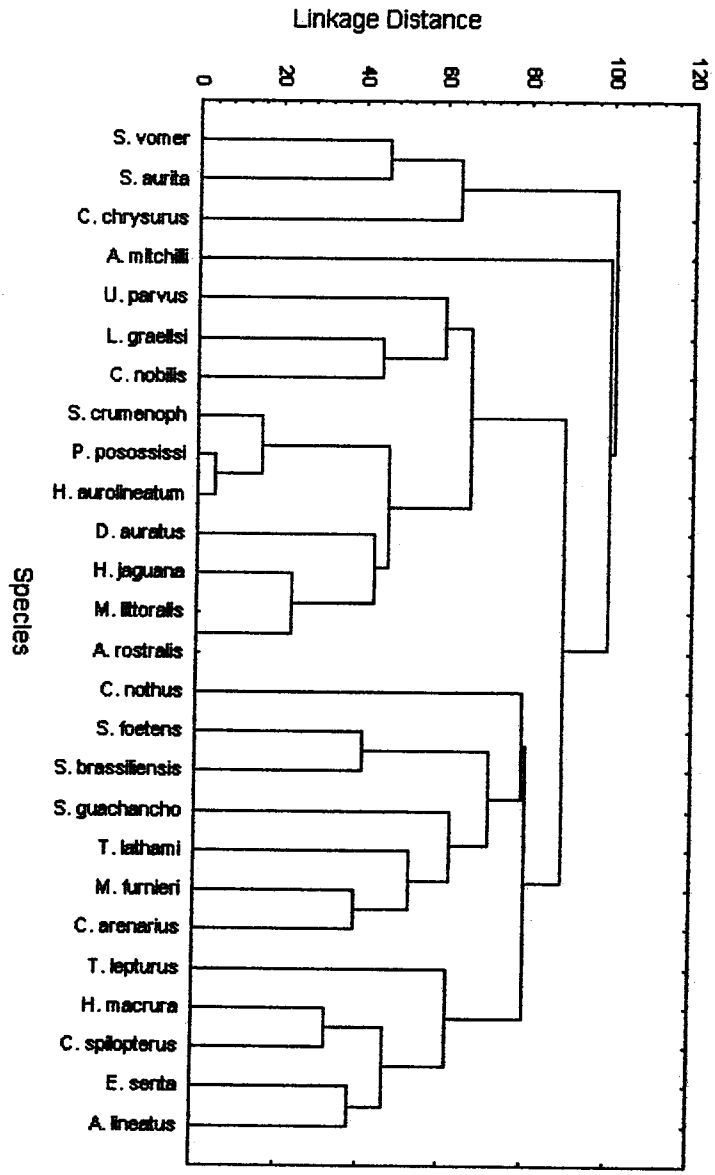

Figure 2. Dendrogram of species according with their food items for the dry season for the area off Alvarado, Veracruz, Mexico.

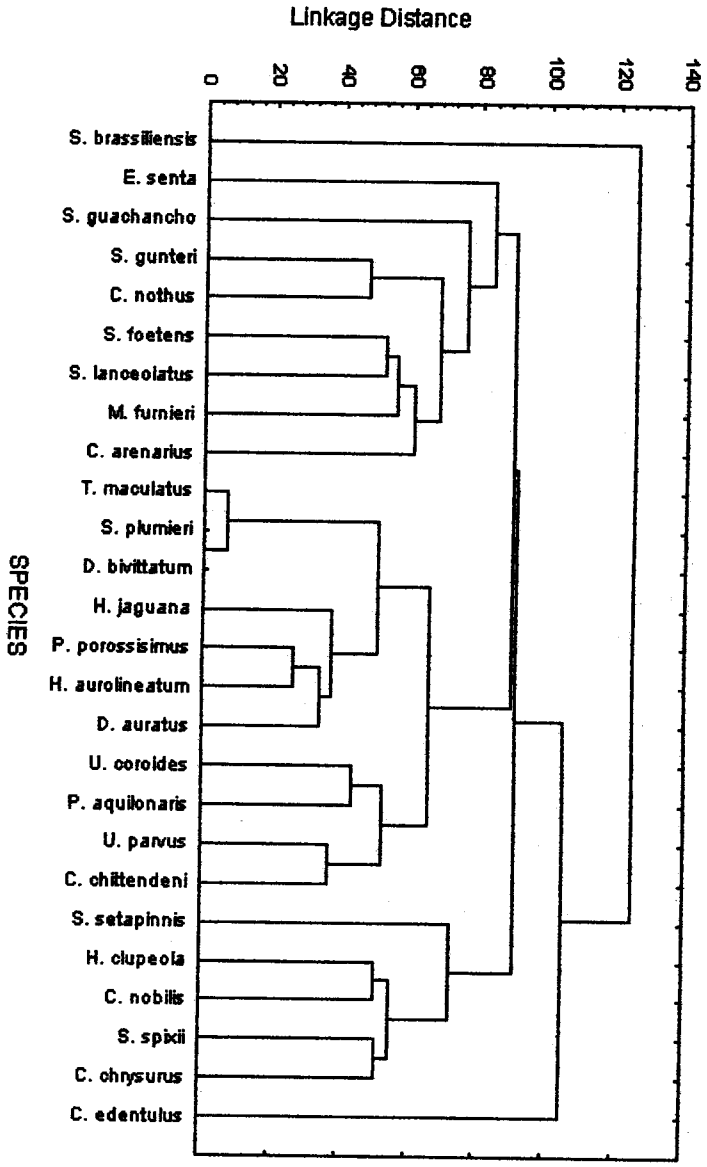

Figure 3. Dendrogram of species according with their food items for the rainy season for the area off Alvarado, Veracruz, Mexico.

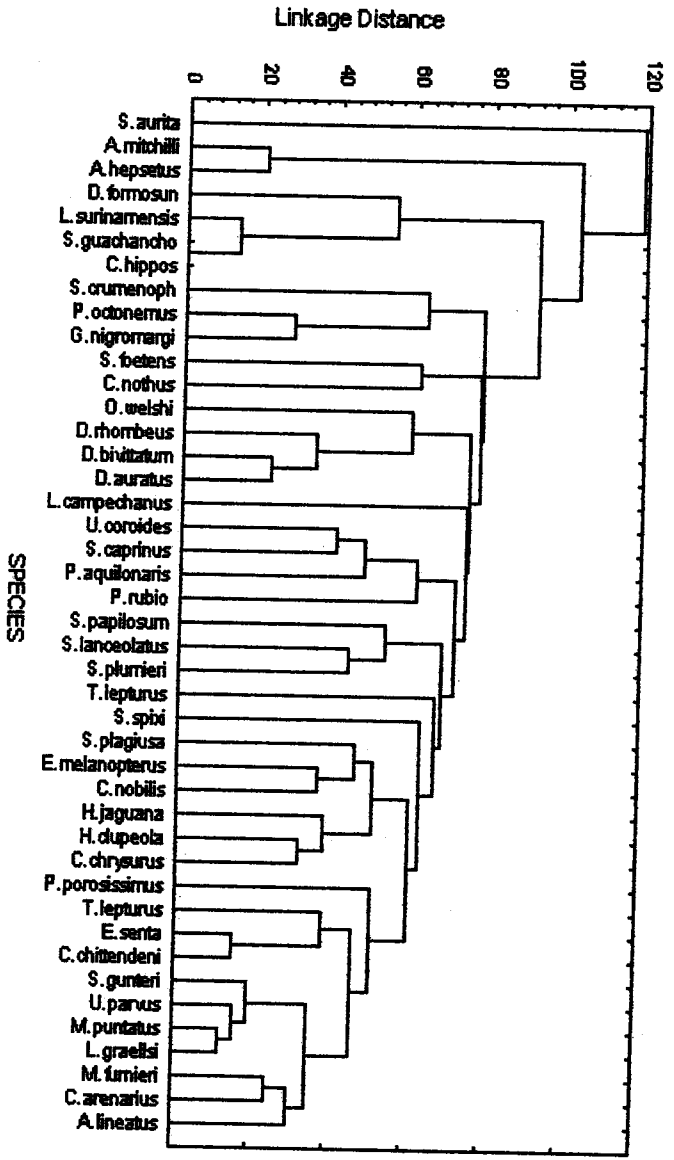

Figure 4. Dendrogram of species according with their food items for the north winds season for the area off Alvarado, Veracruz, Mexico.

DISCUSSION

The number of species found in the area off Alvarado was high (159 species) as expected for a tropical zone (Franco-López, et al. in revision), but lower compared to other similar areas, e.g. Australia (Stobutzki et al. 2001). A tropical system has a high number of species living within its boundaries, meaning that the resources they use, mainly food, have to be shared or partitioned between all of them. The theory in a situation where the resource, e.g. food, is scarce, dictates that competition should appear between species (Odum 1978). However, after a revision of available data, Ross (1986) proposes that the partition of resources between species occurs mainly into three different axes: food, habitat or space, and time. In the case of fish communities, resource partitioning between species is achieved by a high degree of omnivory (Gerking 1994) of the species. One of the characteristics of fishes is their ability to switch food items as the amount them increases or decreases (Sierra et al. 2001, Gerking 1994).

The results of the study revealed a difference of resource partitioning between the fish species between the three different seasons. For the dry and rainy season, with a similar number of species, the number of trophic guilds, and their type is similar. That is, although the species were different for each guild for each season the type of food resource use is the same (e.g. benthophagous, planktivorous). Although the similarity in guilds types the Rekonen overlap measure was different for the same kind of guild between seasons. That is, for the rainy season the planktivorous guild overlap was lower than that for the dry season. This is interesting considering that for the dry season there is one more trophic guild, what can be said of these results is that for the dry season, when the river runoffs are small, the amount of food items is reduced, and fish have to partition more the available preys in order to minimize competition. The opposite occurs in the rainy season when a higher availability of food exist, and fish can share the items with minimal competition.

On the other hand, for the north winds season, with a much high number of species than the previous two seasons, only three trophic guilds from the cluster analysis were found after cutting the dendrogram at the same level as for the former two seasons. One of the guilds was composed by two species of the same genus feeding almost the same items. The biggest of the groups did not present a high niche overlap value as expected considering the high number of species. Considering the relatively low overlap value, the dendrogram was divided further into smaller guilds, producing an increase in the food partitioning between species and a decrease of the niche overlap.

Blanchard (2001) suggests that the biomass variability to be related to the species interactions. In a previous report (Franco-López et al., in revision) it was argued that the biomass oscillations along the four years study might represent a balance of fish species and related to the use of the food resources. The results obtained in this work may support this hypothesis considering that the number of food items found for each season is related to the productivity, and that fish respond to it by increasing their omnivory and opportunism. this two characteristics allow

fish to diminish the competition for food and increase their biomass when the conditions are adequate.

On the other hand, the higher number of species and their resources are also related to the runoff of the adjacent rivers and coastal lagoons during the rainy, dry, or north winds season. A larger runoff produces an adequate environment for a higher productivity, which is used by the benthic and planktonic communities helping the establishment of a certain type of fish communities.

In conclusion, the fish community presented a low degree of food niche overlap within seasons and a marked difference in the number of species during the seasons. The differences between seasons might be related to the amount of food available and the high capacity of fish to share resources between them.

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Comparison of Hydroacoustic Surveys to Traditional Trawl Methods for Determining Nekton Biomass in a Louisiana Estuary

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ABSTRACT

Knowledge of the distribution and biomass of fishes within an estuarine system is needed to make effective management use of the concept of Essential Fish Habitat (EFH). Four basic habitat types are recognized in a typical estuary: marsh, marsh edge, open bay, and channel. Fish distributions and species diversities within these habitat types can vary with season, tide, lunar cycle, weather, and bottom type. Resolution of the influence of these and other variables on EFH is confounded by limitations of traditional sampling gears. Recently, hydroacoustics has been shown to be a useful sampling tool that avoids some of the selectivity issues encountered with traditional gear types. A survey was conducted in coastal Louisiana to evaluate the quantitative capabilities of hydroacoustics in a shallow water setting. Survey objectives were to 1) determine the nekton biomass associated with two different habitats (bay and channel), 2) compare hydroacoustic data to concurrently collected wing-net data, and 3) determine effect and magnitude of ambient acoustic backscatter on nekton biomass estimates.

Based on acoustic sampling, there was no diurnal difference in channel biomass; however, based on channel wing-net samples there was a three-fold greater biomass at night as compared to day. Based on wing-net data, bay anchovy, *Anchoa mitchilli,* dominated the catch (90-97%) in all sites. Diurnal differences between gear types was attributed to avoidance of the wing-net during the day. Length frequency data compared to acoustic data showed a 1 to 3 dB shift from Love's equation. Acoustically derived densities reflected densities from wing-net data. The high sediment load and plankton abundances common to coastal waters do not bias acoustic estimates. The data thus far suggest a positive outlook for the use of hydroacoustics as a tool for estimating biomass and abundance of nekton in ultra-shallow systems such as estuaries, coral reefs, and mangroves.

KEY WORDS: Estuary, hydroacoustics, nekton

Comparación de Encuestas Hidroacusticas con Métodos Tradicionales de Red de Arrastre para Determinacion de Biomasa Nectonica en un Estuario de Louisiana

El conocimiento de la distribución y biomasa de pesces dentro de un sistema estuarimo es necesario para hacer uso administrativo eficaz del concepto del "Habitat Escencial para Peces (siglas en ingles EFH). Se reconocen cuatro tipos básicos de habitat en un estuario típico: marisma, borde de marsima, bahía abierta, y canal. La distribucion de peces y diversidad de especies dentro de cada uno de estos tipos de habitat puede variar dependiendo de la estación, la marea, el ciclo lunar, clima, y tipo de sustrato. La resolución de la influencia de éstos y otras variables en la definicion de EFH es confundida por las limitaciones de los artes tradicionales del muestreo. Recientemente, el uso de tecnicas hidroacusticas ha demostrado ser una herramienta útil de muestreo, la cuál evita algunas de los problemas de selectividad encontrados en los tipos tradicionales del pesca. Se realizo una evaluacion, en las costas de Luisiana costera, de la capacidad cuantitativa de la tecnica hidroacustica en agues someras. Los objetivos de la evaluacion fueron 1) determinacion de la biomasa nectonica asociada a dos tipos de habitat (bahía y canal), 2) comparacion de datos hidroacusticos con los muestreos simultaneous usando una ala-red, y 3) determinacion del efecto y magnitud de ruido ambiental en las estimaciones de la biomasa del necton. De acuerdo con datos de la ala-red, la anchoveta (*Anchoa mitchilli*) dominó la captura (92-97%) en todos los sitios. Las diferencias entre muestreos diurnos se pueden atribuir a la evitación de la ala-red durante el día. De acuerdo con el muestreo acústico, no hubo diferencias diurna en biomasa en el canal. Sin embargo, basado en muestras de la ala-red, en el canal habria una biomasa triple durante la noche que con respecto al día. La comparacion de los datos de frecuencia de longitud con los datos acústicos indicaron un ajuste de 8db en la ecuación de Love, donde el tamaño fue sobrestimado basado en las estimaciones derivadas de la fuerza horizontal del blanco. Las densidades derivadas acusticamente corresponden con densidades de datos de la ala-red. Hasta el momento, los datos sugieren una prognosis positiva para el uso de tecnicas hidroacusticas como herramienta para estimar la biomasa y abundancia de necton en sistemas tales como estuarios, arrecifes coralinos y manglares

.PALABRAS CLAVES: Tecnicas hidroacusticas, distribucion de peces, Louisiana

INTRODUCTION

A quandary with the evaluation of Essential Fish Habitat (EFH) is the development of a reliable tool to quantify or index EFH as stated in the Sustainable Fisheries Act. Acoustics have been widely used in rivers (Burwen and Fleischman, 1998), lakes, and reservoirs (MacLennan and Simmonds 1992, Rudstam et al. 2001), and deep-water systems (Lima and Castello 1995, Stanley and Wilson 1998) for

estimates of nekton populations. However, there is a paucity of literature on the use of hydroacoustics in ultra-shallow (~1 - 5 m) systems for estimating nekton communities (Kubecka 1996). Split-beam hydroacoustic systems have become popular in shallow waters (~10 m) because they allow for *in situ* measurements of individual acoustic target strength (TS) that enables the estimation of nekton densities and biomass. Side-looking sonar has an advantage over traditional sonar due to the beam configuration that provides an extended range of sampling in shallow environments. Advantages of using hydroacoustics over traditional biological sampling methods include: reduced sampling effort, reduced gear selectivity problems inherent in traditional sampling, and reduced biological and ecological impacts. Recent hydroacoustic surveys of a tidal creek near Port Fourchon, Louisiana showed promise for the use of acoustic systems in ultra-shallow water for surveying nekton (Harmon 2001, Karlson, 1999).

Hydroacoustic theory is based on the analysis of patterns of sound wave propagation through water. When a target is encountered by an acoustic wave, a portion of the incident energy is reflected, áσ_{bs}ñ, is the acoustic backscattering cross-section (m^2). Volume backscattering cross-section (s_v) is the sum of the reflecting intensity of all the discrete targets over a given volume (MacLennan et al., 2002). The primary output in hydroacoustic data collection is mean acoustic volume backscattering strength (S_v, in decibels); this is the summation of the amount of acoustic energy reflected from targets in a given volume of water divided by the sum of the samples:

$$S_v = (\rho_c \Sigma(C^2))/ \Sigma_{samples}, \qquad (1)$$

where ρ_c is the density scaling constant and C^2 is the squared digital counts (Biosonics 1999). S_v is commonly used as a proxy for fish biomass. Instead of using S_v as a direct measure of biomass, it must first be transformed into the linear form.

The swim bladder is responsible for approximately 90-97 % of acoustic energy reflected from a teleost target (Foote, 1980). Variations in target strength (TS) measurements are caused by the behavior of the target with respect to its aspect to the beam and swim bladder volume due to depth changes (Fleischer et al. 2000; Romare 2001, Love 1977). Love (1971) reported an empirical relationship between total length and acoustic cross-section of a fish. He sampled eight species in five orders. Bay anchovy was one of the species on which Love experimented. From his experiment he was able to derive an equation on the general relationship of fish length and acoustic backscatter. The lateral aspect TS of an individual fish is determined by:

$$TS_S = 22.8 \log L - 2.8 \log \lambda - 32.4, \qquad (2)$$

where L is the fish length and λ is the wavelength of the transducer, both in feet.

The following is a synthesis of two hydroacoustic experiments that were

conducted near Port Fourchon, Louisiana over the past year. Our goal is to apply hydroacoustic techniques for measuring EFH in the ultra-shallow water habitat of Barataria Bay. The first experiment was a comparison study of nekton estimates derived from traditional net sampling and hydroacoustics. The second experiment was designed to quantify the effect and magnitude of ambient acoustic backscatter from suspended solids on acoustic based estimates of nekton biomass. Our objectives were to:

i) Develop an acoustic sampling technique to quantify nekton distribution and biomass in ultra-shallow water,
ii) Quantify and describe the nekton community associated with two common habitat types: semi-impounded bay and tidal channel, by using traditional net sampling and hydroacoustics, and
iii) Determine acoustic cross-sectional backscatter from non-nekton sources, mainly total suspended solids (TSS) and plankton to conclude if background acoustic noise affected our estimates of biomass.

METHODS AND MATERIALS

Study Site

The study was conducted in Bayou Tartellon (channel) and Bay Champagne (bay) near Port Fourchon, Louisiana. A pontoon boat was used as the sampling platform at each site off which acoustic and environmental monitoring equipment was deployed. The hydroacoustic array consisted of a Biosonics DE 6000 Scientific Echosounder, a personal computer to run acquisition software and store acoustic data, two 420 kHz analog 2° by 6° split-beam horizontally elliptical transducers. In order to maximize sampling range, transducers were deployed horizontally from the port and starboard sides of a pontoon boat. Acoustic data were collected at 5 pings per second with a pulse width of 0.3 ms and a collection threshold of –55 dB. Transducers were run for five minute alternating intervals allowing both to sample within a relatively similar period of time; a total of 30 minutes per site per sampling period were recorded. Data were analyzed with StatView 5.0 and SAS 8.2. Data were tested for normality and significance assuming an α-error level of 0.05.

Experiment One

Acoustic data were collected in Bayou Tartellon at night and during the day, and in the adjacent Bay Champagne during the day. Data were recorded in 1 m strata beginning 1 m from the face of the transducer, in order to eliminate any near-field interference; out to 12 m, the range of the transducer in the ultra-shallow conditions.

In order to make accurate acoustic estimates of nekton utilizing particular habitats, biological data on the composition and distribution of nekton must be collected in order to ground truth acoustic data. Wing-net trawls were conducted concurrently with acoustic sampling. Two 12.19 m^2 wing-nets with a net mesh size

of 2.75 cm and a 0.635 cm nylon mesh insert from mid-trawl to the cod end were towed, from a second vessel with one net on each side of the vessel. Catches from both wing-nets combined as one sample with a total sampling volume of ~4,953 m^3 per sample. Samples were sorted by species; individual lengths (cm) and wet weight (g) were recorded. Catches with greater than 50 individuals of the same species were sub-sampled; total abundance, wet weight, and individual lengths of 50 individuals selected at random were recorded.

Acoustic output included S_v, TS distribution, and FPCM. Acoustic data collected beyond 9 m were excluded from analysis due to interference from surface and bottom as well as entrained air from passing boats. Measured length-frequency data were compared to TS distributions. Nekton density and biomass estimates from hydroacoustic and net sampling were compared.

Experiment Two

The objective was to determine the background acoustic "noise" attributable to plankton and suspended solids. For this study a 1.22 m wide X 1.22 m deep X 3.66 m long semi-enclosed (opening at top of net) box net was used. Net walls were made of 2 mm nylon mesh, to exclude nekton and allow planktonic organisms < 2mm in diameter and suspended solids to pass through.

The acoustic array and methods used for this study was the same as described for experiment one. Data from both transducers were collected from 1 to 3 m, from the transducer face. S_v values that were reported as 0 dB in the output were manually changed to -90 dB for calculation purposes as this was determined to be a reasonably low level of acoustic intensity that essentially signified a zero value for S_v. We subtracted S_v measurements from within the net from S_v measurements outside the net to calculate a "corrected" S_v (Rudstam, personal communication). Prior to subtraction, S_v was converted into FE the linear form using Equation 4.

Plankton samples were collected using a 10 L min^{-1} diaphragm pump. Ten L oblique samples were collected and filtered through a 75 μm mesh, concentrated in a cod end and fixed in a 12% formalin solution. In addition, 1 L water samples were taken to measure total suspended sediment (TSS) every 30 minutes. Analyses of TSS were performed as described by Greenberg et al. (1992).

RESULTS

Experiment One

Based on S_v, fish biomass was highest in the channel during the day (Figure 1); however, there was no difference in fish biomass between the channel and bay during the day. Density estimates varied significantly between sites and sampling period. Mean TS values were -45.5 dB, -44.4 dB, and -43.8 dB; for channel-night, channel-day, and bay-day. Based on the means these were all significantly different indicating that the average size target was smallest in the channel at night.

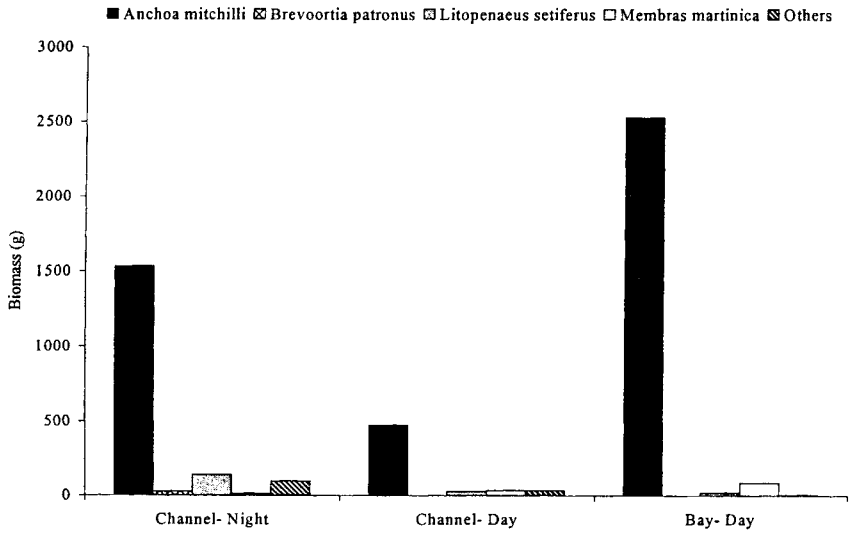

Figure 1. Biomass by species of catch from wing-net trawls by location and sampling period.

Bay anchovy, *Anchoa mitchilli* dominated the catch (90-97%) at all sites (Figure 1). Based on wing-net samples there was a three-fold greater biomass at night as compared to day (Figure 1). Anchovy is clearly the dominant species in terms of both abundance and biomass, as a result we inferred that approximately 90% of the biomass is *Anchoa mitchilli*; consequently, data presented from this point will be in terms of the contribution of anchovy to the system. Comparison of hydroacoustic density and wing-net density shows that acoustically derived densities are similar to densities obtained from net sampling.

Mean bay anchovy length was highest at night in the channel (44.8 mm) and smallest in the channel during the day (41.9 mm). When compared to anchovy length data, TS distributions show the opposite trend with smallest mean TS (-45.5 dB) occurring at night in the channel and largest mean TS (-43.8 dB) occurring in the bay during the day.

Experiment Two

The enclosure net proved to be effective in allowing us to measure the acoustic "background noise" in waters typical of coastal Louisiana. We found no significant interference from the suspended solids in the water column indicating that S_V was from nekton. "Acoustic noise," once converted into the linear form and then subtracted (corrected), is negligible. Corrected values either overlap or closely follow S_V values from outside the net during both sampling periods.

Neither plankton nor suspended sediment affected acoustic reflectivity. Acoustic values were not linearly related to total suspended solids or plankton abundance ($r^2 = 0.265$). Plankton were composed primarily of small copepods (>75 %). TSS values ranged from 47.4 mg/L to 128.5 mg/L with the highest TSS values at night.

DISCUSSION

Hydroacoustic sampling is a non-invasive technique that allows direct estimates to be made about nekton biomass, size frequency, and distribution. Acoustic surveys have proven to be effective tools for estimating and describing nekton communities in various aquatic habitats. Data from these studies suggest that hydroacoustic systems can be used in ultra-shallow water environments common to coastal Louisiana for estimating nekton biomass and distribution associated with different habitats. The use of hydroacoustics and limited net sampling will provide a description of nekton utilization of habitats within the Barataria Bay system and will aid in the identification of EFH of those species important to coastal Louisiana. The largest constraint we anticipate while sampling will be weather conditions, as entrained air from wave action will affect our ability to detect nekton, thereby limiting acoustic sampling to conditions without white-capping. These experiments have led to an understanding and identification of the proper collection and analysis parameters needed for use of acoustics in turbid ultra-shallow waters. Results from these experiments will aid in future endeavors as specific criteria for successful acoustic sampling are identified and refined.

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La Pesquería Ribereña del Cangrejo Moro (*Menippe mercenaria*) de Campeche e Isla Arena, México

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RESUMEN

Se analiza la información de campañas de muestreo por buceo, independiente de la pesquería y de los muestreos de la captura comercial por buceo y trampas durante los meses de junio de 1996 mayo de 1997. Se analizaron los registros oficiales de la captura de 1980-2001. Se calculó relación caparazón - mano. Se hizo un análisis comparativo de las quelas de dos comunidades pesqueras (Campeche e Isla Arena). En esta pesquería según los registros oficiales, el sector privado posee el 78 % de las trampas el resto es del sector social (22 %.). El mayor % de manos regeneradas se presentó en diciembre (73%) y el menor en junio y julio (0%)..El arte de pesca autorizado para la captura de cangrejo moro es la nasa. Pero en la región este recurso en gran porción se extrae por buceo a pulmón, sobre todo en la costa del municipio de Campeche.

Los ejemplares maduros iniciaron su aparición en la zona de pastizales frente a la ciudad de Campeche y conforme transcurrió el año se encontraron más hacia la zona de Isla Arena, Campeche La mayor frecuencia de hembras con hueva expuesta, se encontró de junio a octubre.

Se observan en la captura tanto quelas derechas como izquierdas, lo que hace indica que se extraen ambas manos, aunque por entrevista los pescadores manifiestan quitar solo una.

PALABRAS CLAVES: Cangrejo, *Menippe*, Ribereña

The Stone Crab Fishery (*Menippe Mercenaria*) in Isla Arena, Campeche, México

Independent samples from the fishery obtained through a diving campaign added to the information from the commercial diving and traps, during the months of June 1996 to May 1997, are analyzed. Also official catch records from 1980 – 2001 were reviewed. A claw – shell relationship was estimated, a comparative

analysis of claws between two fishing communities (Isla Arena and Campeche) was studied. According to the official records, the private sector owns 78% of the traps, the rest belong to the social sector (22%). The highest percentage of regeneration of claws was observed in December (73 %), and the lowest in June and July (0%). The officially authorized fishing gear is the trap called "nasa", but in the region it is caught mainly by lung diving, most of all in the Campeche county.

Mature specimens started to appear in the grass beds in front of the city of Campeche, migrating North through the year towards Isla Arena. The highest frequency of females with exposed eggs occurred throughout June to October. It was also observed that in the commercial catch both right and left claws are found, although this is denied by the fishermen, who claim they only take one.

KEY WORDS: Artisanal, crab, *Menippe*

INTRODUCCION

El cangrejo moro *Menippe mercenaria* (Say 1891), es de la familia Xantidae, crustáceo marino, habitante de aguas tropicales y subtropicales. Se ha citado desde la costa Atlántica hasta las Bahamas. En México se encuentra principalmente en el Golfo de México y vive en fondos lodosos, excava cuevas debajo de las piedras para protegerse, tiene un caparazón ancho, ovalado y duro con ornamentaciones y puntuaciones en diversas formas y tamaños que le dan un color pardo que le sirve de camuflaje, posee dos tenazas llamadas comúnmente "manos" las que utilizan para defenderse, atrapar y desgarrar su alimento y son las que contienen gran parte de la carne.

Estudios de patrones de ocupación de arrecifes entre cangrejo moro, peces (*Balistes capriscus, Centropristis striata melana*) y pulpo (*octopus vulgaris*) mostraron que todos se refugian en las cavidades de los arrecifes y entre la vegetación sobre la arena y que la estructura de los que hacen sus refugios, depende del espacio disponible en los arrecifes, en las zonas de pastos y arena y de la abundancia de las presas (McConnaughey y Krantz 1992).

Estudios sobre los efectos de la salinidad en dos especies de cangrejo *Menipe mercenaria* y *M. adina* en juveniles de menos de 10 mm de ancho de caparazón, demostraron que soportan un intervalo de temperatura de 5 - 40°C y salinidad entre 10 y 40 ‰. Se observó un efecto de incremento de la muda en relación con el aumento de la temperatura a 30°C seguida con un descenso ligero, no así con la salinidad (Brown et al. 1991). Trabajos acerca de sobrevivencia en juveniles mostraron que la temperatura en combinación con la salinidad, tiene efecto en organismos menores de 10 cm de ancho de caparazón y sobrevive el 100% en el intervalo de 15 a 25°C y de 25 a 40 ‰. En la zoea 6 no se observó ninguna influencia de estos factores.

Esta especie ha sido estudiada desde el punto de vista biológico y pesquero en Florida, en donde es una pesquería importante, basada solo en manos y con reglas para su aprovechamiento. Se ha demostrado que si se les quitan las dos manos, la

mortalidad se eleva al 47% (Savage 1971). En las quelas tienen la mayor parte de la carne del cuerpo, por lo que es la parte más aprovechable. Si el organismo es bien desquelado no muere por desprendimiento agresivo o por perdida de hemolinfa y cuando es regresado al mar regenera la quela y se puede entonces, basar la pesquería en la cosecha de esta parte de su cuerpo.

En Florida se captura con trampas, para desquelar abordo de la embarcación. El tamaño de quela autorizado es igual o mayor de 7 cm de longitud a partir del carpo. En Cuba se captura con trampas, con talla mínima de captura de 9 cm de ancho de caparazón, este tamaño, corresponde a una longitud de quela de 8.4 cm (Alvarez y Briquets 1983) y debido al descenso gradual de las capturas se implantó una veda a partir 1981 (Ros, R.M. et al. 1981)

En Campeche, Yucatán y en el estado de Quintana Roo, se han hecho propuestas para establecer algunas medidas de regulación para mantener la pesquería. En Campeche, desde 1967, se sugirió una talla mínima comercial provisional de 86 mm de ancho de caparazón o 61 mm en el sentido longitudinal (Solis, comunicación personal). En Quintana Roo Basurto y Zarate (1995), recomendaron no desprender la quela trituradora que es la más importante para su mantenimiento y Re-Regis (1997), determinó que de mayo a septiembre se presentan los mayores porcentajes de hembras maduras.

En Campeche, en los permisos oficiales para su captura se especifica el arte de pesca llamado nasa, sin embargo, la captura se realiza por buceo en la mayoría de las zonas de pesca y solamente frente al puerto de Campeche, con nasas (González y de la Rosa et al. 1996).

La pesca comercial del cangrejo moro existe en el estado de Campeche desde la década de los años cuarenta. Los registros de captura al inicio correspondían al peso del organismo completo y actualmente se refiere solamente a la producción de la quela. Se descarga en las comunidades de Isla Arena, puerto de Campeche, Seybaplaya, Champotón y Sabancuy. Las dos últimas con menores registros. A pesar de ser un recurso con mercado internacional, no existen medidas de regulación oficiales para su captura.

El objeto de este trabajo es caracterizar la pesquería de cangrejo moro y determinar algunos aspectos de interés que puedan ser de utilidad para regular el uso del recurso.

MATERIALES Y METODOS

Se recopilaron los registros de la captura existente de los años 1955 - 2001. Se realizaron muestreos aleatorios de la captura comercial de cangrejo moro por buceo durante los meses de abril a diciembre de 1996 en Isla Arena. Durante el mismo periodo se obtuvieron muestras de la captura a bordo de las embarcaciones de pescadores con nasas en aguas frente a la ciudad de Campeche. Se pesaron y midieron las manitas en ambas pesquerías y en el caso de la captura por nasas, se tomaron medidas del ancho del caparazón de organismos. Para el cálculo de la relación del tamaño del caparazón con relación a la mano, se utilizaron solamente

aquellas que no eran regeneradas. Se analiza la estadística de captura anual del periodo 1955 – 2001 (Fuente: Subdelegación Federal de Pesca SAGARPA).

RESULTADOS

La Pesquería

La captura se autoriza bajo un permiso con el arte de pesca llamado nasa (Fuente: Delegación Federal de Pesca de Campeche, SAGARPA). El esfuerzo aplicado sobre este recurso por los pescadores con nasas legalmente acreditados, se registra a través de los permisos que se otorgan y la entrega de avisos de arribo de captura.

En 1997 se registraron 14,967 nasas para la captura de cangrejo, con 159 embarcaciones (Delegación Federal de la SEMARNAP, hoy SAGARPA). Actualmente hay alrededor de 80 permisos vigentes para la captura del cangrejo moro con 13,042 nasas registradas, sin embargo, gran parte de la captura de cangrejo moro se realiza por medio de buceo autónomo, el sector privado posee el 78 % de las trampas y el sector social el 22 %, según el censo del año 2000, (Delegación Federal de la SEMARNAP, hoy SAGARPA).

Equipos y Artes de Pesca

En el Estado y de acuerdo a los permisos que se emiten en la Delegación Federal de Pesca, el arte de pesca autorizado para la captura de cangrejo moro es la nasa. Sin embargo, se debe resaltar que en esta pesquería gran parte de la captura se realiza por otro grupo de pescadores cuya unidad de pesca es una embarcación con buzos a pulmón, este estilo de captura es muy cuestionado por los demás pescadores y no está acreditado como arte de pesca legal, esto altera el registro del esfuerzo. En algunos casos, sobre todo en la costa del municipio de Campeche se utiliza una compresora para aumentar el tiempo de estancia bajo el agua, lo que inflige mayor esfuerzo y daños a la salud del pescador, que permanece mayor tiempo bajo el agua sin equipo adecuado.

Operación de Pesca con Nasas (Arte Permitido)

La unidad de pesca consta de una lancha de madera o de fibra de vidrio generalmente con 2 pescadores, y de 10 a 20 nasas unidas por una línea (15 nasas en promedio) y tienden entre 10 y 20 lineas o caminos. Las nasas pueden ser de bejuco o de alambre, se encarna las nasas con desperdicio de pescado, raya, en últimas fechas también usan patas y desperdicio de pollo. Al llegar a la zona de captura las nasas se van tirando atadas entre ellas formando caminos paralelos entre sí. Para su localización se les pone una boya. Se dejan en el mar y cada día se revisa la nasa, se vacía el cangrejo en cubos con agua cubiertos, para protegerlos del sol y posteriormente se desquelan para regresar al mar el organismo.

Las zonas de pesca con nasa se localizan frente a Tenabo y puerto de Campeche en la zona de pastizales marinos entre ½ braza a 2 brazas de profundidad.

Durante los muestreos se observó que el cangrejo es muy susceptible a la

exposición solar y a la falta de agua, que le producen la muerte. Para que sobreviva al manejo para la cosecha de la mano, se debe mantener húmedo, en la sombra y ser devueltos de inmediato al mar.

La captura incidental de las trampas se compone de peces, con el arribo del pulpo a la zona, se eleva la captura incidental de estos con las nasas debido a que el cangrejo moro es uno de sus alimentos preferidos.

Operación de Pesca con Buceo (no Considerado en el Permiso)

Los pescadores dedicados al buceo, se desplazan en una lancha que lleva hasta 10 buzos. Se alejan de la costa a profundidades de entre 3 y 5 brazas. Una vez en el lugar seleccionado, los buzos se sumergen con snorkel, aletas, visor, guantes y bolsa. Algunos sacan el cangrejo y lo desquelan en la lancha, para después regresarlo al mar, otros le quitan las manos en el fondo del mar tomando las manos del cangrejo y haciendo palanca hacia atrás del cuerpo para que el cangrejo las suelte. Actualmente, para permanecer más tiempo bajo el agua, algunos buzos se ayudan con compresoras, lo que ha ocasionado daños a su salud. El número de pescadores por buceo, es mayor que a los que pescan con nasas.

También se observó la captura de cangrejos completos de menor tamaño para su venta como carnada de pulpo, debido a que su caparazón es de alta resistencia y permite a los pulperos, capturar varios ejemplares de pulpo, con un solo cangrejo, razón por la que los pescadores se resisten a abandonar su uso a pesar de ser una especie de alto valor comercial. Actualmente se restringe su uso como carnada.

ESTADISTICA DE CAPTURA

El cangrejo moro es otro de los recursos que se comparte con los pescadores de Campeche y Yucatán, en la zona de Isla Arena, e Isla de Piedra. El esfuerzo de pesca que ejercen los pescadores de Celestún, Yucatán, no se registra en Campeche, ya que la captura se desembarca en Celestún, por lo que para conocer la producción real de la zona es necesario contar con la información estadística de la captura que se registra en esa localidad. En Campeche de acuerdo a los registros de captura oficiales (1955 a 2001), que se recaba en las Oficinas Federales de Pesca (antes SEPESCA, después SEMARNAP hoy SAGARPA), la tendencia general es ligeramente positiva, pero se observa la presencia de una variación aparentemente cíclica de ±10 años entre máximos de captura, con excepción de 1997 (127 t) que se separa solo cuatro años del máximo de captura anterior. El período de 1983 a 1986 es el que mantiene las captura por arriba de las 100 toneladas, en este se incrementa la captura probablemente porque se intensifica el buceo, prácticamente sin restricciones. Se observa una tendencia positiva con dos mínimos: 1981 con 31 toneladas, y 1988 con 23 toneladas. Vuelve a rebasar las 100 toneladas en 1991, 1993 y 1997 con mínimos en 1995 con 63 toneladas y en 1998 cae a 42 toneladas.

Es necesario resaltar que por periodos las autoridades correspondientes desarrollan acciones para impedir la captura por buceo, como fue en 1988 lo mismo que a partir de 1996 (Figura 1.), lo que puede estar influyendo la baja en la captura

ya sea por que no se capturó en la misma intensidad o porque se obvió el reporte de la captura a los medios oficiales.

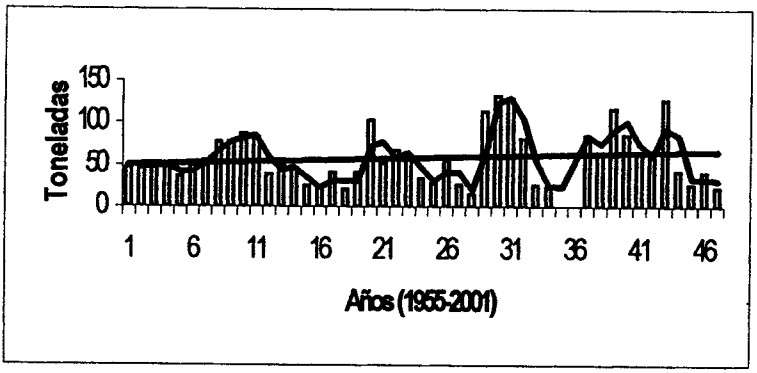

Figure1. Estadística de captura anual 1955 - 2001 (toneladas) de cangrejo moro *(Menipe mercenaria)* Campeche.México. (1 = año 1955)

La porción del cuerpo que tiene interés para consumo humano es la quela que representa el 50% del peso del organismo, una ventaja de esta especie es que la puede regenerar con éxito cuando se cosecha de manera correcta. En la Figura 2 se resalta el punto en el cual se recomienda el corte, cuando se realiza una punción en la base del ischium, el cangrejo suelta la mano por si mismo y tiene mayor facilidad de cicatrización. Sin embargo, a pesar de que el pescador conoce el método de desprendimiento de la quela por punción, la gran mayoría continua con la costumbre de desprender la mano por quiebre al forzar el doblez de la mano hacia la parte dorsal del caparazón, que cuando no se tiene cuidado se rompe mas cerca del cuerpo, con la consiguiente reducción en la capacidad de regeneración de la quela y el aumento de mortalidad por desprendimiento agresivo de la quela y pérdida de hemolinfa.

En el caso del buceo, se encontró que la mayoría de las veces se les quitan las dos manos por lo que ello induce una mortalidad mas alta sobre la parte de la población en que actúa este método de pesca.

Se encontró que el 50 % de las quelas izquierda, están por debajo de los 70 mm de longitud, y el 34 % de las derechas. También se observaron algunos organismos con apéndices en proceso de regeneración.

En la Figura 3 se muestra la longitud promedio y el peso promedio de mano izquierda y derecha de *menippe mercenaria* cosechadas en Isla Arena, en esta

localidad, son de mayor tamaño que en Campeche y fue mayor y más pesada la quela derecha (88 mm y 115 g), mientras que en Campeche el promedio más alto que también es de la quela derecha, fue de 78 mm longitud y 71 g (Figura 4).

En la Figura 5 se describe la relación entre el ancho del caparazón y la longitud de la quela de la captura con nasas en las aguas someras frente a la ciudad de Campeche. El mayor porcentaje de quelas regeneradas en la muestra mensual de nasas se presentó en enero (40) y el menor en los meses de mayo, junio y julio. (Figura 6).

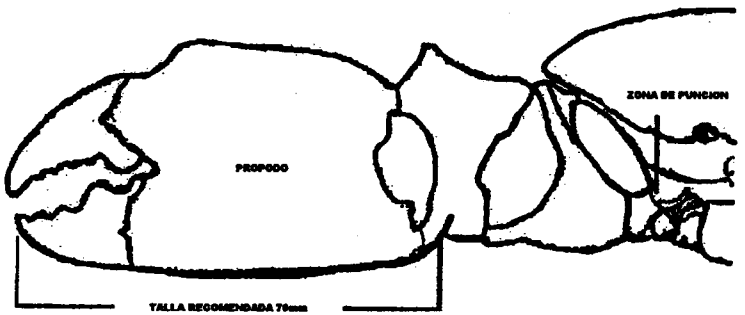

Figura 2. Tamaño y ubicación del corte de la quela en el cangrejo moro.

Con la ecuación de la relación se estimo la longitud de la quela que corresponde al ancho de caparazón de 90 mm, equivalente a 70 mm, longitud que asegura que el cangrejo se ha reproducido (Figura 7).

Los ejemplares maduros iniciaron su aparición en la zona de pastizales frente a la ciudad de Campeche y se recorrieron conforme transcurrió el año hacia la zona de Isla Arena, Campeche. La mayor frecuencia de hembras con hueva expuesta, se observó de junio a octubre, la coloración de la hueva varió de naranja mamey a gris verdoso, este último se adquiere cúando esta a punto de eclosionar.

En la Figura 7 se muestra la distribución de ancho de caparazón promedio de hembras por estadio gonádico.

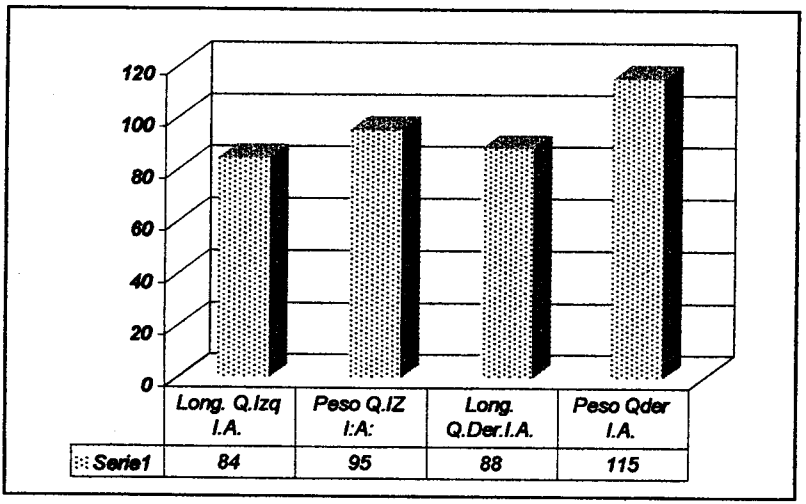

Figura 3. Longitud promedio de la mano izquierda y derecha de cangrejo moro *Menippe mercenaria* en Isla Arena, Campeche, México 1966.

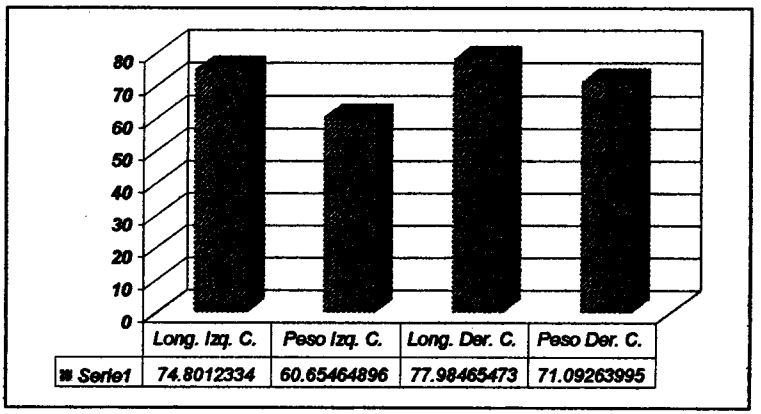

Figura 4. Longitud promedio de la mano izquierda y derecha de cangrejo moro *Menippe mercenaria en Campeche, Camp. México 1996.*

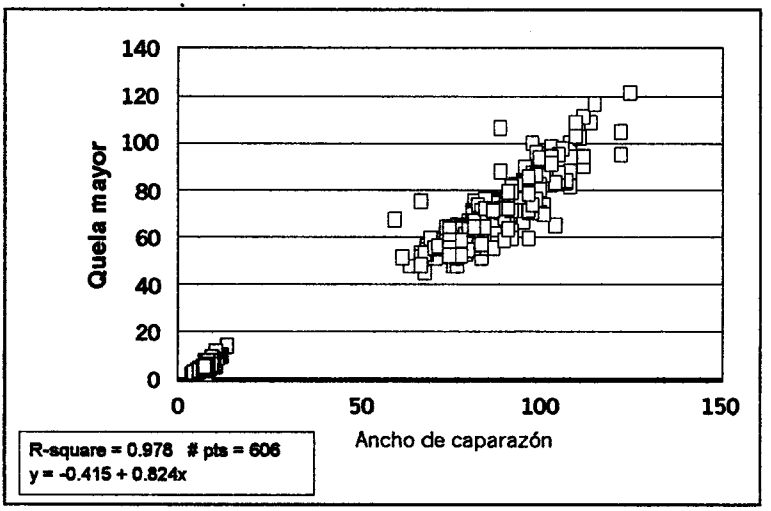

Figure 5. Relación ancho del caparazón y longitud de la quela, *Menippe mercenaria*. Campeche, Mexico.

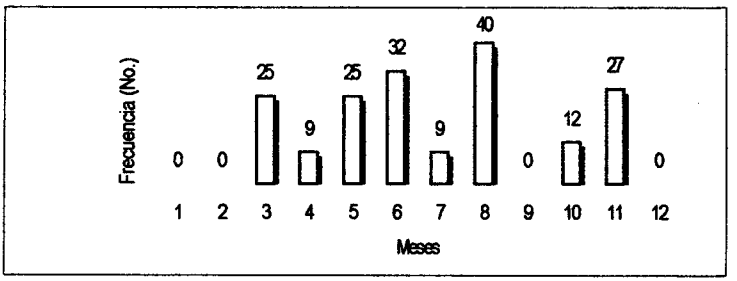

Figura 6. Frecuencia (No.) de manos regeneradas en la muestra de la captura por nasas de *Menippe mercenaria*. 1996. Campeche, Campeche, México. (1= junio 1996 a 12= mayo 1997; N = 1165 organismos)

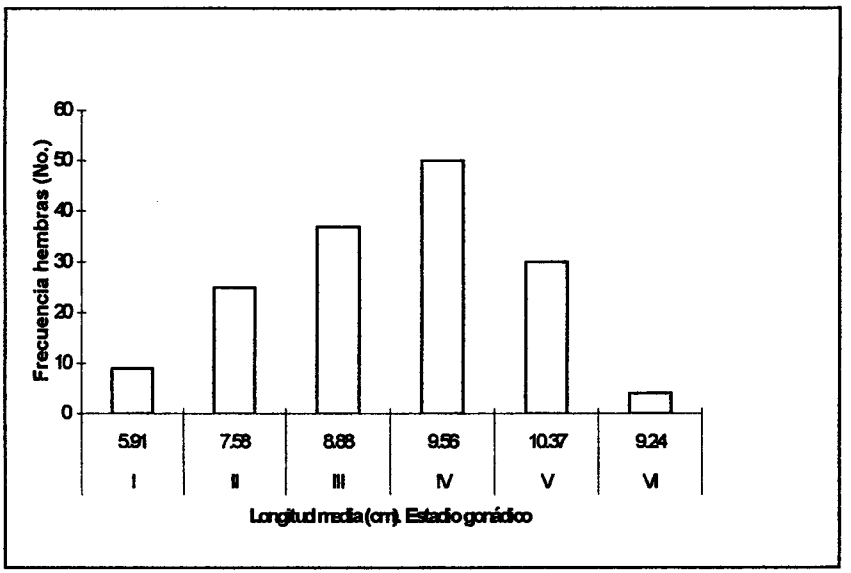

Figura 7. Frecuencia de ancho promedio de caparazón de hembras de *Menippe mercenaria* capturado por nasas. Campeche, México 1996.

DISCUSION Y CONCLUSIONES

Se observa en la captura tanto quelas derechas como izquierdas, lo que hace pensar que desquelan ambas manos, ya que el número de ellas es muy semejante, aunque, los pescadores manifiestan quitar solo una mano. El perder las dos manos le reduce la capacidad de defenderse e incrementa la dificultad para alimentarse (Savage T. Y R. Sullivan 1978). Por lo que se recomienda realizar un programa de sensibilización para los pescadores en este sentido.

Con base en los resultados se concluye que la talla mínima adecuada para el corte de la quela es de 70 mm de longitud, midiendo desde la punta de la pinza hasta el final del segmento llamado própodo, tal como se muestra en la Figura 2. Esta longitud de quela está en relación con el ancho del caparazón de 90 mm, el que permite asegurar, que se ha llevado a cabo previamente la reproducción. El hecho de que se observa que el 50 % de las quelas izquierdas y el 34 % de las derechas cosechadas estan por debajo de los 70 mm de longitud, indica que es necesario implementar medidas de regulación en la captura de esta especie.

La cosecha de las quelas debe hacerse por punción en la base del ischium, a fin de evitar daños que impidan la regeneración o que causen la muerte del organismo.

Es interesante resaltar que la hembra después de ser fecundada, continua el

desarrollo interno de hueva y no se nota hasta que la hueva pasa a ser expuesta (Re-Regis C. 1997) por ello es recomendable que no se capture a las hembras en la época de reproducción (mayo a octubre).

En los crustáceos en general es difícil determinar la edad y esto presenta dificultades para el cálculo de la mortalidad. En esta pesquería, debido a que solo se cosechan las manos, no es posible obtener la estructura por tallas de la población. Para ello es recomendable establecer un programa de estudio especifico avocado a la pesquería. El potencial verdadero de esta especie es aún desconocido. Sin embargo los estudios hasta ahora desarrollados proporcionan algunos elementos que nos indican que es necesario implementar medidas para que se regule la explotación de este recurso, ya que a la fecha no existe ninguna reglamentación.

Se recomienda reactivar las pláticas a la comunidad de pescadores y empresarios del sector pesquero, para dar a conocer cuales deben ser los cuidados del recurso con el fin de utilizarlo de una manera responsable,.

Es necesario promover el uso de las trampas, para ello se deberán hacer experimentos para evaluar el funcionamiento y su eficiencia en los que se integre al pescador actual del recurso, de esta manera, se obtendrán mejores resultados en la adopción de los cambios de arte que resulten más convenientes, tanto para el recurso como para el pescador, para mantener la pesquería a largo plazo.

Dado que se encontró que el buceo es la forma tradicional de captura que utilizan los pescadores de Isla Arenas, Campeche en la captura del cangrejo moro *Menippe mercenaria*, y algunas especies de escama, y que en la comunidad de pescadores de la ciudad de Campeche también existe un núcleo de buzos que no consideran viable la alternativa de las nasas tal como se operan en la actualidad. Por lo que es necesario desarrollar un proyecto de pesca experimental con trampas para obtener alternativas tecnológicas para establecer artes y técnicas de pesca que sean aceptadas por la comunidad pesquera y lograr un cambio en la forma tradicional de captura en la región.

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Monitoreo de la Abundancia de Juveniles de Langosta *Panulirus argus*: Desarrollo de un Protocolo de Muestreo Basado en Hábitats Artificiales

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RESUMEN

Este proyecto se llevó a cabo en Bahía de la Ascensión, durante dos años, con el propósito de aportar bases metodológicas y estadísticas para un programa de monitoreo de la abundancia de juveniles de langosta *Panulirus argus*, como índice de reclutamiento. La investigación comprendió aspectos de tipo práctico, con el diseño y prueba de diferentes artes de muestreo, para lo cual se corrió un experimento comparativo entre dos tipos de minicasita levable y el condominio cubano. Aunque con este último se obtuvo capturas superiores, en la siguiente etapa se empleó también la minicasita porque no requería de buceo libre y su revisión consumía menos tiempo que el condominio. Seguidamente fue establecida en Bahía de la Ascensión una red de 22 estaciones, doce estaciones de condominios y diez estaciones de minicasitas. A partir de los datos de abundancia registrados en esta red fue posible efectuar análisis sobre aspectos estadísticos del muestreo. En primer lugar, con evidencia de tipo experimental y observacional, se encontró que la minicasita levable del diseño probado, presentó un efecto de saturación que le impidió detectar pulsos de abundancia estacionales. Esto la descarta como arte de muestreo con fines de monitoreo. En consecuencia, los condominios resultaron un arte apropiado para el monitoreo local y regional de abundancia relativa de juveniles de *P. argus*, como índice de reclutamiento. Se aplicó un enfoque de optimización que además de suponer la abundancia como Binomial Negativa, considera el tamaño de la unidad de muestreo (*tum*) y restricciones de costos -con tiempo en el mar como costo. Según este análisis, el actual *tum*= 17 min ó 2 condominios/estación, puede ser reducido a tum_{opt} = 5 min (<1 condominio/estación). Para costos restringidos a tres días en el mar, y *tum* = 1 condominio/estación (9 min) se obtuvo n_{opt} = 37 estaciones, con una precisión asociada de 27% en la estimación de la abundancia media. Con este último resultado se estiman los costos totales al año para el monitoreo óptimo de juveniles de langosta en cuatro localidades de Quintana Roo, donde se ubican las principales áreas de crianza de langosta. De este trabajo surge un llamado a hacer el esfuerzo necesario para comenzar programas regionales de monitoreo, recuperación poblacional ("enhancement"); así como investigaciones ecológicas, y acciones de protección, en las principales áreas de crianza de este valioso recurso regional.

PALABRAS CLAVES: Indice de reclutamiento, precisión de muestreo, tamaño de muestra, juveniles posalgales de langosta

Monitoring the Abundance of Juvenile Spiny Lobsters *Panulirus argus* at Local Scale: Developing a Sampling Protocol Based on Artificial Habitats

The current discussion on key issues regarding reef resources such as connectivity and the open *vs* closed nature of populations, has led to a re-assessment of the value of recruitment measurements at local and regional scales for reef fish and invertebrates. In open populations at local scale, the recruitment is decoupled from the reproductive activity of adult stock, and generally, the recruits come from foreign, often unknown, sources. Due to their life history characteristics –with early stages having a long pelagic life, and the complexity of the current systems prevailing in the region, it is very likely that local populations of spiny lobster *Panulirus argus* (from a bay, island or oceanic bank) behave as open populations. Under these circumstances, it is mandatory to monitor the recruitment because then recruitment becomes equivalent to natality. We present a progress report on the developing of a sampling protocol to estimate the abundance of postalgal juveniles of spiny lobster as a recruitment index at local level. In particular, we deal with an index of (relative) abundance based on the use of artificial habitats as sampling gears. Our results include aspects related to the precision of the index and sampling under restrictions due to sampling cost, expressed as days at sea. The fieldwork has been done at Bahia de la Ascensión, located in the Biospehere Reserve Sian Ka an; hence, we also report the spatio-temporal patterns of the abundance of juvenile lobster at that locality. Finally, we discuss the pros and cons of our sampling protocol.

KEY WORDS: Recruitment index, sampling precision, sampling size, postalgal juveniles of spiny lobster

INTRODUCCIÓN

La fluctuación de efectivos ("stocks") ha sido un tema central en la ciencia pesquera como rama de la ecología aplicada desde inicios de siglo, cuando Hjort (1914) postuló que la variación interanual de la fuerza de la clase anual a) era determinada en estadíos de vida tempranos, antes del reclutamiento a la pesquería, y b) no era una función simple del tamaño del efectivo progenitor. En los 1980s resurgió el interés en temas de reclutamiento y ecología de estadíos tempranos de vida en poblaciones de peces (Lasker 1981, Bakun et al. 1982, Sissenwine 1984, Fogarty et al. 1991) e invertebrados – se refieren sólo citas de crustáceos de la familia Palinuridae (Kanciruk 1980, Phillips y Sastry 1980, Caddy 1986, Herrnkind y Butler 1986, Herrnkind et al. 1994). De entre las numerosas poblaciones marinas que poseen fases tempranas pelágicas, es probable que algunas sean poblaciones abiertas; es decir, a escala local, el reclutamiento y la actividad de los reproductores están desacoplados (Caley et al. 1996). Entonces, a una localidad dada llegarían reclutas cuyo origen se localiza corriente arriba, y a su vez los propágulos de

reproductores locales abastecen a las áreas situadas corriente abajo. En esta situación, se incrementa la necesidad de estimar el reclutamiento en poblaciones abiertas, en las que el reclutamiento equivale a la natalidad o número de nacimientos (Caley et al. 1996).

El reclutamiento a la pesquería o ingreso de nuevos individuos al segmento explotable de la población es un proceso aditivo influyente en la abundancia de poblaciones sometidas a alta presión de pesca. El renovado interés por el reclutamiento ha llevado a usar de modo amplio el término; por tanto es necesario señalar con precisión reclutamiento a cual fase, estadio o edad hacemos referencia (Caley et al. 1996). La relación efectivo-reclutas persiste aún como un problema difícil e importante en evaluación de recursos; sobre todo cuando el colapso de varias pesquerías ha estado asociado con severas reducciones del reclutamiento (Hilborn y Walters 1992). El estudio del reclutamiento demanda contar con datos no sólo de la pesquería (Bakun et al. 1982), sino que requiere también muestreos de estadíos juveniles cuyo hábitat y conducta a menudo difieren del adulto; aunque es común emplear índices de ocurrencia de tallas menores en la captura comercial, pesca incidental o fauna de acompañamiento.

La Langosta *Panulirus argus*

La langosta *P. argus* es un recurso soporta una alta presión por pesca y alteración de hábitats en la macro-región del Caribe y áreas adyacentes. Esto se aplica también al caso de Quintana Roo, donde *P. argus* es el principal recurso pesquero y soporta un alto nivel de esfuerzo.

La especie es de ciclo de vida complejo; con cinco estadíos principales: adulto, huevo, larva, poslarva y juvenil (Lipcius y Cobb 1994, Herrnkind y Butler 1997). La reproducción y desove tienen lugar en aguas profundas del arrecife anterior. Del huevo eclosiona la filosoma, larva pelágica que pasa 6 - 12 meses a merced de las corrientes. De la filosoma surge una poslarva (puerulo) que nada hacia la costa y se asienta en fondos con vegetación, sobre todo algas rojas *Laurencia* spp, raíces de mangle y estructuras de arquitectura compleja. Una semana después del asentamiento, el puerulo se transforma en juvenil de vida béntica. Los juveniles pasan 15 - 30 meses en áreas de crianza, y al crecer se mueven a aguas profundas, lo que genera estratificación de tallas con profundidad y tipo de hábitat (Lipcius y Herrnkind 1989).

Reclutamiento y Predicción de Capturas en Langostas Espinosas

Las fluctuaciones poblacionales en langostas espinosas obedecen a factores bióticos y abióticos que actúan sobre diferentes estadíos; su dinámica poblacional se supone controlada por fuerzas estocásticas junto con regulación densodependiente (Lipcius y Cobb 1994). Los factores estocásticos operan en larvas y poslarvas, los densodependientes en juveniles. En lo estocástico, influyen los regímenes meteorológico y oceanográfico que prevalecen en una región (Lipcius y Cobb 1994). Acerca de la denso-dependencia, se sospecha la existencia de "cuellos de botella" demográficos en juveniles, cuando es probable que haya escasez de refugios

apropiados (Caddy 1986, Arce et al. 1997, Sosa-Cordero et al. 1998).

El reclutamiento en palinúridos se estima por el asentamiento de puerulos en estructuras artificiales de variado diseño (Witham et al. 1968, Phillips 1972, Booth 1979, Briones-Fourzán y Gutiérrez Carbonell 1991), índice de sublegales en la captura (Caputi y Brown 1991), arrecifes de bloques (de León et al. 1991) y minicasitas (Arce et al. 1997). Con otros fines se han usado diversas estructuras (Herrnkind y Butler 1994, Mintz et al. 1994, Lozano-Alvarez et al. 1994). En este campo influyen mucho las investigaciones sobre *Panulirus cygnus* de Australia, ahí el asentamiento de puerulos en artefactos flotantes -como índice de reclutamiento- permite predecir con éxito la captura 4 años después (Phillips 1986). Así, el reclutamiento a la pesquería lo determina el ingreso de poslarvas, más que una limitada capacidad de carga en las áreas de crianza. La predicción de las capturas mejora al combinar índices de puerulos y de juveniles (Brown y Caputi 1991); ambos se complementan, el índice de puerulos apoya la predicción de captura a mediano plazo (4 años) y el índice de juveniles mejora la predicción a corto plazo, la captura del año siguiente.

Objetivos

El presente trabajo presenta resultados de investigación dirigidas a desarrollar un programa de monitoreo de la abundancia relativa de juveniles posalgales de langosta *Panulirus argus*, a través del empleo de hábitats artificiales. Este índice sería un predictor del reclutamiento a la pesquería, 1-1.5 años después. Para ello se abordan aspectos prácticos como la selección del arte de muestreo y aspectos estadísticos que permitan recolectar con eficiencia datos de abundancia de juveniles. El trabajo de campo se efectuó en Bahía de la Ascensión durante dos años, 1998-1999. Finalmente, se estimó el costo de un programa de monitoreo regional (Quintana Roo, México) de la abundancia de langostas juveniles, y se discute el alcance de los resultados.

METODOS

Muestreo de Juveniles

Los muestreos mensuales fueron hechos con una lancha ballenera de fibra de vidrio, de 8.24 m de eslora y motor fuera de borda (40 HP). Cada estación de condominios tenía dos estructuras que eran revisada por buceo libre, uno a dos buceadores por estación. Las langostas juveniles eran primero contadas y luego capturadas con redes de cuchara. Las langostas capturadas eran llevadas a bordo para tomar datos de talla, longitud de carapacho a la 0.1 mm más cercana, y determinación de sexo. Los individuos capturados eran mantenidos vivos y liberados uno por uno en hábitats similares a una distancia de 0.6 - 1 km de la estación de recolecta. Por tanto, en cada ocasión de muestreo las estructuras eran clareadas; lo que también se aplicó a otros taxa que ocupaban las estructuras. Se

procuró que la manipulación de los individuos capturados fuera lo menos traumática posible.

En las estaciones de minicasitas, con cuatro estructuras cada una, las estructuras eran cobradas desde cubierta, se revisaba la presencia de morenas o rayas, y después su contenido se vaciaba en cubetas. El contenido era revisado sobre un tamiz de malla gruesa y se eliminaba el exceso de vegetación en la abertura de entrada. La captura de la minicasitas era procesada de igual forma que la descrita para condominios.

La construcción de minicasitas siguió el diseño de la minicasita levable tipo-1. Esta estructura tiene un marco metálico de varilla corrugada, rectangular de 80 x 70 cm, a la que se adapta una cubierta de concreto sobre la parte superior y en dos caras laterales, una tercera cara lateral se forra de malla metálica inoxidable y opuesta a esta última, la cuarta cara lateral constituye la entrada de altura 4 cm. Esta dimensión es crítica para definir el acceso a la minicasita. La superficie opuesta al techo de concreto, que hace contacto sobre el fondo también fue forrada de malla de criba.

El condominio es una estructura simple formada por 16 bloques de concreto. Se colocan sobre el fondo los primeros ocho bloques, en un arreglo cuadrangular de dos bloques por lado; sobre ellos se coloca un segundo juego de ocho bloques en arreglo similar – a modo de segundo piso. Es crítico el tamaño de los orificios del bloque; nosotros usamos el bloque más pequeño disponible en el mercado 40 cm x 20 cm x 10 cm., cada uno con tres orificios 10.2 cm x 3.8 cm. Otra vez, esta dimensión de 3.8 es crítica para definir el acceso a los orificios del bloque. Este bloque posee dimensiones muy similares al usado en Cuba (de León et al. 1991).

RESULTADOS Y DISCUSIONES

Comparación de Condominios vs Minicasitas como artes de Muestreo

Primera etapa: experimento de corto plazo — Fueron comparadas tres diferentes tipos de estructuras como arte de muestreo de langosta: minicasita levabl e- 1, minicasita levable - 2 y condominio cubano, en un experimento de campo con diseño de bloques completos aleatorizados BCA (Sokal y Rohlf 1995). Los bloques fueron cuatros sectores o áreas de Bahía de la Ascensión: Río, Vigía Chico, Tres Marías y Cayo Valencia. El diseño BCA considera aleatorio al efecto de bloques -áreas y admite de entrada que las áreas difieren en factores no controlados abióticos: tipo de fondo, refugio disponible, temperatura, salinidad; y bióticos: asentamiento de poslarvas, abundancia de predadores y presas. El factor fijo fue tipo de estructura, cada una con diferente capacidad de atracción, por lo que interesa evaluar cómo esto afecta su ocupación por juveniles. El objetivo del diseño es evaluar la significancia del efecto del factor fijo, tipo de estructura (tratamiento). Fueron colocadas cuatro estaciones, una por sector selecto de la bahía (Tabla 1). Cada estación con cuatro estructuras: dos minicasitas levables - 1, una minicasita levable - 2 y un condominio

cubano. La variable de respuesta fue captura total acumulada, número de individuos juveniles de langosta, en las recolectas mensuales de julio a noviembre de 1998 (Tabla 1). Usar esta variable, en vez de valores mensuales, evita la práctica controversial de tomar los datos de conteos secuenciales como réplicas o mediciones repetidas independientes.

En la Tabla 1 se aprecian algunas tendencias. De Julio a Noviembre, la captura total de juveniles de langosta fue de 118 individuos; el grueso de esta captura, 78 individuos (66 %), se obtuvo en condominios cubanos. A su vez, del total capturado, la mayor parte, el 58.5% (69 individuos), provino de una sola estación: Cayo Valencia. Así, en cuanto a tipo de estructura, el condominio cubano tuvo capturas visiblemente superiores; y en cuanto a estaciones, destacó Cayo Valencia (Tabla 1).

Tabla 1. Captura total de juveniles de langosta, en número, acumulada de julio a noviembre de 1998 en las diferentes estructuras (tratamientos) y estaciones (bloques) en Bahía de la Ascensión. Datos sin transformar.

Estaciones (Bloques)	Tipos de estructura (Tratamientos)			
	Minicasita levable-1		*Minicasita levable-2*	*Condominio cubano*
	a	*b*		
Río	1	2	2	6
Vigía Chico	1	0	0	2
Tres Marías	0	0	0	35
CayoValencia	8	10	16	35

A la captura total se aplicó un análisis de varianza (anova) bifactorial, sin repeticiones. Al diseño BCA corresponde un anova de modelo mixto (Sokal y Rohlf 1995). El factor fijo fue tipo de estructura y el factor aleatorio los bloques: estación o área (Tabla 2). La captura total, X, fue antes transformada a $(X+ 0.5)^{0.5}$. Las comparaciones de medias *a posteriori* aplicaron las pruebas de Tukey-Kramer (Sokal y Rohlf 1995). Según el anova, bajo un $\alpha= 0.05$, la captura de juveniles de langosta varió significativamente con el tipo de estructura ($Fs = 5.89$, $p = 0.017$) (Tabla 2). Las comparaciones de medias *a posteriori* no detectaron cuáles medias (estructuras) ocasionaron la significancia en el anova; pero la captura, en número de juveniles, de los condominios cubanos fue muy superior a las capturas de las estructuras restantes, e incluso mayor que la suma combinada de dichas capturas (Tabla 1). Los principales supuestos del anova fueron cumplidos satisfactoriamente.

Tabla 2. Tabla del anova bifactorial[a] de la captura total de juveniles, X: no. de individuos, de julio a noviembre 1998, transformada a $X' = (X + 0.5)^{0.5}$. Anova de modelo mixto. El factor fijo es tipo de estructura: tres minicasitas levables, dos de diseño-1, una de diseño-2 y un condomi-nio cubano. El factor aleatorio, bloque, son las cuatro estaciones en diferentes áreas de la bahía.

Fuente de Variación	g. de l.	Suma de Cuadrados	Cuadrados Medios	F_s	P
Tipo de estructura (Factor fijo)	3	19.1634	6.3878	5.885[b]	0.0166*
Area o Estación (Bloque)	3	16.2032	5.4011	4.976[c]	0.0264*
Estructura x área (Interacción)	9	9.7686	1.0854		

Notas: a) sin repeticiones; b) $F_s = CM_E / CM_{ExA} = 6.3878 / 1.0854$ sin suponer interacción nula o no-significativa; c) $F_s = CM_A / CM_{ExA} = 5.4011 / 1.0854$, requiere que la interacción sea no-significativa.

El experimento dió bases para tomar dos decisiones prácticas para el proyecto. Primero, la decisión de usar simultáneamente dos artes de muestreo, minicasitas levables y condominios en la siguiente etapa del proyecto de monitoreo. El argumento fue que la ocupación de una estructura es sólo un criterio, aunque las minicasitas arrojan menores capturas entre sus ventajas están un menor tiempo de revisión y que no dependen del buceo. Segundo, dado el nivel de captura por arte registrado en el experimento; decidimos que en la segunda etapa, una estación de condominios la formasen dos condominios y una estación de minicasitas levables tuviese cuatro minicasitas. El espaciamiento entre los condominios vecinos fue de 25 metros, igual que entre minicasitas a lo largo de una sola línea recta.

Segunda etapa: patrones de abundancia a mediano plazo — De Marzo a Diciembre de 1999 fueron monitoreadas mensualmente 22 estaciones: doce de condominios y diez de minicasitas levables (Figura 1). Algunas estaciones ubicadas relativamente cerca entre sí; podrían considerarse estaciones pares. En el caso de Xoken, Cayo Valencia y Cedros las estaciones pares, una de minicasitas y otra de condominios, estaban muy próximas, ~0.3 - 0.5 km entre sí. Otras estaciones pares, i) Río (c)-Río (m), ii) Culebras (c)-Canal (m), e iii) Colonia (c)-Faro (m) también estuvieron próximas entre sí, a distancias de 0.5 a 1.5 km. Por tanto, los registros de abundancia de estos pares de estaciones permiten comparar, a mediano plazo, las dos artes de muestreo. Ello complementa el primer experimento comparativo arriba descrito, de corto plazo; con diseño limitado a cuatro bloques, y pequeño número de unidades de muestreo por estación: un condominio y tres minicasitas.
En la Figura 2 se aprecian los patrones temporales de ocupación o abundancia relativa en estos pares de estaciones. En cuatro de seis casos: Xocen, Valencia, Cedros y el par Culebras-Canal durante los meses primaverales los patrones de abundancia fueron relativamente similares, pero los notorios picos de meses otoñales

sólo fueron registrados en condominios (Figura 2). En el período otoñal hubo gran diferencia, a favor de los condominios, en la ocupación registrada en el par de Cayo Valencia y el par Cayo Culebras-Canal (Figura 2). Esto sería un primer indicio de un posible comportamiento de saturación de las minicasitas, sobre todo en períodos en los que ocurren pulsos estacionales de alta abundancia de juveniles.

Por la evidencia de un posible efecto de saturación en las minicasitas, sobre todo a altos valores de abundancia relativa, se consideró que las minicasitas levables –del diseño aquí empleado, no son recomendables como artes de muestreo para monitoreo a largo plazo de la abundancia de juveniles de langosta; aunque las minicasitas fueron ocupadas por un elevado número de peces y crustáceos pudieran tener potencial para monitoreo de otras grupos de fauna arrecifal.

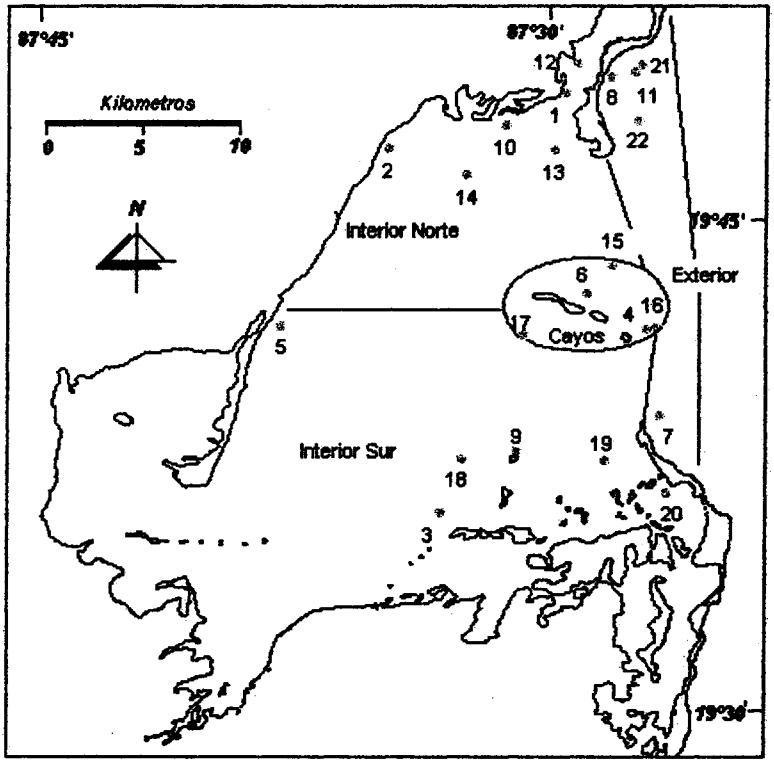

Figura 1. Area de estudio, Bahía de la Ascensión, las cinco áreas o estratos considerados y la red de 22 estaciones de muestreo. Doce estaciones de condominios (# 1 a # 12) y diez estaciones de minicasitas (# 13 a # 22).

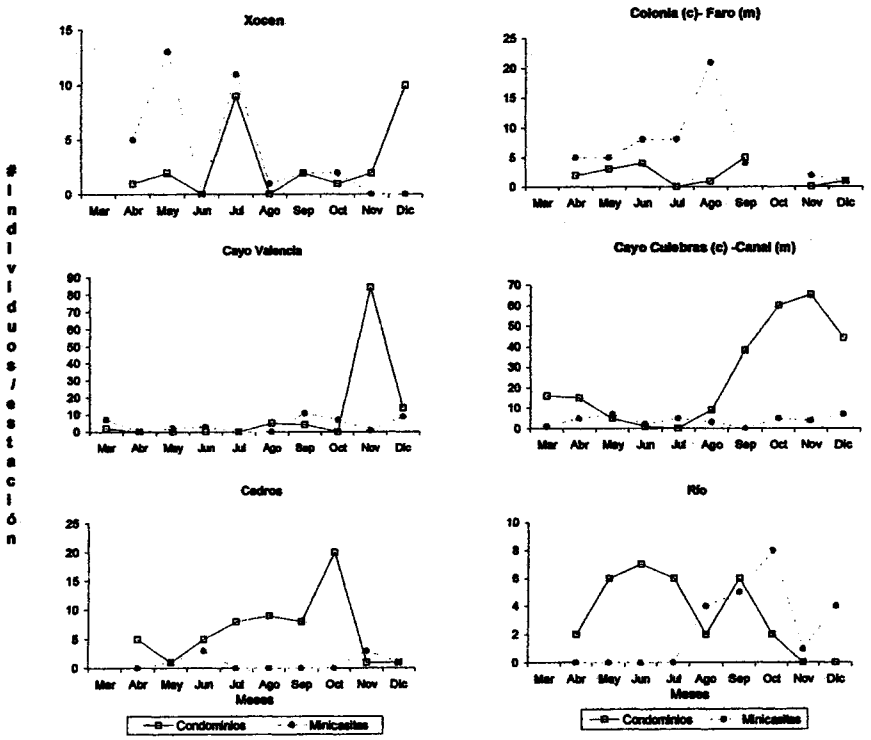

Figura 2. Comparación de la abundancia mensual de juveniles de langosta, individuos/estación, en pares de estaciones vecinas, pero de diferentes artes: condominios vs minicasitas. Los pares del lado izquierdo son estaciones más cercanas entre sí, distancia máxima 0.5 Km; que los pares de estaciones del lado derecho, con distancia entre sí de 0.6- 1.5 Km.

Muestreo en Una Red de Estaciones, Muestreo Óptimo con Condominios

Abril-Diciembre de 1999. Monitoreo en 22 estaciones — Una vez emplazada la red completa de 22 estaciones en Bahía de la Ascensión (Figura 1), comenzó formalmente el monitoreo mensual de la abundancia relativa de juveniles de langosta *Panulirus argus*. Por lo tanto, esta fase del monitoreo mensual comprendió nueve meses, de abril a diciembre de 1999. Esto permitió abordar aspectos estadísticos del muestreo –sin obviar los aspectos prácticos. Son consideradas algunas cuestiones sobre índices de precisión de las estimaciones de abundancia relativa promedio mensual, los modelos probabilíticos que puede seguir esta variable abundancia relativa; el tamaño de muestra n, en número de estaciones de muestreo

independientes, y el tamaño de la unidad de muestreo (*tum*) que representa de manera aproximada el número de estructuras en cada estación.

El muestreo siguió un diseño aleatorio simple (Cochran 1977). No obstante, suponer que las estaciones fueron emplazadas al azar es una hipótesis de trabajo razonable para fines del análisis. En la práctica, la elección de sitios donde se colocaron estaciones no fue enteramente aleatoria. Por un lado, se trató de cubrir ciertos sectores o estratos de la bahía (Figura 1); en particular, cinco:

i) Exterior de la bahía- Norte, con hábitats propios de laguna arrecifal, desde Punta Xoken a frente de los Cayos centrales;
ii) Exterior de la bahía-Sur, hábitats similares al anterior, desde frente de los Cayos Centrales a Punta Pájaros;
iii) Cayos centrales, con hábitats bénticos de alta cobertura de macroalgas y pastos marinos, cerca de márgenes de manglar;
iv) Interior de la bahía-Norte, hábitats de menores cobertura de pastos y macroalgas, cerca de márgenes de manglar, pequeñas lagunas costeras, y presencia de fondos fangosos y rocosos; y
v) Interior de la bahía-Sur, similar al anterior pero con presencia de varios cayos, canales y lagunas bordeadas de manglar.

Quedó fuera una gran porción central de la bahía; que los pescadores tampoco usan como área de pesca de langosta por poseer fondos sin vegetación, fango con rocas dispersas, y sobre todo alta turbidez en todo el año.

Por otra parte, la ubicación de estaciones dentro de cada sector, fue de primera intención aleatoria; con elección de números aleatorios para definir las coordenadas geográficas de cada estación, pero también fue influenciada por cuestiones prácticas como evitar fondos fangosos y extensas áreas sin vegetación o arenales. Otro factor fue encontrar pescadores que permitieran el acceso a sus campos del grupo de investigación en todo tiempo (veda incluída); así como un grado de colaboración en el cuidado de las estaciones de muestreo.

Abundancia por estación de condominios: observaciones y modelos — En el análisis de muestreo óptimo, la variable central es la abundancia relativa de juveniles de langosta *Panulirus argus*, en número de individuos por estación, exclusivamente para condominios. El análisis abarca el período de nueve meses, de abril a diciembre de 1999, en el que fueron obtenidos datos de abundancia relativa en la red completa de 22 estaciones (Figura 1).

Cuando se emplean artes activos como redes de arrastre y transectos o cuadrantes, al llegar a la estación se activa el equipo de muestreo y el tiempo define el tamaño de la unidad de muestreo, porque éste define el tamaño del área barrida o volumen filtrado. En cambio, con artes estacionarios, ocupar una estación significa revisar estructuras – condominios, que han operado por cierto tiempo de calado ("soak time") y han ejercido su influencia atractora sobre un área definida. Esta última, depende del diseño y dimensiones de la estructura así como del número de estructuras por estación. El tiempo de calado, tiempo entre una revisión y otra, no se incluye en el presente análisis porque se mantuvo relativamente constante, con

diferencia de pocos días. También, en cada muestreo mensual fue uniforme entre estaciones, ~1 día de diferencia. Por tanto, el tamaño de la unidad de muestreo (*tum*) es el número de estructuras, dos condominios o cuatro minicasitas, por estación. El tamaño de muestra (n) estuvo dado por el número de estaciones. El número de individuos por estación es un índice de abundancia relativa porque se desconoce el tamaño del área de influencia de cada estructura, sobre la que una estructura de cierto tipo ha operado durante el tiempo de calado.

Si la abundancia relativa es vista como variable aleatoria, surge entonces la interrogante de cuál modelo o distribución de probabilidad sigue. Hay abundante literatura acerca de cómo se comporta la abundancia en poblaciones marinas, que usualmente sigue distribuciones de tipo asimétrico, o de tipo contagioso como la Binomial Negativa para el caso discreto, la log-normal para el caso continuo (Seber 1982, 1986, Pennington y Volstad 1991, Hilborn y Mangel 1997).

Se obtuvo la mediana de valores mensuales $\bar{x}$ y s^2 para el período de Abril a Diciembre; así como para dos intervalos: i) baja abundancia: Abril - Agosto, ii) alta abundancia: Septiembre - Diciembre. De las estimaciones muestrales, cada mes fue estimado el parámetro k de la Binomial Negativa por el método de momentos

$$k = \frac{(\bar{x})}{(s^2 - \bar{x})}$$

(Elliot 1977, Hilborn y Mangel 1997) para datos de condominios. Fue calculada la mediana de las estimaciones mensuales de k, como valor representativo de cada uno de los tres períodos, ya citados.

Precisión de la media estimada, índice K — Una primera idea de la precisión de las estimaciones mensuales de abundancia media de juveniles de langosta en la red de 22 estaciones de Bahía de la Ascensión, es dada por el índice de precisión aplicado a la media estimada. Este índice bien conocido, se denomina coeficiente de variación de la media,

$$CV\ \bar{x} = \frac{s}{\bar{x} \cdot \sqrt{n}}$$

En condominios, los valores mensuales del índice de precisión tendieron ligeramente a ser estables de Abril a Agosto, y aumentaron en el siguiente, Septiembre a Diciembre (Figura 3).

La cuestión del tamaño de muestra n, número de observaciones independientes que integra una muestra, a partir de la que se estiman parámetros poblacionales, es un asunto central en el muestreo de poblaciones biológicas (Elliot 1977, Seber 1982, 1986, Hilborn y Mangel 1997). Existen varios métodos y aproximaciones para determinar tamaños óptimos de muestra.

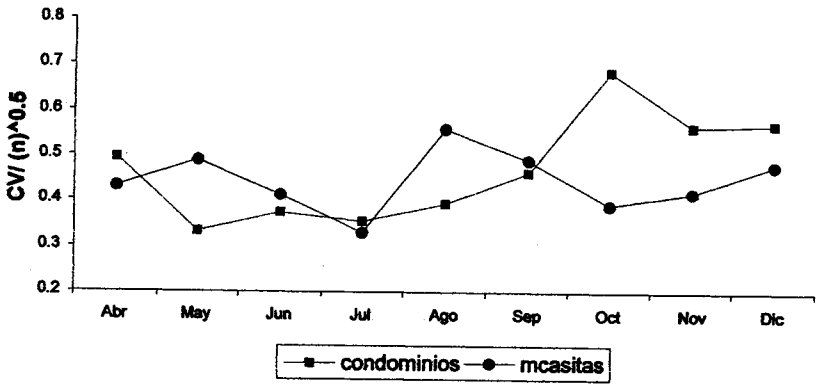

Figura 3. Indice de precisión K registradas para las medias mensuales estimadas de abundancia de langostas juveniles; para estaciones de condominios y minicasitas. El índice K estima el coeficiente de variación de la media , a partir de estimaciones muestrales de varianza y media.

Muestreo óptimo, Precisión, y Tamaño de la Unidad de Muestreo ante Restricciones — Por tanto, es de interés práctico conocer aproximaciones a la optimización de muestreo que hacen explícitas las restricciones; en particular en dos situaciones: a) costos fijos, C –en cuyo caso conviene minimizar K; y b) K fija –en cuyo caso se busca minimizar los costos. Además, este enfoque introduce un factor no incluído en los métodos vistos previamente: el tamaño de la unidad de muestreo o tum.

Varios autores han abordado en forma general la cuestión de muestreo con restricciones (Cochran 1977, Sokal y Rohlf 1995). En aplicaciones en ecología marina destacan las aproximaciones desarrolladas por Lenarz y Adams (1980) y de Pennington y Volstad (1991). Estos últimos autores tratan el asunto desde la perspectiva de relevamientos ("surveys") en cruceros dirigidos estimar la abundancia poblacional de recursos, donde es conveniente expresar los costos en tiempo de trabajo en el mar (horas, días). En particular, estos autores consideran poblaciones que siguen la Binomial Negativa, BN(m, k) de parámetros m y k; o poblaciones cuyos datos de abundancia cumplen la relación de Taylor. En el contexto de este trabajo, la situación bajo análisis coincide con lo planteado por Pennington y Volstad (1991). Sin embargo, el presente trabajo tiene un par de diferencias fundamentales. Uno, tales autores consideran el uso de redes de arrastre; con el tamaño de unidad de muestreo (*tum*) definido por el tiempo en que operan un equipo de muestreo. Aquí, con artes estacionarias, ocupar una estación consiste en recuperar -revisar

estructuras que han operado por un determinado tiempo de calado ("soak time") sobre el área de influencia del arte. El *tum* sería el producto del número de estaciones por esta área unitaria de influencia. Entonces, el tiempo en la estación aquí sólo refleja el tiempo de revisión de un número dado de estructuras. Dos, Pennington y Volstad (1991) representan la función de costos vs n, número de estaciones, mediante una relación no-lineal. En nuestro caso la relación es lineal. A partir de estas diferencias, fueron elaboradas extensiones a las ecuaciones de los autores citados (Sosa-Cordero, no publicado). Aquí fue empleado también el costo en tiempo en el mar para expresar los recursos que necesitan los muestreos efectuados durante el período de estudio, dirigidos a estimar la abundancia relativa de juveniles. Para ello, sirvieron de base los registros de tiempo dedicado a diferentes actividades durante los recorridos mensuales en la red de 22 estaciones, de Abril a Diciembre de 1999 (Tabla 3). Estos datos, clasificados con el enfoque de Pennington y Volstad (1991), permitieron definir los valores que correspondieron a los tiempos siguientes:

c_1 es tiempo (min) de maniobra de ocupar (llegar a) una estación, y preparativos para revisión;
c_2 es tiempo (min) de viaje entre estaciones, expresado en tiempo de viaje/estación, que supone se ha seguido la ruta de longitud mínima;

tum, tamaño de la unidad de muestreo, comprende el tiempo de revisión, colecta y medición en cada estación, al reflejar el número de estructuras revisadas, es descriptor del *tum* real;

Para las estaciones de condominios, de los registros de campo (Tabla 3) sobre los tiempos arriba citados, quedaron definidos los valores siguientes: $c_1 = 8$ min., $c_2 = 22$ min., y *tum* = 17 min. Estos últimos valores y las estimaciones muestrales de los respectivos parámetros poblacionales fueron introducidas a las ecuaciones respectivas para determinar valores óptimos de tamaño de muestra (n_{opt}) y tamaño unitario de muestra (tum_o). Para ambos casos, si la abundancia sigue la Binomial Negativa o cumple la relación de Taylor y diferentes niveles prefijados de precisión K, se presentan las estimaciones muestrales de los parámetros usadas y los resultados de aplicar las ecuaciones a los datos de abundancia de las estaciones de condominios (Tabla 4).

De este análisis se desprenden tres resultados principales. Uno, el análisis sugiere reducir el tamaño de la unidad de muestreo (*tum*) en estaciones de condominio; de hecho, el *tum* óptimo estimado ($tum_o = 5.2$ min) en términos proporcionales significaría revisar menos de un condominio por estación. De ahí que el análisis haya considerado como opción práctica usar un *tum* equivalente a un condominio (Tabla 4). Dos, con *tum* de 9 min., equivalente a un condominio por estación, es posible alcanzar un nivel de K fijado en 25 %, con solamente 10 estaciones (Tabla 4). Extrapolado esto a un *tum* igual al usado, *tum* = 17 min ó dos condominios/estación; entonces, sería factible cubrir $n \geq 20$ estaciones lo que aumentaría la precisión (disminuye K). Tres, con *tum* = 9 min., para un costo fijo

en 3 días de muestreo se podría alcanzar n = 37 estaciones de condominios, asociado a un K= 0.27 (Tabla 4).

Tabla 3. Tiempos (en min) dedicados a diferentes actividades en las campañas mensuales de monitoreo de juveniles de langosta. Se indica n, el número de estaciones de cada tipo que fueron revisadas al mes. Se incluyen estaciones de dos tipos emplazadas en Bahía de la Ascensión.

Mes	n	Tiempo/ estación minicasitas	n	Tiempo/ estación condominios	Tiempo de viaje	Tiempo total
Abril	10	166	12	229	452	847
Mayo	10	224	12	315	368	907
Junio	10	128	12	154	498	780
Julio	10	175	12	231	552	958
Agosto	10	244	12	194	362	800
Septiembre	10	189	12	270	363	822
Octubre	10	178	10	303	389	870
Noviembre	10	150	12	332	376	858
Diciembre	10	106	11	149	581	836

En síntesis, bajo la suposición que la abundancia por estación sigue una distribución Binomial Negativa (BN), con estimaciones muestrales de media, varianza y k-BN; con restricción de costos, el análisis incorpora el *tum*, se sugiere reducir el *tum* de estaciones de condominios (*tum* = dos condominios o 17 min), hacerlo menor a dos condominios por estación. Esto abre la posibilidad de ensayar nuevos arreglos con los bloques utilizados. En este caso, para una *tum* de un condominio por estación es posible con n = 10 estaciones alcanzar niveles de precisión de 25 %. A su vez, para costos fijos, por ejemplo fijados en tres días de muestreo en el mar (1440 min), es posible alcanzar una n_{opt} = 37 estaciones con precisión de 27 %. La aplicación de los enfoques más elaborados ha permitido develar aspectos que difícilmente podrían ser sugeridos si se aplicaran los métodos usuales para determinar tamaño de muestra. Estos resultados son de clara utilidad práctica en el proceso de buscar, de proponer alternativas y planes de monitoreo eficientes en costo-precisión; lo que haga más factible el monitoreo de los valiosos recursos regionales.

Tabla 4. Tamaño óptimo de muestra n_{opt}, número de estaciones, cuando la abundancia sigue la Binomial Negativa en presencia de restricciones (ver sección: Muestreo óptimo II). Dos casos son considerados: a) para un índice fijo de precisión K, a varios niveles; y b) para un costo fijo, en tiempo en el mar (min, o días). La Binomial Negativa con parámetro k = 0.415. Los valores de tiempo asociados al muestreo: c_1= 8 min, c_2= 22 min, *tum*= 17 min. La media muestral de abundancia, del período de menor precisión observada (sept-dic), ξ = 7.9 entró en los cálculos como m´= ξ/*tum*. Un tamaño de unidad de muestreo (tum_o) de 5.2 min implicaba menos de un condominio/estación; por lo que se incluye cálculos con tum_o= 9 min ó 1 condominio/estación. La relación entre costos C (en min) y n es lineal: Costos= $(c_1+tum)n + c_2(n)$.

Precisión K fija, minimizar costos C

		tum_o= 5.2 min.				tum_o= 9 min.		
K	0.1	0.25	0.30	0.5	K	0.1	0.25	0.3	0.5
n_{opt}=	83	13	9	3		65	10	7	3
Costo (min)	3904	625	434	156		3074	492	342	123
(días)	8	1.5	1	0.5		6	1	1	0.5

Costo C fijo, minimizar precisión K

		tum_o= 5.2 min.				tum_o= 9 min.		
C (días)	4	3	2	1	4	3	2	1
(min.)	1920	1440	960	480	1920	1440	960	480
n_{opt}	55	41	27	14	49	37	25	12
K	0.23	0.26	0.32	0.46	0.23	0.27	0.33	0.46

Monitoreo eficiente del reclutamiento de langosta a escala regional — A partir de los análisis anteriores, se estimaron los costos, en tiempo y dinero, que llevaría implantar un programa de monitoreo de juveniles de langosta a largo plazo en Bahía de la Ascensión. Asimismo, con los últimos análisis de optimización del muestreo, ya puede ser fijado en tres días el tiempo de muestreo. Habría que decidir si se mantiene la tum actual, dos condominios por estación, o se hacen arreglos para reducirla a 1 - 1.5 condominios por estación. Otra posibilidad es cambiar el diseño del condominio. Constituye un avance el fijar en tres días la duración del muestreo, lo que permite programar costos totales en tiempo y recursos (dinero) para el monitoreo; además de establecer niveles de precisión de la estimación de abundancia entre el 25 y 27 %; que son aceptables como meta general en el campo de la ecología marina (Sissenwine et al. 1983).

A continuación se hace un análisis económico de costos totales del monitoreo regional que comprende cuatro localidades, Bahía de la Ascensión, Banco

Chinchorro, Cabo Catoche y Cayos-Contoy (Tabla 5). Las dos últimas se ubican en el norte de Quintana Roo, la primera y la segunda en las zonas central y sur, respectivamente. Estas cuatro localidades albergan las más importantes y extensas áreas de crianza de langosta en Quintana Roo. En sus áreas de pesca se lleva a cabo el grueso de la actividad pesquera del estado de Quintana Roo.

Tabla 5. Costos totales por año en $ US para el monitoreo regional del recurso langosta, en particular muestreos de la abundancia de juveniles en estaciones de condominios. Se considera que en las localidades norteñas el patrón estacional del reclutamiento es igual al de Cayos-Contoy lo que demanda 9 salidas (8 datos mensuales); en las localidades central y sureña se considera el patrón de Bahía de la Ascensión con 8 salidas al año (7 datos mensuales).

Costos $ US	Z. central/ B. de la Ascensión	Z. sur/ Banco Chinchorro	Z. norte/ Cabo Catoche	Z. norte/ Cayos-Contoy	Total
Costos Fijos					
Viajes a la localidad	8 x $ 175 1,400	8 x $ 225 1,800	9 x $ 300 2,700	9 x $ 350 3,150	9,050
Lancha, motor, etc. (compra o renta/viaje)	8 x $ 400 3,200	8 x $400 3,200	9 x $ 400 3,600	9 x $ 500 4,500	14,500
Equipo de muestreo: artes, GPS, boyas, etc. (compra única)	2,500	1,500	2,500	1,500	8,000
Salarios –personal del proyecto: 4 personas (una por localidad).	12x $ 600 7,200	12 x $600 7,200	12 x $ 600 7,200	12 x $ 600 7,200	28,800
Costos Fijos-subtotal	14,300	13,700	16,000	16,350	60,350
Costos Variables					
Lanchero-guía	8 x 4x $ 75 2,400	8 x 4 x $ 75 2,400	9 x 4x $75 2,700	9 x 4 x $ 75 2,700	10,200
Combustible	8 x $ 250 1,000	8 x $250 1,000	9 x $ 250 1,250	9 x $ 250 1,250	4,500
Estancia en campo	8 x $ 400 3,200	8 x $ 400 3,200	9 x $ 400 3,600	9 x $ 400 3,600	13,600
Costos Variables Subtotal	6,600	6,600	7,550	7,550	28,300
Costos Totales /localidad	**20,900**	**20,300**	**23,550**	**23,900**	**88,650**

Este análisis hace varias suposiciones. En primer lugar, supone que la variabilidad de la abundancia encontrada en Bahía de la Ascensión, es semejante y aplicable a las otras localidades, lo cual parece razonable - al menos para Cayos-Contoy, la única localidad que cuenta con antecedentes de abundancia relativa de juveniles (Arce et al. 1997). Supone también que en cada localidad se considera un área objetivo (universo) de muestreo de magnitud equiparable, del orden de los 500 km^2. El método supone un diseño de muestreo aleatorio simple, por los que los resultados tendrían que ser modificados para otros esquemas de muestreo, como el estratificado. Por tanto, este análisis queda como línea de base para contrastar otras posibilidades de muestreo.

Una consideración adicional de tipo práctico, es proponer el muestreo de juveniles durante un período que asegure incluir los meses pico de reclutamiento, junto con algunos meses –el inicial y el final, de la temporada "baja" en abundancia de juveniles. Para esto, es necesario suponer que en la zona norte ocurre el patrón estacional de Cayos-Contoy (Arce et al. 1997); donde la temporada de alta abundancia es de Enero a Septiembre, con picos máximos en Abril, Mayo y Junio (Arce et al. 1997). Para localidades de esta zona se proponen nueve salidas al año, de Enero a Agosto, que aportarán ocho valores mensuales de abundancia al año. En cambio, para la zona sur y central; se supone que ocurre el patrón estacional de Bahía de la Ascensión, con altas abundancias de Agosto a Diciembre, y picos máximos en Octubre-Diciembre. En estas localidades, se propone efectuar ocho salidas al año, de Junio a Diciembre, lo que aportará siete datos mensuales por año.

La Tabla 5 contiene los costos totales anualizados para cubrir las costas de Quintana Roo, con vistas a un monitoreo regional del reclutamiento de un programa de monitoreo del reclutamiento de juveniles de langosta *Panulirus argus*, que comprende las áreas de crianza asociadas a las localidades pesqueras más importantes. Sin más comentarios sobre los montos, este ejercicio de análisis de muestreo eficiente en costo-precisión, representa un elemento esencial para considerar el monitoreo regional del recurso langosta, en concordancia con su valor social, económico y ecológico en la región.

CONCLUSIONES

El condominio resultó el arte de muestreo que dió mejores resultados, sus valores de ocupación o abundancia relativa de juveniles de langosta tendieron a ser más altas que las de minicasitas. Con este arte sí fueron detectados aumentos en la temporada otoñal, caracterizada por picos máximos en Octubre - Noviembre. En cuanto a tallas este arte incide en los juveniles posalgales, el grupo de talla objetivo en este tipo de estudios sobre reclutamiento.

La minicasita levable, del diseño probado, tuvo un comportamiento de saturación, por evidencias experimentales y observacionales. Con este arte no fue detectado el pulso otoñal de alta abundancia en 1999. En consecuencia, no se recomienda usar minicasitas levables, del tipo probado, en el monitoreo de la abundancia de juveniles. Lo positivo del efecto de saturación es que probablemente

se deba la competencia o predación dentro de las minicasitas, esto por el alto número de juveniles de peces arrecifales que las ocuparon. Por lo tanto, la minicasita levable funcionó mejor como arte de muestreo para juveniles de peces arrecifales.

A partir del comportamiento de los valores mensuales de varianzas y medias muestrales, el análisis se basó en la suposición de que la abundancia de juveniles sigue la distribución Binomial Negativa (resta efectuar pruebas de bondad de ajuste que exige datos adicionales). Por otro lado, los datos de abundancia de minicasitas y condominios en conjunto sí cumplen satisfactoriamente la ley de Taylor.

Una aproximación al muestreo óptimo, tuvo el propósito de optimizar el tamaño de muestra n, junto con el tamaño de la unidad de muestreo (*tum*), cuando existen restricciones de costos. Con costo expresado en tiempo en el mar, como función lineal de n. Según el análisis, se puede reducir el *tum* actual, 17 min ó 2 condominios/estación, a un tum_0 = 6 minutos (< 1 condominio/estación). Para un *tum* alterno de 9 min (1 condominio/estación), se obtuvo una n_{opt} = 10 a una precisión fija de K= 25 %; así como n_{opt} = 37 para costo fijo en 3 días de muestreo, con precisión asociada de nivel K= 27 %. Esta última opción se consideró como razonable para trabajar en Bahía de la Ascensión en particular; y en las costas de Quintana Roo en general.

A partir de los resultados de muestreo óptimo, se hace un análisis económico de los costos totales al año de un programa regional de monitoreo de la abundancia de juveniles de langosta como índice de reclutamiento. Esto considera costos fijos y costos variables al año para cubrir cuatro localidades, Cabo Catoche, Cayos-Contoy, Bahía de la Ascensión y Banco Chinchorro, que contienen las áreas de crianza de langosta (y otros recursos arrecifales) más importantes de Quintana Roo.

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Modelo de Distribución Geográfica de Áreas de Reproducción de la Langosta (*Panulirus argus*) en Zonas Arrecifales Profundas de la Costa de Yucatán

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RESUMEN

En las costas de Yucatán, México, la pesquería de langosta tuvo lugar durante muchos años entre las 2 y las 18 brazas de profundidad en la zona costera y en el Arrecife Alacranes ubicado aproximadamente a 70 millas al Norte de la línea de costa y se utilizaba el buceo como técnica de captura. En los últimos años se ha incorporado a la pesquería el uso de trampas en las zonas arrecifales profundas (a más de 20 brazas de profundidad). El registro de las capturas provenientes de barcos de pesca que usan trampas para la captura de langosta (pesca exploratoria, pesca de fomento y pesca comercial), ha permitido obtener datos de una buena cantidad de hembras ovígeras así como de las zonas en donde éstas fueron capturadas. En este trabajo se utilizan los datos provenientes de la captura con trampas para proponer un modelo de distribución geográfica de las principales zonas de reproducción de langosta en la Costa de Yucatán.

PALABRAS CLAVES: Modelo de áreas de reproducción de langosta, Plataforma de Yucatán, *Panulirus argus.*

Geographic Reproductive Areas Distribution Model of Spiny Lobster (*Panulirus argus*) in Depth Arrecifal Zones of Yucatan Coast

Along the coasts of Yucatan, Mexico, spiny lobster fishery is conducted at depths between 2 and 18 fathoms for both coastal waters and Arrecife Alacranes area, wich is located at 70 milles from shore. The traditional capture method in this fishery has been diving, however, more recently, the use of lobster traps has been frequently used on deep on deep arrecifal zones (20 fathoms or more). Records of lobster captures from traps fishing vessels (exploratory and commercial fishing) allowed us to obtain data about the number of ovigerous females and the zones where they were captured. In this study, trap lobster fishing data are used to propose

a geographic distribution model of the main reproduction areas for lobster in Yucatan coasts.

KEY WORDS: Lobster reproduction areas model, Yucatan Platform, *Panulirus argus*

INTRODUCCIÓN

Hasta hace alrededor de cinco años en las costas del Norte de la Península de Yucatán la pesquería de langosta se había llevado a cabo en la zona litoral, desde el puerto costero denominado el Cuyo hasta el puerto de Celestún y en el Arrecife Alacranes, en profundidades aproximadas entre las 2 y las 18 brazas (Ríos et al. 1996, Ríos et al. 1998). El buceo libre y con hookah eran las únicas formas de capturar langosta. Sin embargo a partir de 1997 en la flota mayor que actúa tanto en la parte somera del arrecife Alacranes como en zonas profundas que le circundan, se ha ido introduciendo paulatinamente el uso de trampas como arte de pesca y como resultado, actualmente la flota mayor tiene acceso a nuevas áreas de pesca en zonas más profundas (alrededor de las 37 brazas de profundidad).

La pesquería de langosta actualmente, puede ser caracterizada por zonas y arte de pesca utilizado: a) las zonas más pegadas a la costa, oriente (de Dzilam de Bravo a El Cuyo) y poniente (Progreso y Sisal) en donde la técnica de captura sigue siendo exclusivamente el buceo (libre y con hookah) y se capturan preadultos y adultos; b) la zona somera del arrecife Alacranes, en donde la complejidad y profundidad del arrecife solo permite la entrada de embarcaciones pequeñas (18 pies con motores fuera de borda o "alijos" sin motor), el primer mes de la temporada de pesca se captura solo por medio de buceo libre y después se captura con ambos métodos: buceo libre y con hookah; en esta zona se capturan principalmente preadultos y c) las zonas arrecifales rocosas profundas en donde tiene influencia la flota mayor, se pesca con trampas y se capturan gran cantidad de adultos (nueva área de explotación).

Los cambios en la forma de capturar langosta en algunas zonas de la plataforma de Yucatán, han permitido la extensión de las áreas de pesca hacia aguas más profundas, en donde generalmente habitan langostas grandes que antes no se atrapaban, esto a originado una modificación en la estructura de la población explotada. La fracción de adultos a la cual antes no se tenía acceso, debido a la limitación que representa la técnica de captura tradicional en Yucatán (buceo), ahora se ha vuelto significante en los volúmenes de captura. Si bien la producción de langosta en el Estado se ha incrementado, existe el temor de que se esté capturando una parte importante de la población de reproductores, fundamental para la persistencia de langosta en las áreas de pesca.

Ante este nuevo esquema de explotación de la población de langosta en las costas de Yucatán, es necesario analizar la pesquería de manera diferente a la que se había planteado en los últimos años, tanto para evaluar el recurso como para proponer medidas de manejo. Esta forma novedosa de análisis se hace dentro de un

contexto de metapoblaciones, en donde el análisis de dimensión espacial cobra importancia (Hanski 1999). En este caso la población local de langosta (Plataforma de Yucatán) se considera abierta, con intercambio con otras áreas de pesca a través de la migración o la dispersión larval. Es necesario entonces entender la dinámica local del recurso con base en diversos aspectos como: la evolución de la pesquería, el conocimiento que se tiene sobre biología y ecología de la especie e incorporando los conocimientos existentes sobre geología, meteorología y corrientes marinas, con el fin de poder plantear estrategias de manejo lo más acorde posible con la idealidad de la sustentabilidad.

Como parte de todo el trabajo que pretende una visión integradora de la dinámica de la población de langostas en la Plataforma de Yucatán, es necesario abordar el conocimiento de la distribución de las áreas de reproducción en la plataforma peninsular, zonas que no se han estudiado y que actualmente son importantes áreas de pesca.

El objetivo de este trabajo es proponer un modelo de distribución geográfica de áreas de reproducción de la langosta (*Panulirus argus)* en zonas arrecifales profundas de la costa de Yucatán, considerando aspectos geológicos, meteorología, corrientes marinas, ciclo biológico, distribución de hábitat preferencial, migraciones y estrategias reproductivas.

METODO

En este trabajo se utilizó información existente sobre el origen y conformación geológica actual de la Península de Yucatán y el Banco de Campeche o plataforma peninsular norte, de igual manera se hizo una revisión de las características meteorológicas y oceanográficas de la región poniendo énfasis en el comportamiento de las corrientes marinas y los eventos que tienen importancia en el movimiento de las aguas superficiales y pueden influir en la deriva de las larvas planctónicas y por lo tanto explicar su dinámica en el área. De manera paralela se hizo una revisión de la información existente sobre el ciclo biológico de la langosta *Panulirus argus* centrando el interés en migraciones o movimientos de las langostas adultas, en conocimientos existentes sobre la deriva larval, comportamiento y procesos de asentamiento de larvas.

Los datos sobre zonas de reproducción se obtuvieron de cinco cruceros de pesca exploratoria realizados durante 1996 y principio de 1997, de barcos de pesca comercial de langosta (1999, 2000, 2001 y 2002) y de pesca de fomento (2002). En todos los casos se utilizaron trampas para capturar a las langostas en aguas profundas. Para el 70% de los cruceros se estimó la proporción de hembras en etapa reproductiva (con espermatóforo u ovígeras) y se obtuvieron los pesos medios de los organismos capturados.

Se incorpora al análisis información obtenida mediante el enlace con patrones de embarcaciones langosteras con una experiencia mayor de diez años en la pesquería que se realiza en zonas arrecifales profundas, así como en la zona costera oriente y poniente de Yucatán. También se agregan datos procedentes de la

pesquería de langosta en el estado de Yucatán.

Los puntos georeferenciados procedentes de los cruceros se archivaron en formato ascci, se importaron como vectores al programa Surfer y se desplegaron sobre un mapa base de la península de Yucatán construido con anterioridad por Bello y Hernández, (2000), el análisis de los datos se realizó considerando dos escalas espaciales, una considerando el área de operación de cada crucero lo que permite visualizar la distribución de las langostas en una escala de fracciones de milla cuadrada y la otra que considera todos los cruceros en la plataforma peninsular y cuya escala es de varios grados de latitud y longitud, es decir de cientos de millas náuticas cuadradas. En este caso fue importante que todos los datos se encontraran en el mismo sistema de referencia para que las operaciones entre capas fueran posibles (Figura 1).

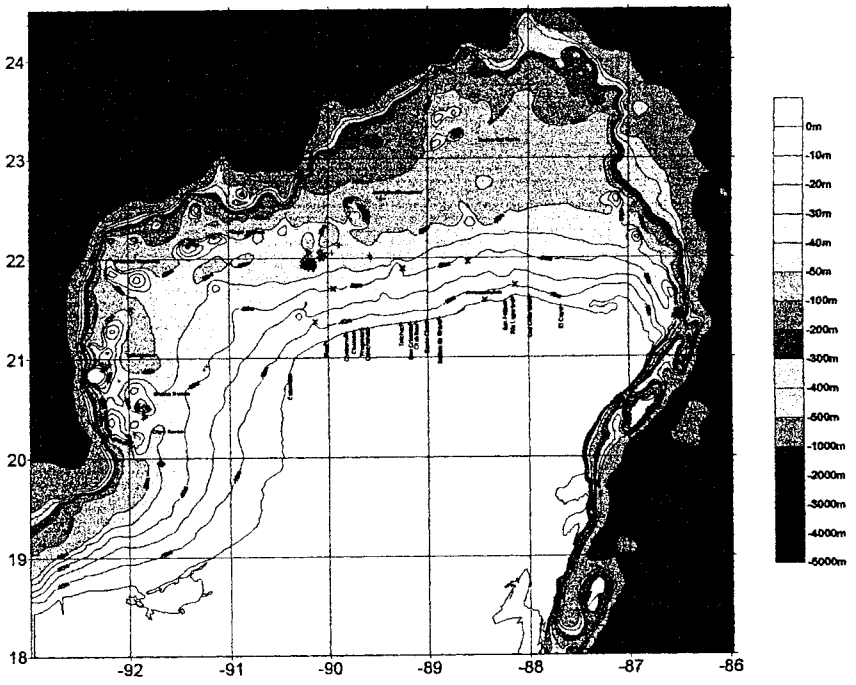

Figura 1. Batimetría y formaciones arrecifales de la Plataforma de Yucatán

Partiendo del supuesto de que las langostas se encuentran en estrecha relación con procesos de dispersión larvaria mediados por factores físicos y patrones de movimientos y migraciones en búsqueda de habitats propicios para persistir. Se sigue el patrón de distribución de áreas de reproducción en la plataforma y se asocia

a los acontecimientos importantes que ocurren en la plataforma (movimientos de las masas de agua a través de las corriente proveniente del Canal de Yucatán, surgencia, meteorología, formación geológica de la plataforma y ciclo biológico de la langosta del Caribe. Finalmente se plantea un modelo de distribución geográfica de áreas de reproducción de la langosta (*Panulirus argus)* en zonas arrecifales profundas de la Costa de Yucatán.

RESULTADOS Y DISCUSION

Geología

Los fondos marinos de la plataforma continental del Banco de Campeche y el norte de la península de Yucatán tienen su origen en la acumulación de materiales calcáreos en su mayoría procedentes de procesos biológicos. Así la precipitación de carbonato de calcio debido a procesos fotosintéticos como la asimilación de carbonatos en estructuras duras de los organismos (carapachos, esqueletos, conchas) y su deposición en el fondo después de la muerte de los organismos contribuyeron a la formación de la plataforma peninsular Yucateca. Se piensa que la formación de la península de Yucatán es un proceso paulatino que se desarrolla en un ambiente de fluctuaciones del nivel del mar y condiciones meteorológicas que responden a ciclos de diferente magnitud; así los procesos de formación de materiales, deposición, erosión, cementación, se siguen en ciclos bajo diferentes condiciones que en ocasiones se repiten en diferentes escalas de tiempo. Estos eventos que dan origen a la plataforma peninsular conforman una estructura que se caracteriza por la presencia de terrazas de materiales calcáreos duros alternados con capas de materiales menos consolidados todo esto con un suave declive hacia el norte. En un plano, la estructura peninsular no es homogénea ni en la parte emergente ni en la plataforma continental sumergida. Desde la línea de costa hasta el talud continental la plataforma del Banco de Campeche muestra una conformación heterogénea caracterizada por la presencia de áreas de sustrato duro con poco relieve, cavidades longitudinales de diferente longitud, áreas de material no consolidado como lodo, arenas, conchuela, etc. y áreas de una topografía complicada de diferente elevación con respecto al medio en donde se encuentran localizadas y que alcanzan altitudes de hasta ochenta metros sobre la profundidad media en donde se localizan. A pesar de la heterogeneidad de los fondos la distribución de las estructuras sigue patrones más o menos regulares. Así, las elevaciones coralinas forman una franja cerca del talud continental, en dirección a tierra son comunes terrazas de fondo duro alternadas con parches arenosos y cordilleras de baja elevación y hacia la costa se forman franjas paralelas a la costa de rocas planas, cordilleras de diferente longitud y normalmente baja elevación y materiales no consolidados principalmente de grano grande (conchuela) y mediano (Lynch 1954, Logan 1969, López Ramos 1976). Las mayores elevaciones coralinas emergen de la superficie del mar y son muy conocidas, tal es el caso del arrecife Alacranes, Cayo Arcas, Triángulos, entre otros. Otras elevaciones arrecifales no emergen a la superficie pero son también conocidas

tanto por los navegantes para quienes pueden representar un peligro como para los pescadores que las han utilizado como bancos pesqueros debido a su gran productividad (Figura 1).

Metereología

Los eventos meteorológicos de mayor importancia en la Península de Yucatán tienen componentes cíclicos y ocasionales o menos regulares. Entre los eventos cíclicos se presentan la época de nortes, una época de secas y una época de lluvias. La característica importante de la época de nortes es la presencia dominante de vientos fuertes con dirección hacia las áreas costeras y que tiene un influencia determinante en el movimiento de las masas de agua y de los elementos de deriva que finalmente se dirigen a la costa.

Durante la época de sequía los vientos dominantes son vientos de tierra o suestes que imprimen energía al agua superficial con dirección mar adentro.

Durante la época de lluvias se alterna la dirección del viento, lo más común es la presencia de vientos de tierra durante una parte del día (comúnmente la madrugada y la mañana) y vientos procedentes del mar (noreste) durante la otra parte del día (comúnmente la tarde y parte de la noche). Durante esta época del año se presenta también un proceso de fertilización de la zona costera debido al aporte de aguas continentales vía conductos subterráneos que desembocan en lagunas costeras y en sitios puntuales dentro de una franja importante de la costa que alcanza al menos los diez metros de profundidad.

Entre la época de secas y época de lluvias es común la ocurrencia de un evento muy importante en el ambiente costero de la plataforma peninsular. Se trata de una surgencia de aguas profundas procedentes del canal de Yucatán que fertilizan las aguas de la plataforma incrementando notablemente la productividad primaria. Este evento es anual aunque su intensidad varía y algunos años es más notable.

Aunque las presencia de tormentas tropicales, ciclones o huracanes son componentes anuales en las aguas del Caribe, no todos los años siguen las mismas rutas ni se presentan con igual intensidad, sin embargo en los últimos años la presencia de eventos de gran magnitud ha sido más notable. Estos eventos tienen la capacidad de mover grandes cantidades de agua superficial y de alterar de una manera considerable la configuración del hábitat costero. Su efecto sobre las comunidades marinas rompe equilibrios por lo que constituye una fuerza perturbadora de gran intensidad y poca duración de manera que después de presentarse las comunidades tienden a nuevos equilibrios algunas veces bajo condiciones considerablemente distintas (Leipper 1954, Merino 1992).

Corrientes Marinas

La corriente marina característica del área de estudio es la corriente de Yucatán, esta corriente tiene su origen en la corriente nor - ecuatorial que cruza el Atlántico Norte hacia América entre los cinco y veinte grados de latitud norte. Una parte de esta corriente se une a la corriente sur ecuatorial que corre al norte de Brasil como corriente de las Guayanas y penetra al Caribe por el arco antillano y forman la

corriente del Caribe, el flujo dominante en el Caribe es hacia el Oeste Noroeste hasta arribar a las costas de Yucatán. Al sur de la Isla de Cozumel el núcleo de la corriente tuerce hacia el norte y se alinea con la costa para dirigirse al canal de Yucatán para formar la corriente de Yucatán. La velocidad que alcanza es de 4 nudos. A partir de Cabo Catoche el núcleo de la corriente se alinea con el borde de la plataforma aunque la posición exacta cambia a lo largo del año. El núcleo de la corriente se separa de la plataforma en un punto que varía en relación con la penetración y forma la corriente de lazo dentro del Golfo de México. Adicionalmente a esta corriente que baña la mayor parte del Banco de Campeche durante todo el año, en el área se presenta una surgencia con carácter estacional y que se presenta con mayor intensidad alrededor de Abril y que se ha observado en Septiembre (Cochrane 1969, Bessonov et al. 1971, Ruiz 1979, Merino 1992, Mooers and Maul 1996).

Ciclo de Vida de la Langosta del Caribe

El ciclo de vida de la langosta espinosa *Panulirus argus* se puede resumir en una etapa larvaria plantónica de una duración aproximada de nueve meses, el asentamiento y crecimiento de puerulus a juvenil con una duración de un año y el crecimiento hasta la edad reproductiva en un período de aproximadamente tres años (Kanciruk 1980, Herknkind and Butler 1986, Cruz et al. 1991, Baisre y Cruz 1994), alcanzada la edad reproductiva se estima que las langostas presentan una longevidad aproximada de trece a quince años (Zetina y Ríos 2001). La reproducción de las langostas requiere de la cópula durante la cuál el macho "parcha" a la hembra, es decir, deposita los espermatozoides en una estructura con aspecto de parche (espermatóforo) que se pega en le región ventral del cefalotórax de la hembra (Cruz y de León 1992 reportan apareamiento de Febrero a Marzo e incubación de Abril a Mayo en aguas cubanas). Cuando las hembras fueron parchadas se mueven hacia los bordes arrecifales o a regiones costeras con abundantes refugios, en estos sitios se lleva a cabo la incubación, la eclosión de los huevos y la liberación de las larvas al plancton (Buesa 1965).

La prolongada etapa plantónica de las larvas permite desplazamientos de gran magnitud que son de "búsqueda" de condiciones propicias para el asentamiento, este parece ser un mecanismo exitoso de sobrevivencia en aguas de poca productividad y reducidas plataformas continentales e insulares características de las aguas del Caribe y además ha permitido una amplia distribución de la especie. Es probable que las subpoblaciones de langosta espinosa del Caribe tengan un intercambio genético importante debido a la configuración de las corrientes y a la ocurrencia frecuente de perturbaciones ciclónicas que mueven grandes cantidades de agua superficial, sin embargo en algunas regiones del Caribe los movimientos de las masas de agua en giros locales hace suponer que las larvas procedentes de los núcleos poblacionales de mayor magnitud nutran mayoritariamente a estas mismas unidades de población.

Hacia un Modelo de Reproducción de Langosta en las Costas de Yucatán

Dinámica de las Corrientes y el Ambiente Geológico — La plataforma peninsular Noroeste que comprende el Banco de Campeche y las regiones arrecifales del norte de Yucatán tienen un régimen de corrientes marinas dominadas por dos grandes sucesos periódicos:

i) La entrada de la corriente de Yucatán formada por aguas superficiales que antes atravesaron el Caribe y se movieron por el borde Este de la Plataforma de Yucatán. Estas corrientes son las dominantes aproximadamente de Octubre a Marzo, período durante el cuál son frecuentes los nortes que mueven las aguas superficiales con dirección a la costa.

ii) Las surgencias de agua profunda del canal de Yucatán rica en nutrientes, frecuentes entre Abril y Septiembre, período durante el cuál hacen acto de presencia las perturbaciones ciclónicas. Durante este tiempo las aguas superficiales se mueven hacia el interior del Golfo de México pero "bañan" las zonas arrecifales situadas más al norte de la península de Yucatán, creando giros locales debido a la presencia de protuberancias arrecifales que se levantan hasta ochenta metros sobre el lecho marino.

Movimientos de Langostas en el Área — *Panulirus argus* tiene patrones complejos de movimiento local y migraciones de largas distancias (García et al. 1992). Los conocimientos que se tienen sobre los movimientos masivos de langosta, en la costa norte de Yucatán, proceden principalmente de las observaciones relacionadas a la pesca comercial de estos crustáceos. Se sabe que después del primer norte las langostas inician un movimiento en contra de la corriente dirigiéndose hacia el Caribe, este movimiento es aprovechado por los pescadores para pescar utilizando redes o mediante el buceo, pero lo más común es el uso de redes. Estos movimientos masivos seguirán pulsos durante el invierno (Diciembre-Enero).

Con menos frecuencia se han observado movimientos de langostas desde las zonas profundas hacia regiones costeras de complicada estructura arquitectónica y estos movimientos se llevan a cabo durante los meses de nortes (Octubre-Marzo).

Composición de las Capturas en las Zonas Costeras y Zonas Arrecifales de Poca Profundidad — La captura por unidad de esfuerzo en la pesquería de langostas de Yucatán en áreas someras (captura por buceo) se caracterizó por dos máximos, uno a inicios de temporada (julio) y otro durante los meses de diciembre-enero. En ambos casos la composición de las tallas capturadas era similar, lo que hace pensar en dos cohortes anuales que se integran a la pesquería.

Frecuencia de Captura de Hembras Ovígeras — Aunque la información relacionada a la ocurrencia de hembras ovígeras está limitada debido a que no se tienen registros de captura durante el período de veda y hasta hace poco solo se contaba con datos de organismos capturados por buceo que a lo máximo alcanzaban las dieciocho

brazas, se sabe que ocurren hembras ovígeras durante todo el año pero existe una época en la que la proporción de éstas se incrementa y esta época se presenta entre enero y julio. Los patrones espaciales de distribución de hembras ovígeras que muestran los cruceros de investigación son los siguientes: a) a una escala de fracciones de millas cuadradas se presentan varias agrupaciones de langostas a lo largo de formaciones rocosas de configuración variada y que en los datos de los cruceros se pone de manifiesto por las líneas de mayor densidad (Figura 2), y b) a escala de cientos de millas el número de cruceros resulta insuficiente para definir con nitidez un patrón espacial general, sin embargo mediante esta información es posible apreciar la presencia de formaciones rocosas que cubren grandes espacios (cordilleras o márgenes de terrazas) de fondo profundo, una de estas formaciones se presenta al sur oeste del arrecife Alacranes y otra al oeste del mismo arrecife. Los datos también muestran la presencia de langostas ovígeras en la mayor parte de las elevaciones arrecifales localizadas cerca del borde de la plataforma peninsular.

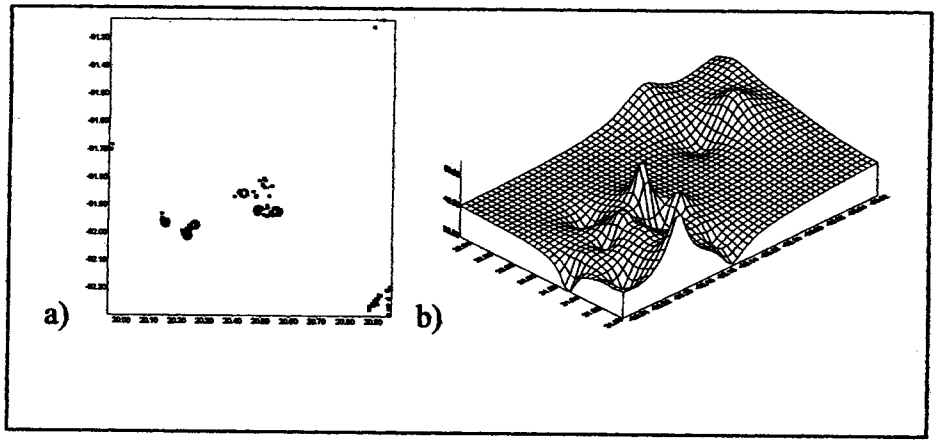

Figura 2. Grafico de distribución de concentraciones de langosta en escala de fracciones de milla cuadrada (crucero): a) Localización de los puntos de muestreo y b) interpolaciones de densidades

Distribución de la Langosta Espinosa — La distribución de la langosta espinosa *Panulirus argus* en la región del Caribe y sus alrededores, después del asentamientos de larvas, está fuertemente ligada a la distribución de hábitat con características requeridas por la langosta en sus diferentes estadios de crecimiento y a la disponibilidad de alimento. En este caso tanto la arquitectura como la extensión del hábitat resultan de gran importancia. La Plataforma de Yucatán dadas su características geológicas presenta áreas complejas en donde se pueden encontrar

los diferentes tipos de hábitat propicios para las diferentes etapas de crecimiento de esta especie. Hay áreas de asentamiento, y formaciones rocosas y coralinas de diferente extensión que proporcionan refugio a langostas de diferente tamaño. Se podría pensar en un esquema de distribución en parches dentro de los cuales las langostas encuentran sitios propicios para asentarse, alimentarse, crecer, refugiarse e incluso reproducirse. Algunos de los sitios con estas características son: el arrecife Alacranes, franjas costeras del oriente del estado de Yucatán de baja profundidad como la Reserva Municipal Actamchuleb (entre 2 y 3 m) en donde se pueden encontrar puerulus, juveniles, preadultos y adultos algunos de los cuales son hembras ovígeras, frente a las Coloradas en profundidades entre las 6 y las 7 brazas y del lado poniente al norte de Sisal en donde hay zonas con todos los ambientes requeridos por la langostas en áreas relativamente "reducidas" (Figura 1).

Ocurrencia de hembras ovígeras en el Caribe y en la Plataforma de Yucatán — Para el Caribe la reproducción de *Panulirus argus* se da durante todo el año, sin embargo hay algunos meses donde se presentan mayor número de langostas ovígeras. Hay reportes de otras pesquerías del Caribe sobre estos repuntes: en Cuba se reportan estos picos durante los meses de Marzo a Mayo y en el mes de Septiembre (Cruz y De león 1991), en las costa de Quintana Roo se presentan de Febrero a Julio (Ramírez 1996), en Turks y Caicos la proporción de hembras ovígeras es alta durante todos los meses del año sin embargo las más altas de éstas se reportan entre marzo y Agosto (Medley and Ninnez 1997), en Florida entre Abril y Septiembre (Lyons et al. 1981) y en Nicaragua las más altas se localizan en Marzo Junio y Septiembre (Castaño y Cadima (1993).

Aunque en Yucatán se tienen registros de langostas hembra ovígeras cerca de la costa, se ha detectado una mayor concentración de adultos en zonas arrecifales rocosas ubicadas al noroeste de la Península entre los 40 y 50 m de profundidad. Si bien no se han llevado a cabo cruceros de investigación en los meses de veda, se conoce a través de datos provenientes de los viajes de pesca y exploratorios que a finales de Enero y principios de Febrero empieza a incrementarse la presencia de ovígeras en la captura; de entrevistas con pescadores se sabe que hay más langostas en estas condiciones durante los meses de marzo a junio. Según la información colectada a través de los viajes de pesca y exploratorios se tiene que la presencia de ovígeras durante la temporada de pesca es más alta en los meses de Febrero y Julio (que son el último y el primero de la temporada), dentro de los cuales quedarían los meses de veda (Marzo-Junio) y Septiembre, patrón muy parecido al reportado para Cuba (Tabla1).

El Modelo

El Caribe tiene aguas con características oligotróficas, fuertes corrientes y reducidas plataformas continentales, es decir poco hábitat disponible. En estas condiciones la deriva larval de las langostas es quizá el mecanismo estratégico que ha permitido su sobrevivencia, pero además les ha brindado la posibilidad de una enorme dispersión. Las poblaciones de langosta dispersas en el Caribe

probablemente tienen una fuerte dependencia de aportes de larvas procedentes de otras poblaciones cercanas y en menor proporción de poblaciones distantes, así se explica la relativamente rápida recuperación de poblaciones devastadas por eventos como los huracanes, mareas rojas o la pesca. Las condiciones geológicas y oceanográficas prevalecientes en la península de Yucatán y las evidencias de ubicación de los núcleos poblacionales de aguas someras y aguas profundas así como los registros de localización de hembras ovígeras, sugieren que las larvas que alimentan las poblaciones locales de langosta provienen mayoritariamente de diferentes regiones del Caribe que nutren la corriente de Yucatán y principalmente de la plataforma peninsular de Yucatán al norte de Cozumel.

Tabla 1. Proporción de hembras, hembras ovígeras y hembras parchadas, calculadas de datos procedentes de cruceros realizados en la Plataforma Yucateca entre 1996 y 2002.

Mes	Año	Proporción de H.C.	Proporción de HO/ TH	Proporción HP/TH	H.P. + H.O.	Zona
Ago-Sept.	1996	0.56	0.05	Ninguna	0.05	Cayo Arcas
Sept-Oct.	1996	0.70	0.09	Ninguna	0.09	Triángulos y Banco Nuevo
Oct.-Nov.	1996	0.46	Ninguna	Ninguna	Ninguna	Alacranes y Sur de Alacranes
Nov.-Dic.	1996	0.53	0.02	Ninguna	0.02	Cayo Arcas
Feb.	1997	0.34	Ninguna	Ninguna	Ninguna	Alacranes y Bajos del Norte
Feb.	1999	0.52	0.01	0.42	0.43	Alacranes
Feb.	2000	0.38	0.38	0.53	0.91	Noreste Alacranes
Oct.	2000	0.53	0.01	0.02	0.03	Sureste Alacranes
Jul.	2001	0.26	0.16	0.09	0.25	Suroeste Alacranes
Feb.	2002	0.48	0.39	0.61	1.00	Suroeste Alacranes
Jul.	2002	0.39	0.26	0.01	0.27	Suroeste Alacranes
Sept.	2002	0.39	0.07	0.27	0.34	Alacranes

Una hipótesis alternativa que explica la ubicación de hembras ovígeras en la región central de la plataforma peninsular de Yucatán sería que las larvas que se producen localmente tienen períodos muy corto de asentamiento de larvas de tal manera que tanto la liberación de larvas como el asentamiento ocurrieran de manera simultanea en la región.

Los datos y la información existente en este momento permiten hipotetizar que existen dos períodos de asentamiento de larvas de langosta en la plataforma peninsular de Yucatán, el primero durante la temporada de nortes y el segundo durante los afloramientos de primavera verano. El asentamiento de las larvas

durante los nortes favorece el repoblamiento de áreas costeras durante los meses de invierno. En este régimen de vientos es de esperarse que las larvas que se producen en el norte de la plataforma peninsular constituyan un aporte significativo tanto de las zonas arrecifales situadas más al sur como de las áreas costeras, sin embargo los asentamientos en las formaciones arrecifales situadas en los bordes de la plataforma peninsular proceden de la deriva larval que entró al Golfo de México vía la corriente de Yucatán y los afloramientos de aguas profundas procedentes del canal de Yucatán. El afloramiento de aguas profundas del canal de Yucatán es el segundo evento que favorece el asentamiento de larvas debido a un incremento significativo en la productividad primaria que se traduce en alimento disponible. Este segundo asentamiento, de acuerdo a la dirección de las corrientes tiene lugar principalmente en las zonas arrecifales situadas más al norte, y las larvas en su mayoría son procedentes del mar Caribe. La única evidencia de dos períodos de asentamiento en las costas de Yucatán es la existencia de dos máximos en la captura por unidad de esfuerzo de langostas juveniles y adultas de tallas pequeñas que se capturan tanto en la laguna arrecifal del arrecife Alacranes como en la mayor parte de la costa de Yucatán, estos máximos en la captura por unidad de esfuerzo se presentan a principios de la temporada de pesca y a finales de diciembre y principios de enero.

En cuanto a la distribución espacial de las hembras ovígeras a escala de fracciones de milla cuadrada las langostas forman varias agrupaciones distribuidas de acuerdo a la conformación de los fondos, a una escala mayor las agrupaciones de hembras ovígeras se sitúan en las elevaciones arrecifales así como en cordilleras y orillas de formaciones rocosas situadas en aguas profundas y que aparentemente constituyen formaciones de una escala geológica.

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Análisis de la Abundancia del Pulpo Rojo *Octopus maya* en la Península de Yucatán

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RESUMEN

Se realizó una evaluación de la abundancia y disponibilidad pesquera del pulpo rojo *Octopus maya* para recomendar medidas apropiadas de administración del recurso. Para ello se efectuaron campañas de muestreos durante los meses de mayo a julio del 2002 en un área de muestreo total de 5,075 km^2. La zona de muestreo fue dividida en cinco estratos: (1) Champotón - Seybaplaya, (2) Campeche – Tenabo, (3) Isla Arenas – Celestún, (4) Telchac – Dzilam y (5) Rio Lagartos – El Cuyo. La estimación de la abundancia poblacional absoluta fue obtenida por medio del método de la distancia, cuya información se obtuvo a través de recorrer 191 transectos por medio de buceo autónomo. Asimismo, la disponibilidad del recurso para la pesca fue obtenida por medio del método tradicional de pesca usando el método de área barrida. En este último caso se realizaron 40 viajes de pesca dentro de las cinco zonas descritas. Los resultados obtenidos fueron los siguientes: (1) La mayor densidad de organismos y biomasa por kilómetro cuadrado fue localizada en el estado de Campeche, especialmente en la zona localizada entre Seybaplaya y la Cd. de Campeche. (2) Celestún fue la zona con mayor biomasa susceptible a ser pescada y (3) el análisis de las tallas de los organismos muestreados nos indicaron que existe diferencias espaciales y que un porcentaje de la población no es susceptible a ser capturada aún por el arte de pesca, esta fracción estará disponible durante los siguientes meses.

PALABRAS CLAVES: Yucatán Peninsula, *Octopus maya*, abundancia

Analysis of Red Octopus *Octopus maya* Abundance in Peninsula of Yucatan

Red Octopus *Octopus maya* abundance and its fishing availability assessment were realized to recommend an appropriate management measures. Sampling surveys were realized in May to July 2002, within a total sampling area of 5,075 km^2. It was divide in five strata: (1) Champotón – Seybaplaya,(2) Campeche –

Tenabo, (3)Isla Arenas – Celestún, (4) Telchac – Dzilam y (5)Rio Lagartos – El Cuyo. Population absolute abundance assessment was obtained by applying distance sampling method. this information was obtained to go through 191 lineal transects by scuba. Likewise relative abundance (fishing availability) was obtained by traditional fishing method ("garete" fishing) using swept area method. 40 fishing trips were realized in five described zones. The results were: 1) The most high density of organisms and biomass by square kilometer was locate in Campeche state, specially in the area between Seybaplaya y Campeche city. (2) Celestún was the zone with the most high fishing biomass and (3) analysis of the octopus sizes obtained indicated us that spatial differences exist and a percentage of population was not susceptible to fishing, this fraction will be available during next months.

KEY WORDS: Yucatán Peninsula, *Octopus maya*, distance sampling; abundance

INTRODUCCIÓN

El pulpo, es uno de los recursos más importantes de la Península de Yucatán, sus capturas han fluctuado durante los últimos cinco años, entre 14 y 20 mil t (Anónimo 2000a). La importancia socio–económica de la pesquería, ha hecho necesario realizar monitoreos continuos anuales a fin de contar con bases de datos que permitan determinar medidas de administración pesquera que tengan como objetivo una explotación sustentable del recurso (Anónimo 2000b).

La pesquería del pulpo en la península de Yucatán esta basada en dos especies: *Octopus maya* (Voss y Solís 1966) y *O. vulgaris*. De estas dos especies *O. maya* es la principal debido a que contribuye con el 80 % de la producción de la captura total del molusco en la región.

En el presente documento se describen los resultados obtenidos de los estudios realizados durante parte del período de veda del 2002, del pulpo rojo (O. maya), en la Península de Yucatán. Entre los cuales destacan como aspectos relevantes de la población: Patrones de distribución de la abundancia y su disponibilidad pesquera.

MÉTODOS

Estimación de la Biomasa

El área total de muestreo en la distribución del pulpo rojo, fue dividida en cinco estratos definidos por su ubicación geográfica y área de influencia de las principales flotas artesanales en la zona. Abarcó un área aproximada de 5,075 km^2 (Figura 1). Para cada estrato, las estaciones se eligieron y distribuyeron con base a un diseño sistemático con arranque aleatorio (Cochran 1980). En total se realizaron 191 transectos. En cada punto se recorrió a buceo autónomo un transecto lineal de 150 m, de acuerdo con la técnica sugerida por Buckland et al. (1993). Donde se registró la distancia perpendicular de cada pulpo observado a la línea de transecto, con apoyo de una cinta métrica de tela plástica, además de anotar cada uno de los realizados:

hora (entrada y salida), profundidad (m), tipos de substrato observados en el lecho marino, cobertura biológica, altura del buzo con respecto al fondo y, visibilidad (m). A cada pulpo observado y colectado se le midió la longitud del manto en mm, peso en gramos y se le identificó el sexo.

La información obtenida por buceo autónomo (distancias y tasas de encuentro) fue analizada por medio del Método de la Distancia (Buckland et al. 1993), mismo que permitió la evaluación de los diferentes modelos probabilísticos. Para el ajuste de la función de detección, se utilizó el programa Distance (v. 3.5)(Laake et al. 1998). Para detalles del método refiérase al documento sobre Análisis de la Abundancia de pulpos durante 2001 (página electrónica del INP: www.inp.semarnat.gob.mx).

Los modelos probados fueron: función de tasa de riesgo y normal media. El ajuste se realizó utilizando series de cosenos, polinomios ortogonales o polinomios de Hermite (Buckland y Turnock 1992). Cada ajuste se evaluó con base en la aplicación de diferentes criterios de información, tales como el de Akaike y la razón de verosimilitud. Este método permite estimar la densidad de pulpos por área y la abundancia absoluta de organismos en toda el área de distribución.

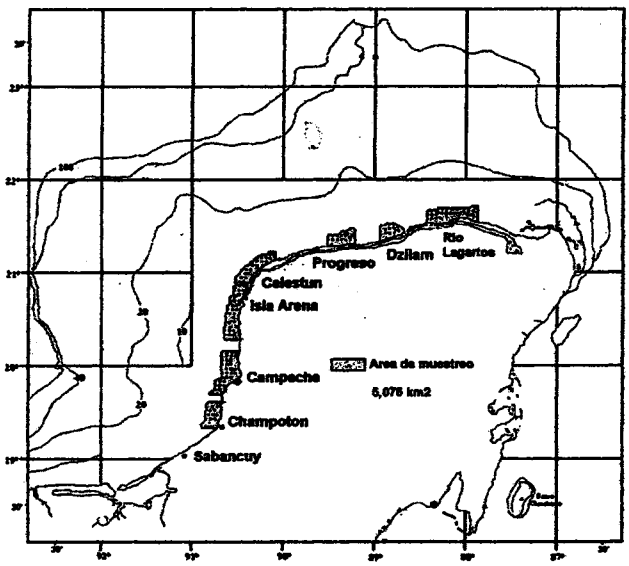

Figura 1. Área de distribución del pulpo rojo (*Octopus maya*) y zonas de muestreo en la Península de Yucatán

Estimación de la Biomasa Susceptible a la Pesca

Para determinar la biomasa susceptible a la pesca se aplicó el método de área barrida (Hernández et al. 2000), donde se utilizó el arte de pesca tradicional local denominado "gareteo" (Solis et al. 1997, Arreguín et al. 2000), el cual consiste en

dejar las embarcaciones a la deriva, inclinar el motor fuera de borda sobre la popa y soltar de diez a 12 líneas pulperas atadas a un costado de la lancha y a las varas de bambú (jimbas), estas últimas con una longitud de influencia de 15 a 17 m, utilizando jaiba azul *Callinectes* sp o maaxkil o cangrejo araña *Libinia dubia* como carnada, (Figura 2). En cada una de estas operaciones se registró la ubicación, con ayuda de un GPS (geoposicionador por satélite), aproximadamente cada 100 m. Con esta información se estimó la distancia recorrida (Sparre y Venema 1989).
Con la distancia estimada, se calculó el área barrida con la siguiente fórmula:

$$A = d\,W$$

Donde: A, es el área barrida, d, es la distancia recorrida y W, es la longitud medida entre cada extremo de las jimbas de proa y popa de la lancha.

En cada garete se anotó : Posición geográfica y número de pulpos capturados. A estos últimos se le tomó : la longitud del manto (mm), peso (g), sexo y estado de madurez de la gónada (ovario) de las hembras. Se anotó el número y peso total de aquellos ejemplares que no alcanzaron a ser muestreados, cuando las capturas obtenidas fueron muy grandes y no fue posible realizar los muestreos biológicos del total de las mismas

Para el análisis de lo anterior, se empleó la información generada en 40 viajes en total a bordo de embarcaciones artesanales, para los cinco estratos.

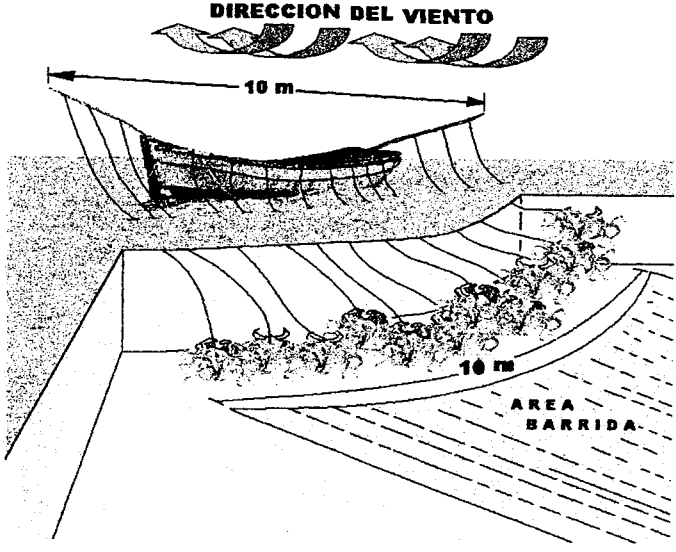

Figura 2. Esquema de la maniobra de pesca experimental "al garete"

RESULTADOS

Estimación de la Biomasa

Para las estimaciones de la abundancia, los mejores modelos para las diferentes zonas se encuentran en la Tabla 1.

Tabla 1. Resultados de los modelos seleccionados para cada región. Donde: L, Longitud total de transectos; n/L, número de observaciones por transecto; AIC, criterio de información de Aikake; f(0), función de densidad a la distancia cero y C.V., coeficiente de variación.

Región	L	n/L	AIC	f(0)	Modelo	C.V.
Champotón - Seybaplaya	3300	0.0088	39.95	0.794	normal media/Coseno	30.71
Campeche-Tenabo	4950	0.0129	150.13	0.472	normal media/Coseno	24.98
Isla Arena-Celestún	8550	0.0060	151.43	0.368	normal media/Coseno	10.32
Progreso-Dzilam	4950	0.0057	77.39	0.417	normal media/Coseno	27.09
Río Lagartos-El Cuyo	5250	0.0036	61.34	0.356	Riesgo/ Cosine	46.42

La distribución de los valores observados de tasas de encuentro (número de pulpos por transecto recorrido, n/L), nos muestra una mayor cantidad de pulpos en las costas de Campeche, principalmente entre los puertos de Seybaplaya y Campeche (Figura 3). En la zona oriental de la Península, por su parte, también se observa una concentración importante de pulpos, aunque menor a la anterior, principalmente frente a los puertos de Telchac y Río Lagartos.

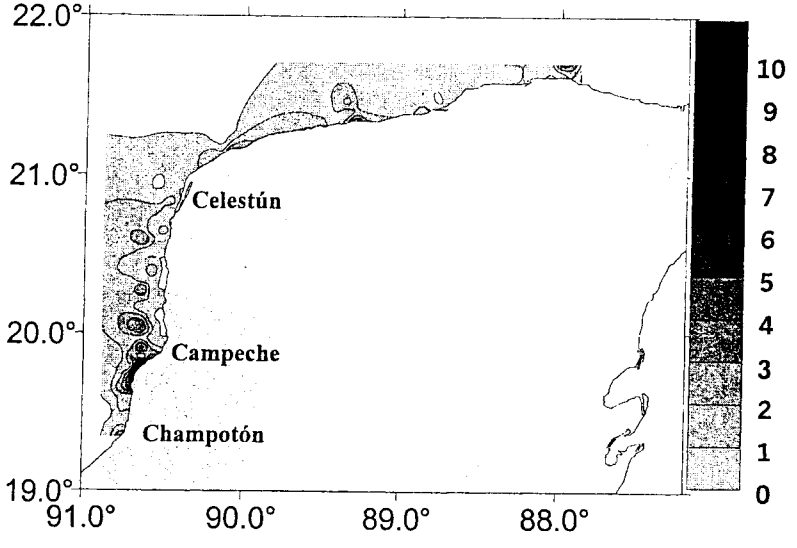

Figura 3. Patrones Espaciales de las Tasas de Encuentro de pulpo (n/L).

En el área o estrato Celestún e Isla Arena se observa una repartición heterogénea de pulpos. Frente a Isla Arena es donde se observan dos núcleos importantes de pulpos. Uno cercano a la costa y el otro más alejado a profundidades medias de 5 brazas. En este lugar abundan fondos mixtos con disponibilidad de refugios para el pulpo. Frente a Celestún, los fondos son también propicios para el establecimiento de individuos de pulpo rojo, sin embargo, en los transectos realizados frente a ese puerto se detectaron una menor cantidad de organismos. En la Tabla 2 se presentan las estimaciones de densidad y biomasa por km^2 y por región en la Península de Yucatán. Las estimaciones mostraron que la población está heterogéneamente distribuida a lo largo de la costa.

Tabla 2. Estimación de numero de pulpos y biomasa por km^2 de las diferentes estratos.

Estado	Región	Densidad (n/Km^2)	Peso promedio (Kg)	kg/km^2
Campeche	Champoton-Seybaplaya	3490.7	0.666	2325
Campeche	Campeche-Tenabo	3050.6	0.575	1754
Campeche	Isla Arena-Celestún	1096.2	1.088	1193
Yucatán	Progreso-Dzilam	1178.3	0.510	601
Yucatán	Río Lagartos-El Cuyo	644.82	1.071	691

Estimación de la Biomasa Susceptible a la Pesca

La captura promedio por viaje, por embarcación, en las cinco zonas estudiadas fue de 11.5 kg. por viaje de duración aproximada de cuatro horas.

Según puede observarse los valores más altos de densidad (organismos/km^2) se ubicaron en la zona Campeche y Tenabo, Campeche (Tabla 3). El peso promedio de los organismos y la biomasa de los organismos susceptibles a la pesca fue mayor en el área de Isla Arenas, Campeche y Celestún, Yucatán (Figura 4).

Tabla 3. Estimación de numero de pulpos y biomasa susceptibles a la pesca por km^2 de las diferentes estratos.

Estado	Región	n/km	Peso promedio (Kg)	kg capturable/km^2
Campeche	Champoton-Seybaplaya	252.28	0.666	168
Campeche	Campeche-Tenabo	369.45	0.575	212
Campeche	Isla Arena-Celestún	271.29	1.088	295
Yucatán	Progreso-Dzilam	189.43	0.510	97
Yucatán	Río Lagartos-El Cuyo	113.21	1.071	121

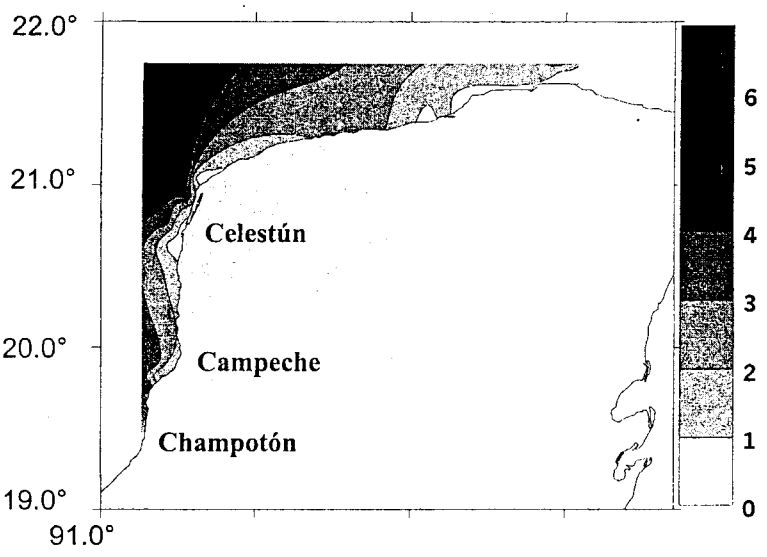

Figura 4. Distribución de biomasa susceptible a la pesca de pulpo rojo (*O. maya*) durante julio del 2002. (kg/km^2 X 100)

Comparando las tallas de los organismos capturados con los diferentes métodos de muestreo estudiados, se apreció que las mayores se ubican en los muestreos realizados con el método de pesca "al garete". Esto nos indicó la selectividad del arte de pesca (garete), además de haberse detectado que aproximadamente el 50 % de la población que no era susceptible a ser pescada en el momento de realizar las campañas de muestreo. (Figura 5).

DISCUSIONES

La existencia de zonas de mayores densidades de pulpos nos indica, posiblemente, la calidad del habitat. Aunque en la zona frente a Celestún, a pesar de tener fondos propicios para el establecimientos de individuos de pulpo rojo, se detectaron pequeñas cantidades de organismos, lo cual se deba posiblemente, a la práctica de la pesca ilícita durante el periodo de veda.

Las menores concentraciones de pulpo detectadas en Yucatán posiblemente sea consecuencia de la aparición de un fenómeno de marea roja en agosto del 2001 y que abarcó gran parte de la zona oeste del litoral de Yucatán. Aunque también existe la posibilidad de que el caso se explique con base a que el esfuerzo que se aplica en esa área sea mucho mayor que el que se ejerce en Campeche. Otro factor importante es que las tallas encontradas en las costas de Yucatán fueron mas pequeñas, por lo que se podría esperar que su detección en el campo sea mas difícil, teniendo como consecuencia una subestimación de la biomasa.

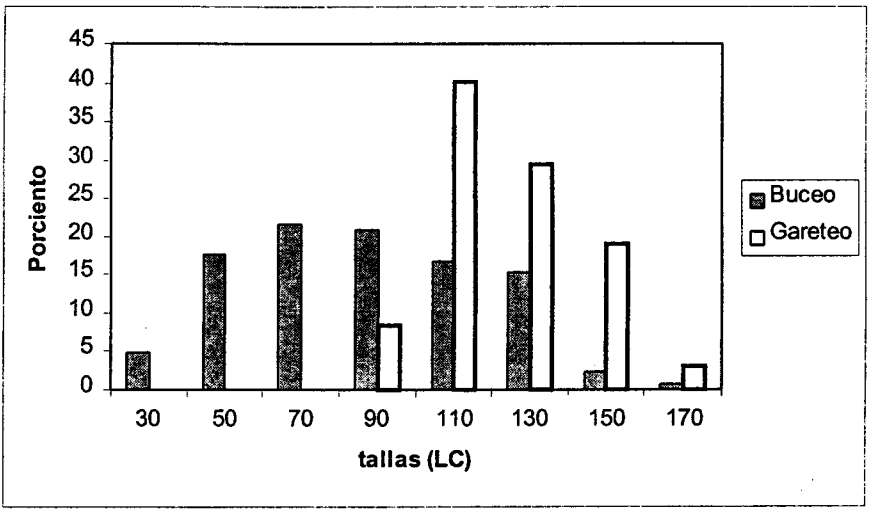

Figura 5. Distribución de tallas de pulpo rojo obtenidas con los dos métodos de muestreo.

En cuanto a la biomasa a ser pescada, la zona de Isla Arena – Celestún, resultó con los valores mas altos, esto a pesar de no contar altos valores de densidad. Esta situación es debida a que el peso promedio de los organismos era mayor que en otras zonas. Por lo tanto, se esperaría que al inicio de temporada los rendimientos sean mejores en el área de Isla Arenas- Celestún.

Es importante destacar, sin embargo, que la comparación de las tallas de los organismos atrapados con los diferentes métodos utilizados nos indica que existía una porción de la población que no era susceptible a ser capturada por su tamaño en el momento del muestreo, por lo que se podría esperar un repunte de las capturas principalmente en las zonas de Yucatán.

Las diferencias de tallas de los organismos en las diferentes áreas muestreadas nos indica diferencias espaciales y temporales propias del reclutamiento y de la reproducción que presenta esta especie a lo largo de la península de Yucatán.

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La Pesquería de la Almeja *Mercenaria* sp. en México

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RESUMEN

Se realizaron censos pesqueros socioeconómicos durante 1998, 1999 y 2002 donde se entrevistó a pescadores, compradores, personal del gobierno y gente local, con el objetivo de reportar las áreas donde se localiza la almeja *Mercenaria* sp., además se describen algunos aspectos de la pesquería, como: equipos y métodos de captura, horas de trabajo y comercialización. Se encontró que en la mayoría de las áreas visitadas, la extracción es esporádica y su consumo es doméstica, únicamente en la Laguna del Carmen, Tabasco existe una pesca comercial incipiente, aunque existen pequeñas extracciones en Tamaulipas y El Bellote, Tabasco. Las capturas en la Laguna del Carmen, Tabasco de 1995 a 1998 fueron de alrededor de las siete toneladas. En esta zona existen 20 pescadores de almeja, todos ellos hombres, cuyas edades fluctúan entre 15 y 20 años. Se transportan a las áreas de captura en lanchas de 7.5 metros de longitud. El método de captura es manual y mediante tacto con los pies a una profundidad de 1 y 1.20 m. Cada pescador extrae de 200 a 250 almejas en una jornada de cuatro horas. El precio pagado por almeja a los pescadores varía dependiendo del tamaño ($ 0.40 a $ 0.80 pesos por pieza) y el precio de venta en los mercados va desde $1.50 a $ 2.00 pesos. Los lugares donde se comercializa son: la capital, diversas ciudades y poblaciones del país como son Oaxaca, Coatzacoalcos, Veracruz y Paraíso. La pesquería de esta almeja se encuentra subdesarrollada debido a la poca demanda local. Existe poca información sobre el potencial de los bancos de almeja, así como su biología y ecología, por lo tanto, se recomienda realizar estudios para conocer la disponibilidad del recurso en las diferentes zonas para recomendar futuras medidas de administración para su extracción.

PALABRAS CLAVES: Almeja, *Mercenaria* sp., la pesquería, México

Fishery of the Clam *Mercenaria* sp. in Mexico

Surveys were carried out during 1998, 1999 y 2002 when interviews were performed to fishermen, buyers, government officers, and local people. The main objective was to describe the existent areas where the clam *Mercenaria* sp. is located and some important fishing issues, such as fishing gears, harvesting methods, labor

periods and marketing. In most areas, clam harvest is uneven and has domestic consumption, only in Carmen lagoon, Tabasco an incipient commercial fishing exists, although small extractions exist in Tamaulipas and El Bellote, Tabasco. Clam production in Carmen Lagoon, Tabasco, from 1995 to 1998 was around seven tons. In this area there are 20 clam fishers, all men, ranging in age between 15 and 20 years. They attend the harvest areas using boats of 7.5 meters of length. The harvest method is manual, and it comprises "feet touching" to a depth of 1 to 1.20 m. Each fisherman extracts 200 to 250 clams in one single trip of four hours. The paid price by clam depends on size ($ 0.40 to $ 0.80 Mexican pesos by piece) and the prices of sale in the markets are $1.50 to $ 2.00 pesos. The clam markets are Mexico City and other cities and towns, such as Oaxaca, Coatzacoalcos, Veracruz and Paraiso. Due to the demand on such a small-scale fishery, further development is likely. However, little information about the potential of clam banks is available, as well as their biology and ecology. Therefore, it is recommended to carry out studies to know the resource availability in the different zones to recommend future management measures for extraction.

KEY WORDS: Hardshell clam , *Mercenaria* sp., fishery, Mexico

INTRODUCCIÓN

En México, en su litoral del Golfo de México, se presentan posiblemente dos especies de la almeja, *Mercenaria, M. Campechiensis* y *M. Mercenaria*. La primera tiene una mayor distribución en el litoral mexicano según trabajos realizados (García -Cubas 1981, Antolí y García-Cubas 1985, García-Cubas y Reguero, Reguero et al. 1991b, Baqueiro 1997), y la segunda posiblemente solo en la parte mas norteña del país: Laguna Madre, Tamaulipas.

Debido a que este tipo de almeja representa una pesquería importante en los Estados Unidos, es posible esperar que en México se presente como una actividad potencial en el futuro. Para esto es necesario que se tengan bases científicas que permitan su adecuada explotación.

Existe muy poca información sobre la pesquería y biología de la almeja Mercenaria sp. en México. Por lo tanto en este trabajo se pretende describir la pesquería de la almeja *Mercenaria* sp en México. La mayoría de la información fue obtenida por medio de visitas a campo a los lugares donde este organismo es capturado, además de entrevistas a personas involucradas en la actividad.

MÉTODOS

Durante 1998 y 1999, se realizaron visitas de prospección a diferentes zonas costeras del Golfo de México, como lo fueron: Isla Arenas y Isla Aguada en Campeche, Paraíso y Sánchez Magallanes en Tabasco, Coatzacoalcos, Alvarado, Veracruz, Tampamachoco y Tuxpan en Veracruz, Tampico, Carboneras y Mezquital en Tamaulipas donde se realizaron censos pesqueros socioeconómicos y se

entrevistaron a personas involucradas en la pesquería de la almeja como lo son: pescadores, compradores, personal del gobierno, así como a la gente local, con esto, se obtuvo conocimiento de algunos aspectos de la pesquería, sus formas de comercialización y consumo. Además se revisó la literatura y se consultó las estadísticas pesqueras en las diferentes oficinas de pesca.

RESULTADOS

Estadísticas de Capturas de *Mercenaria* sp.

La captura reportadas por el gobierno mexicano no separan las diferentes clases de almejas por lo que los reportes de las mismas vienen mezcladas.

En 1997. Las extracciones de almejas en México fueron de 8,475 ton métricas. Las costas del Océano Pacífico contribuyeron con 6,075 ton métricas y en el Golfo de México con 866 t. En las costas del Golfo de México, el estado con mayor producción fue Veracruz con 834 t, Tamaulipas con 15 t y Tabasco con 6 t. (Anónimo 1998).

Las producciones de Veracruz y Tamaulipas, están constituidas principalmente por *Rangia* sp., en cuanto a Tabasco la producción reportada es de M. *campechiensis*, la cual es extraída de la Laguna del Carmen frente a Sánchez Magallanes.

Lugares Donde se Encuentran las Almejas

La almeja *Mercenaria* sp. esta presente en costas y lagunas con salinidades parecidas a la marina (Figure 1). En el caso de *M. Campechiensis*, en la Laguna de Términos, su distribución es muy restringida y es localizada en los Bajos de Punta Gorda (García-Cubas 1981). Otras lagunas donde la literatura ha reportado la presencia de esta almeja son las lagunas del Carmen, donde se extrae a nivel comercial, Tupilco y Tampamachoco. (Antolí y García-Cubas 1985, García-Cubas y Reguero Reguero et al. 1991b).

Según estudios y el resultado de las visitas a esos lugares, en las lagunas de Alvarado, Pueblo Viejo y Camaronera no se encuentran *Mercenaria* sp. (Reguero y García-Cubas 1989, 1991a, 1993).

Estos debido a la salinidad presente en las lagunas que presentan, la cual es baja. En la Laguna Madre, esta almeja se localiza en Carboneras, en la zona de la Pesca hasta Boca Santa Isabel, aunque se encuentra presente en casi toda la laguna

Los Pescadores

El número de pescadores varia dependiendo del periodo del año, ya que ellos combinan la captura de almeja con los de otras especies.

Los pescadores de almeja son todos hombres con bajos ingresos. En Laguna del Carmen, Tabasco hay alrededor de 20 pescadores cuyas edades flutuán entre los 15 y 20 años, aunque existe algunos con mas de 40 años. En Laguna Madre existen ocho pescadores y cuyas edades estan entre los 20 y 30 años (Cruz Jiménez 2002).

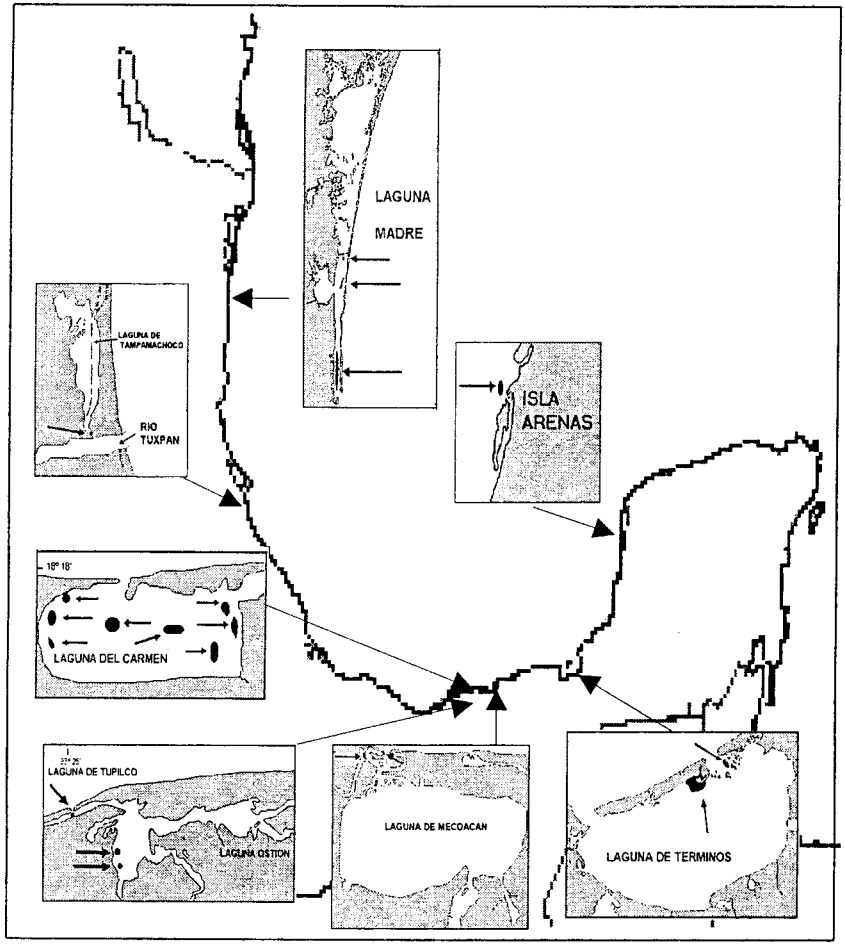

Figura 1. Pescadores extrayendo almejas en Laguna del Carmen, Tabasco, México.

Métodos de Captura

Esta almeja es pescada solo en lugares específicos a nivel comercial, en la mayoría de los lugares se extrae de manera esporádica y domestica, como ocurre en la Laguna de Término, Isla Arenas, Campeche y laguna Madre Tamaulipas.
El lugar donde se extrae de manera importante es: La Laguna del Carmen Tabasco.

Los pescadores pescan la almeja por medio del tacto con los pies, pero también es pescada ocasionalmente con rastrillos por los pescadores de ostión. En la laguna

del Carmen y Laguna Madre, la principal forma de captura es por medio del tacto. En laguna del Carmen, se colocan en los pies una especie de botas hechas con retazos de telas como manera de protección para evitar cortaduras provocadas por las conchas de ostión, además algunos usan guantes y visores.

Las almejas son colocadas sobre recipientes de plásticos con flotadores hechos con envases vacíos de refresco (Figura 2).

Cuando son las crecientes de los ríos generalmente en los meses de octubre a diciembre los periodos de pesca disminuyen debido a que el nivel de la laguna aumenta.

Figure 2. Pescador con caja con flotadores hechos de envases de refrescos.

Los pescadores se transportan al área de captura por medio de embarcaciones de fibra de vidrio de 7.6 metros con motores fuera de borda de 15 HP.

Los pescadores capturan aproximadamente de 200 a 250 almejas por día, la captura diaria depende de la demanda que exista del producto. La captura se realiza de manera diaria y generalmente trabajan 4 horas diarias de 10 a.m. a 14 p.m.

Mercado y Comercialización.

El consumo de la almeja es muy limitado en la parte sur de México, La pesca de la laguna del Carmen se empezó a registrar de manera comercial a partir de 1994 y es comercializada principalmente fuera del estado, pequeñas cantidades se consumen en restaurantes cercanos a Paraíso Tabasco, otra pequeña cantidad a Coatzacoalcos y Villahermosa. Pero la mayoría de la producción se va al estado de Oaxaca y México D. F:

La almeja es vendida dependiendo del comprador, si es por kilo esta es vendida a 4.00 pesos, de forma individual su precio varía dependiendo del tamaño que va de 0.40 a .0.60 pesos. Una almeja de .40 centavos tiene un tamaño de 60 mm de longitud de concha y una de 60 de 80 mm .

En el mercado municipal de Coatzacoalcos, Veracruz el precio de las almejas varia entre 1 a 2 pesos dependiendo del tamaño, estas almejas provienen principalmente de la laguna del Carmen de Tabasco, aunque esporádicamente se comercializa también almejas provenientes de la laguna de Ostión, Veracruz. Esta misma almeja se vende en el mercado de mariscos de Villahermosa, Tabasco en 2 pesos (aunque su venta es muy limitada).

En un restaurante de El bellote Tabasco cerca de Paraíso Tabasco, la cual compra aproximadamente 3,000 almejas a la semana a un precio de 50 centavos. El cóctel de almeja conteniendo aproximadamente 20 almejas es vendido a 25 pesos, otros platillos como la almeja al vapor y ahumada con aproximadamente 16 almejas es vendida a 20 pesos.

Para evitar que la almeja muera al no venderse, esta es colocada en sacos en una laguna frente a el restaurante al abrir este y nuevamente son guardadas cuando este cierra con esta maniobra evitan que se descompongan las almejas.

Formas de Consumo Local.

Los pescadores de ostión generalmente sacan una pequeña cantidad de almejas que son consumidas por ellos mismos. Los pescadores que se dedican a la extracción de la almeja generalmente comen almejas dos veces por semana.

Las almejas son preparadas de muchas formas:

i) En cocktail, las cuales son cocidas y comidas con limón, cebolla, cilantro,
ii) Cocidas al vapor con jugo de limón y cebolla kepchup y chile
iii) Ahumadas o cocidas sobre hojas secas de coco,
iv) En sopa de mariscos con pescado, ostión, jaibas (ver foto) , con jugo de tomate.

Intentos de Cultivo

Los intentos del cultivo de esta especie son incipientes, actualmente se encuentra en fase experimental para la producción de semillas.

La finalidad del cultivo es de tener una fuente segura de producto a través del tiempo ya que existen compañías enlatadoras de sopas que se interesan en comprar la producción ya que esta actualmente se importa (Baqueiro com. pers.).

DISCUSIÓN

Actualmente la explotación de las almejas en general en la costa este de México se encuentra subexplotada (con excepción de *Rangia* sp.), esto debido a que no existe demanda por el consumo de estos organismos. Además existe poca información acerca de los bancos existentes de *Mercenaria* sp en México, así como de su biología y ecología. Por lo tanto es necesario dar inicio a una serie de trabajos enfocados a estos rubros, que tengan como finalidad fomentar la explotación sustentable de esta almeja como un recurso alternativo a las pesquerías tradicionales.

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Densidad, Distribución Poblacional y Patrón de Actividad del Cangrejo Fantasma (*Ocypode quadrata*) en Montepío, Veracruz, México

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RESUMEN

El cangrejo fantasma (*Ocypode quadrata*) es muy abundante en las playas mexicanas y en el área de Monte Pío se usa como carnada para la pesca. Existen pocos trabajos sobre comportamiento y densidad para esta especie. Nuestro objetivo es calcular la densidad y distribución poblacional del cangrejo fantasma en un playa del Golfo de México, así como describir algunos parámetros conductuales y relacionarlos con variables ambientales en la época seca. Para lograr estos objetivos calculamos en primer término el área mínima de muestreo para estimar la densidad poblacional, tipo de distribución, distribución por tallas, patrón de actividad y repertorio conductual. El área de estudio esta localizada en La Reserva de los Tuxtlas y abarca un área de 2.8 km paralelos por 30 m perpendiculares a la línea de costa. Para establecer el área mínima de muestreo se probaron cuadrantes de diferentes tamaños desde 0.25 hasta 25 metros cuadrados que fueron trazados sistemáticamente a lo largo de la playa con una separación de 100 m, contando los hoyos habitados contenidos en cada cuadrante. Este procedimiento se siguió durante las horas de actividad de los cangrejos. El análisis dio como resultado un cuadrante de nueve metros cuadrados como el área mínima de muestreo. El horario de actividad de los cangrejos se estimó a partir de 66 horas de observación cubriendo toda la franja horaria diaria. Durante los meses de muestreo el cangrejo fantasma mostró una actividad de dos periodos en el transcurso del día para ésta área, que fueron de 9:00 a 14:00 horas y de las 22:00 a 24:00 horas. Los resultados mostraron que los cangrejos se distribuyen preferentemente en zonas húmedas y de manera agregada y que la distribución por tallas es al azar. En lugares donde el efecto del oleaje es fuerte o la arena esta completamente seca, prácticamente no hay cangrejos. A partir de grabaciones digitales, se elaboró el repertorio de conductas de la especie.

PALABRAS CLAVES: Cangrejo fantasma, conducta, ecología.

Population Density, Distribution, and Activity Pattern of the Ghost Crab (*Ocypode quadrata*) in Montepío, Veracruz, Mexico

The ghost crab (*Ocypode quadrata*) is abundant in the beaches of Mexico and in the area of Monte Pío is used as bait to capture fishes. Few works on the behavior of this species have been done, and their density in this region of Mexico is unknown. Our objective was to determine population density and to observe the crab's behavior. It's supposed that an increase in the population density will increase the number of inter-individual encounters producing different responses as a function of the participant sizes. To test this hypothesis we calculated in first instance the minimum quadrant size to estimate the crab's population density, size distribution, activity budgets, and behavioral repertoire. The study area was located within the Tuxtlas Reserve and the beach is 2.8 km long by 30 m width. In order to establish the minimum sampling area, different square sampling areas ranging from 0.25 to 25 square meters along the beach separated every 100 m were used for counting the inhabited holes in each quadrant. This procedure was carried out along the crabs daily activity hours. The analysis of these samplings resulted in a square of nine square meters as the minimum sampling area. The activity time for crabs was estimated based on 66 observation covering 24 hours observations. During the sampling months, the ghost crab had an activity distributed in two periods per day between 9:00 to 14:00 hrs and between 22:00 to 24:00 hrs. Results indicate that the distribution of crabs was aggregated in areas where the sand is humid, and that size class dispersion is random. Areas with high influence of ocean waves, or completely dry areas, were not significantly used by crabs. Based on digital video recording we elaborated on the behavioral repertoire of the crab.

KEY WORDS: Behavior, ecology, ghost-crab.

INTRODUCCIÓN

La actividad antropogénica sobre playas arenosas es cada vez mayor, por lo que la presencia de organismos que habitan en ellas se ha visto disminuida. El cangrejo fantasma (*Ocypode quadrata*) es uno de ellos, y se distribuye en el Atlántico Oeste desde el norte de las Carolinas hasta el Brasil, pasando por zonas templadas, subtropicales hasta tropicales (Brown y McLachlan 1990). Esta especie ha presentado una disminución en su densidad poblacional, en playas perturbadas debido a construcción de edificios y caminos, lo que ha ocasionado un deterioro ecológico difícil de restaurar (Fisher y Tevesz 1979, Barros 2001). Los cangrejos fantasma es importante ecológicamente al eliminar detritus orgánicos y participar en la transferencia de energía entre niveles tróficos (Wolcott 1978, Alberto y Fontoura 1999). El conocimiento y comprensión de aspectos conductuales y ecológicos de estos cangrejos, es indispensable en el planteamiento de estrategias de manejo que

ayuden a disminuir el deterioro ecológico en las playas y por lo tanto permitan proteger a ésta y otras especies.

Los cangrejos fantasma son habitantes importantes en las playas, ya que pasan la mayor parte de su vida en la arena, aunque regresan al mar varias veces al día para mantener sus branquias siempre húmedas y poder respirar. Estos cangrejos excavan en la arena formando un agujero, que es individual y que usan como madriguera. Durante éste proceso, remueven el sustrato permitiendo la aireación y absorción de nutrientes, lo que favorecerá el crecimiento de los pastos intersticiales, importantes como refugio de larvas de ésta y otras especies. Adicionalmente forman parte de la red trófica. Se alimentan de microalgas, detritus, de otros cangrejos y de huevos de tortuga, y son depredados por otros cangrejos de mayor tamaño, peces, aves y mamíferos (Backwell et al. 1999).

Los cangrejos fantasma presentan una actividad básicamente nocturna, aunque los juveniles pueden estar activos durante el día para evitar la depredación por sus congéneres adultos (Strachan et al. 1999, Fisher y Tevesz 1979). Por otra parte también se ha observado que los animales con diferente grado de madurez habitan distintas zonas de la playa, estando los animales de mayor talla cerca de la duna (Fisher y Tevesz 1979). Este trabajo aborda parámetros poblacionales locales del cangrejo fantasma e intenta determinar algunos aspectos de su conducta relativos a la topografía y distribución.

RESULTADOS

El trabajo se realizó en Montepío, una colonia del Municipio de San Andrés Tuxtla dentro de la Reserva de la Biosfera de Los Tuxtlas, Veracruz, México en una playa con posición geográfica de 95° 6' 02" W 18° 39' 02" N y 95° 6' 53" W 18° 39' 11" N (Figura 1).

Densidad Poblacional

Para valorar la densidad poblacional se determinó en primer lugar el tamaño del cuadrante mínimo óptimo de muestreo. El método consistió en la elaboración de una serie de cuadrantes concéntricos cuya superficie iba desde los 0.25 m^2 hasta los 25 m^2 (Manly 1992, Krebs 1998). Para evitar sesgos se diferenciaron en la anchura de la playa zonas de acuerdo al grado de humedad de la arena. Distinguimos una zona extremadamente húmeda próxima al mar (zona 3), una zona de humedad aún presente pero no tan acusada que se situaba a continuación de la anterior (zona 2) y una zona seca que se extendía desde ésta hasta la duna (zona 1). El análisis de las desviaciones estándar de las diferentes áreas estandarizadas a un metro cuadrado, estableció como tamaño óptimo el cuadrante de 9 m^2. Se calculó que debían realizarse 15 cuadrantes aleatoriamente distribuidos para conocer la densidad poblacional del cangrejo fantasma en el lugar de estudio con un error del 5 %. La cifra de individuos se estimó en 85714.2 (Figura 2).

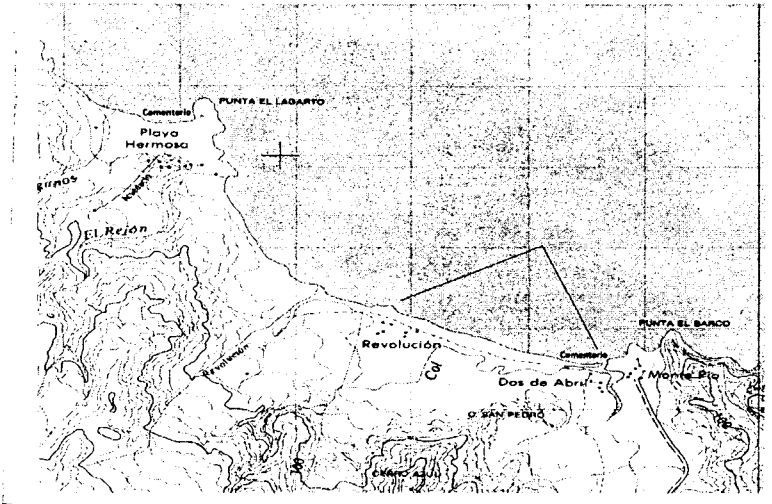

Figura 1. Ubicación geográfica de la zona de estudio Montepío, Veracruz en el Golfo de México

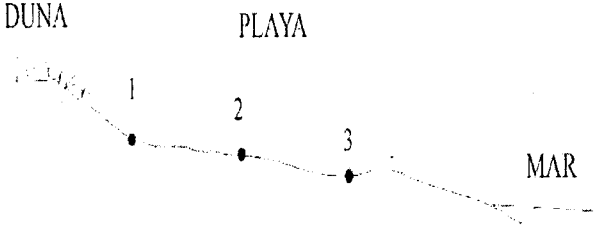

Figura 2. Perfil de la playa desde la duna al mar, ubicando los puntos de muestreo de los cuadrantes concéntricos.

Distribución Poblacional

Este parámetro se determinó mediante el establecimiento de dos cuadrantes de 270 m^2 (15 x 18 m) ubicados en zonas húmedas de diferente densidad poblacional. El conteo de hoyos se realizó en cada metro cuadrado dentro de ésta área, dando como resultado para el primer cuadrante 125 hoyos y para el segundo 238 hoyos. A pesar de la continuidad de la playa, la densidad de cangrejos fluctuaba a lo largo de ésta por parámetros que aún nos son desconocidos. La fluctuación nos permitía delimitar claramente dos zonas, en las cuales se establecieron los dos cuadrantes. Ambos abarcaron la distribución total de hoyos en el punto de muestreo. El análisis gráfico de ambos cuadrantes pone claramente de manifiesto la existencia de una distribución agregada de la población con una mayor concentración de individuos en las zonas próximas al mar (Figura 3a y 3b).

Adicionalmente se tomaron medidas del diámetro de los hoyos, las cuales están directamente relacionadas con la talla del cangrejo (Schober y Christy 1993, Alberto y Fontoura 1999), en la zona adyacente al mar. La presencia de una amplia variedad de diámetros sugiere que al menos en esta parte de la playa no existe un grupo de edad dominante, ajustándose bastante a una curva normal (Figura 4a y 4b).

Actividad Diaria

Se muestreó de modo sistemático la actividad de los cangrejos para determinar sus picos a lo largo del día. Se realizó un conteo de los animales que se hallaban fuera del hoyo completamente en un cuadrante de 9 m^2 situado en la zona de máxima concentración de hoyos, a lo largo de ciclos de 24 horas. Encontrando dos periodos de actividad por día, uno por la mañana de 9:00 a 14:00 hrs. y el segundo por la noche de las 22:00 a las 24:00 hrs. Puesto que uno de los principales parámetros que se relacionan en la literatura con la actividad de los cangrejos es la temperatura, también se registró ésta al tiempo de los conteos de actividad para la época secas (Figura 5).

Conducta

A partir de grabaciones se estableció un repertorio básico de comportamiento del cangrejo fantasma

Limpieza del Hoyo

i) Cangrejo saca arena del hoyo con las patas locomotoras y el quelípedo de un solo lado arrastrando la masa de arena de manera lateral
ii) Cangrejo saca arena del hoyo con las patas locomotoras y el quelípedo de un solo lado cargando la masa de arena de manera lateral
iii) Cangrejo saca arena del hoyo con las patas locomotoras y el quelípedo de un solo lado arrastrando la masa de arena de manera lateral, inclinando el pedúnculo ocular hacia el extremo que no lleva la carga.
iv) Cangrejo saca arena del hoyo con las patas locomotoras y el quelípedo de un solo lado carga la masa de arena de manera lateral acumulándola en un solo lado del hoyo.

v) Cangrejo saca arena del hoyo con las patas locomotoras y el quelípedo de un solo lado carga la masa de arena de manera lateral y fuera del hoyo la arrastra alejándola de la entrada.

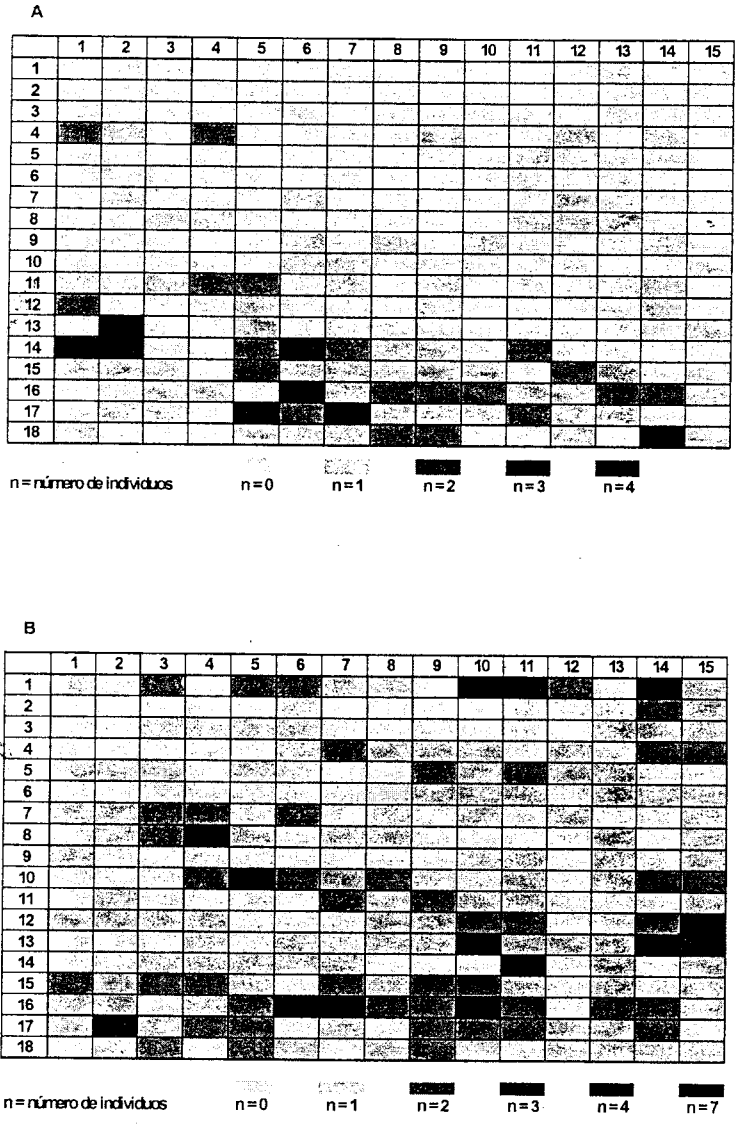

Figura 3. a) Distribución espacial del cangrejo fantasma en un área de 270 m^2 con un total de 125 hoyos. b) Distribución espacial del cangrejo fantasma en un área de 270 m^2 con un total de 238 hoyos.

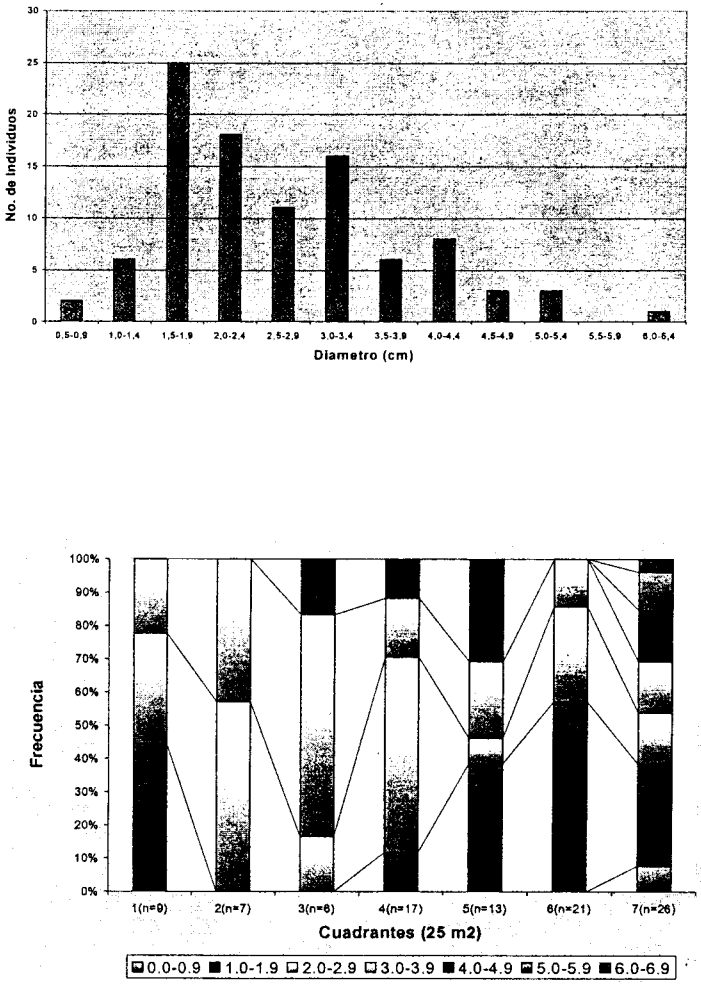

Figura 4. a) Distribución de los diámetros de 99 hoyos en la zona húmeda de la playa. b) Frecuencia de los diferentes diámetros de hoyos en cada cuadrante de muestreo.

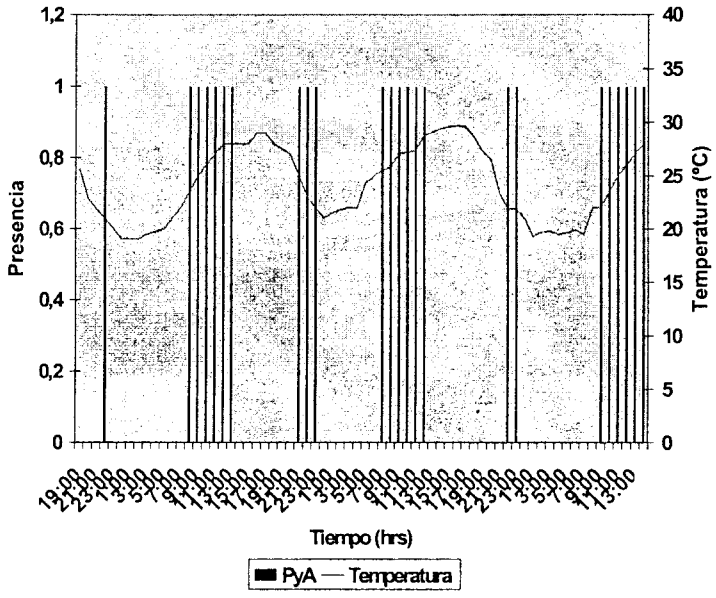

Figura 5. Relación de los periodos de actividad y la temperatura en tres ciclos de 24 hrs. para la época de secas.

Posterior a la Limpieza

i) Cangrejo permanece al borde del hoyo con la mitad del cuerpo hacia fuera sin hacer movimientos.
ii) Cangrejo permanece al borde del hoyo con la mitad del cuerpo hacia fuera sin hacer movimientos, se limpia solo un ojo con el palpo del maxilípedo del mismo lado con un movimiento semicircular de afuera hacia dentro.
iii) Cangrejo permanece al borde del hoyo con la mitad del cuerpo hacia fuera sin hacer movimientos, se limpia ambos ojos con los dos palpos del maxilípedo haciendo un movimiento semicircular de afuera hacia dentro.
iv) Al acercarse otro individuo a su hoyo el residente sale de su hoyo.
v) Cangrejo permanece al borde del hoyo con la mitad del cuerpo hacia fuera sin hacer movimientos, al acercarse otro individuo el residente eleva todo el cuerpo abriendo ambos quelípedos.
vi) Al acercarse otro individuo el residente eleva todo el cuerpo abriendo ambos quelípedos golpeándolo con el quelípedo de mayor tamaño.

Alimentación

i) Cangrejo parado escarbando el arena con los quelípedos y llevándose partículas a la boca con un quelípedo.
ii) Cangrejo parado escarbando el arena con los quelípedos y llevándose

partículas a la boca con ambos quelípedos de manera alterna.

iii) Cangrejo parado escarbando el arena con los quelípedos partiendo un trozo de alimento con ambos quelípedos y alternándolos en su dirección a la boca.

iv) Cangrejo caminando lateralmente arrastrando ambos quelípedos.

v) Cangrejo caminando diagonalmente arrastrando ambos quelípedos.

DISCUSIÓN

Nuestros datos relativos a la distribución local de los cangrejos fantasma en la playa contrastan fuertemente con los aportados por otros autores. Alberto y Fontoura (1999) en un estudio en Brasil, observan que la máxima concentración de hoyos se sitúa a partir de los 20-30 m de distancia del mar, mientras que nosotros la encontramos en los primeros 10 metros de arena.

Por otra parte, nuestros datos tampoco justifican la afirmación de los mismos autores que ubican a los animales de mayor talla en la proximidad de la duna. En nuestro trabajo se observa una distribución de todas las categorías de talla en esta parte de la playa y una ausencia de hoyos en la zona más distante del agua.

Los periodos de actividad de los cangrejos se distribuyen para todas las tallas en dos picos, uno de ellos diurno que es el de mayor duración. Los reportes a este respecto afirman que la actividad es casi exclusivamente nocturna (Strachan et al. 1999), aunque los juveniles pueden estar activos durante el día para evitar la depredación intraespecifica (Fisher y Tevesz 1979). No pudimos confirmar ninguna de estas aseveraciones. Nuestros datos sugieren además una fuerte relación entre la actividad y la temperatura para el mes de marzo.

Es posible que el cangrejo fantasma presente amplias diferencias locales de conducta que justifiquen todas estas divergencias.

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Cultivo en el Laboratorio del Gasterópodo *Melongena corona bispinosa* (Neogastropoda: Melongenidae)

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RESUMEN

El gasterópodo *Melongena corona bispinosa* representa una fuente de trabajo para los habitantes de Chuburná Yucatán, México, donde es explotado artesanalmente todo el año por ribereños de todas las edades. El 70% de la población (1,000 habitantes) realiza la pesca de este caracol, extrayendo en promedio 3 kg de pulpa por persona en jornadas de 8 horas lo que representa 40 toneladas anuales de peso vivo (12 millones de organismos).

En el trabajo se determinó el efecto de dos alimentos a tres raciones sobre el crecimiento y sobrevivencia de *M. corona bispinosa*. Estos fueron: tejido blando de la almeja *Polymesoda maritima*, que es el alimento natural de estos organismos y alimento para tilapia. Las raciones fueron proporcionadas al 3 %, 6 % y 9 % de la biomasa húmeda de los organismos. Las tasas de crecimiento diario en términos de longitud de heliconcha y peso húmedo total con el alimento de almeja fueron: 32 µm/día y 4 µg/día al 3 %, 28 µm/día y 5 µg/día con 6 % y 29 µm/día y 6 µg/día con 9 %. Con el alimento para tilapia, la tasa de crecimiento fue igual para las tres raciones, siendo de 12 µm/día y 3 µg/día. La sobrevivencia no difirió entre los tratamientos. Se realizó el análisis entre dietas y raciones con diferentes índices fisiológicos de condición. Los resultados del trabajo aportan bases para su programa de cultivo.

PALABRAS CLAVES: Alimentación, cultivo, Melongenidae, nutrición, sobrevivencia

Culture of the Gastropod *Melongena corona bispinosa* (Neogastropoda: Melongenide) under Laboratory Conditions

The gastropod *Melongena corona bispinosa* represents a job source for the inhabitants from Chuburná, Yucatán, México, where it is exploited throughout the year by hand catching. Approximately 70 % of the citizens (1,000 people) catch of 3 kg of meat per eight hour day per person, representing 40 tons per year of live weight. This study determined the growth and survival of *M. corona bispinosa* provided two feeds with three feeding schedules. Meat of the clam *Polymesoda maritima*, (natural food of *M. corona*) and tilapia food (PURINA). The schedules were 3 %, 6 % and 9 % of the gastropod biomass (wet weight). The growth rate in shell length and total wet weight were 32 µm/day and 4 µg/day respectively, with 3 % of *P. maritima*, 28 µm/day and 5 µg/day with 6 %, and 29 µm/day and 6

µg/day with 9 %. In constrast, the growth rate obtainedfrom tilapia feed was the same for the three schedules (12 µm/day and 3 µg/day). Analysis of survival does not reveal any significant differences between treatments. Analysis between schedules and foods with physiological conditions index was done. *M. corona bispinosa* have suitable characteristic for the culture. This work provides the basis for a culture program for this species.

KEY WORDS: Culture, feed, Melongenidae, nutrition, survival

INTRODUCCIÓN

El cultivo de gasterópodos en el ámbito mundial se ha limitado a haliotidos y strombidos, ambos herbívoros. El cultivo de organismos carnívoros como melongénidos, turbínidos, buccinidos y fisurelidos no se ha desarrollado a pesar de su importancia comercial (Davis y Dalton 1991, Fleming y Bewrnevel 1996, Foster y Hodgson 1998, Foster et al. 1999, Glazer et al. 1997, Oakes y Ponte 1996).

Los estudios sobre alimentación de gasterópodos realizados entre 1970 y 1990 han sido con tres grupos: nueve especies de haliótidos, tres especies de Strombus y un tercer grupo que incluye a 45 especies de gasterópodos.

Los haliótidos, por su importancia comercial y tipo de alimentación, han sido el grupo más estudiado, habiéndose determinado en los años 90 sus requerimientos alimenticios (Uki et al. 1986, Stuart y Brown 1994, Capinpin y Corre 1996, Fleming y Berneveld 1996, Quing et al. 1996).

Respecto a *Strombus* sp, la investigación sobre su alimentación de 1970 a 2001 ha sido principalmente para la fase larvaria (Aldana Aranda et al. 1989, Aldana Aranda et al. 1996, Brito y Aldana Aranda 1997).

De las otras 45 especies de gasterópodos, los estudios sobre su alimentación han sido sobre sus preferencias alimenticias y contenido estomacal (Morton 1986, Villareal 1989, Fostery Hodgson 1998, Zetina Zarate y Aldana Aranda 1998, Foster et al. 1999).

En México, *M. corona bispinosa*, se localiza en las lagunas de Campeche y Yucatán (Abbott 1974, Flores Andolais 1980, García Cubas 1981, González et al. 1991, Hathaway 1958, Villareal Chávez 1989). El principal sitio de extracción en Yucatán, es la ciénaga de Chuburná donde la pesca de este recurso es la actividad más importante de la región. Su extracción es artesanal durante todo el año generando US$351,000 (Kaplowitz 2001, Zetina Zárate y Aldana Aranda 1998). Debido a su importancia económica y a la poca información de su ciclo de vida, es necesario estudiar su alimentación y reproducción para un manejo pesquero y acuícola adecuado.

En el presente trabajo se determinó el efecto de dos alimentos a tres diferentes raciones sobre el crecimiento, sobrevivencia y condición fisiológica de *Melongena corona bispinosa.*

MATERIALES Y MÉTODOS.

El muestreo se realizó en la ciénaga de Chuburná, 21°15', 21°12' Latitud Norte y 89°50', 89°47', Longitud Oeste (Figura 1).

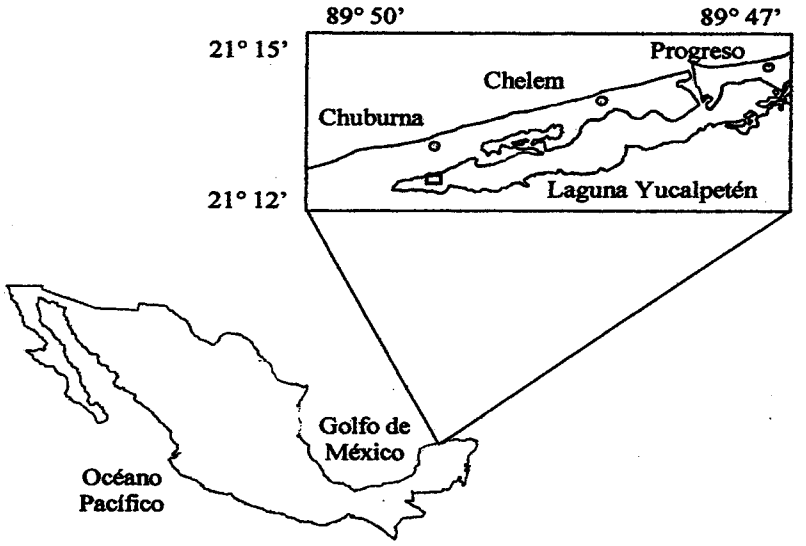

Figura 1. Sitio de muestreo de *Melongena corona bispinosa* en Chuburná, México

Durante la marea baja se colectaron 410 ejemplares de *M. corona bispinosa* con una longitud sifonal promedio de 20 ± 2.03 mm. En la misma localidad, se extrajeron 1000 almejas de la especie *Polymesoda maritima*, alimento natural del gasterópodo. Los organismos se transportaron en recipientes isotérmicos. Las medidas de cada acuario fueron de 30 cm de ancho, 40 cm de largo y 10 cm de alto, teniendo tres litros de agua de mar filtrada a 20 µm y aireación constante. Los acuarios con sus respectivas réplicas se etiquetaron de acuerdo al tratamiento y fueron cubiertos con una malla de 2 mm de luz para evitar el escape de los organismos. La densidad de los organismos fue de 3.3 organismos/litro de agua de mar

Los alimentos fueron la almeja *P. marítima* (Alimento natural de *M. corona* y un granulado para tilapia de la marca PURINA. Estos alimentos se pesaron y proporcionaron al 3 %, 6 % y 9 % de la biomasa húmeda de los gasterópodos de acuerdo al tratamiento. Los recambios de agua se realizaron cada tercer día para mantener la calidad del agua.

El crecimiento se determinó por el incremento en la longitud sifonal (LS) peso húmedo total (PHT) y tasa de crecimiento de los organismos. La longitud sifonal se midió con un calibrador Vernier de 0.5 mm de precisión y el peso con una báscula analítica marca A&D serie HR-120, con una precisión de 0.0001 g. Las biometrías

se realizaron: Al inicio del experimento (día 0) y a los 15, 47, 76, 99, 140, 168 y 187 días.

La tasa de crecimiento se determinó aplicando la fórmula:

$$G = (B-A)/(t-1)$$

Donde:

G = tasa de crecimiento,

B = Longitud sifonal media o peso húmedo total al final del experimento,

A=Longitud sifonal media o peso húmedo total al inicio del experimento y

t = tiempo de crecimiento (Garcia Santaella y Aldana Aranda 1994).

La sobrevivencia se determinó según la ecuación propuesta por Olvera Novoa (1994):

$$S = (Nf/Nj)100$$

Donde:

S = sobrevivencia,

Nj = número de organismos al principio del experimento,

Nf = número de organismos al final del experimento

El estado fisiológico de *M. corona bispinosa* se determinó al inicio y al final del experimento con base en dos índices de condición Lucas y Beninger (1985), Mann (1978).

$$PCI_1 = (PSP/PHP)100,\ PCI_2 = (PSP/PSC)100$$

Donde:

PHP = Peso húmedo de los tejidos blandos,

PSP = Peso seco de los tejidos blandos,

PSC = Peso seco de la concha

Para la separación del tejido blando de la concha se sacrificaron 170 organismos metiéndolos en un horno de micro ondas por 15 segundos (Luna 1968). Se registró el peso húmedo de tejido blando y de la concha. Por último, se eliminó la humedad introduciendo ambas partes en una estufa a 70°C por 24 horas para determinarles el peso seco. El estado fisiológico al final del experimento se determinó a los organismos sobrevivientes tratándolos como se describió anteriormente.

Para el análisis estadístico se utilizó el software Statistica (StaSoft 1999). A los datos de crecimiento se les aplicó análisis de varianza (MANOVA) de dos vías y análisis de regresión. Los índices de condición fueron evaluados con un análisis multivariado y las diferencias entre tratamientos con el análisis LSD. La longitud de la heliconcha fue correlacionada con el peso húmedo total. Los datos fueron correlacionados para encontrar tendencias en el crecimiento. Los análisis se realizaron a un nivel de significancia menor o igual a 0.05.

RESULTADOS

La talla inicial de los organismos fue de 20 ± 2.03 mm y 0.94 ± 0.27 g de peso húmedo total (n = 240). Se encontró una relación lineal entre la talla y el peso con coeficientes de correlación cercanos a uno durante el período de medición y en todos los tratamientos.

Se pudo observar dos etapas en el crecimiento: La primera etapa, se caracterizó por un escaso crecimiento, la cual comprende del inicio del experimento a 99 días. La segunda etapa, comprendida de 99 a 187 días del experimento, la cual presenta un crecimiento significativo en longitud y el peso (Figuras 2, 3 y 4).

El análisis estadístico ($p > 0.05$) no reveló diferencia significativa en el crecimiento en longitud y peso al comparar las tres raciones de un mismo alimento. Contrariamente, sí se encontraron diferencias estadísticas entre las curvas de crecimiento en longitud sifonal de los organismos alimentados con *P. maritima* y alimento para tilapia al 3 % después de 168 días de cultivo (figura 2ª y 2b respectivamente). Los organismos alimentados con P. maritima y alimento para tilapia al 6 % (Figuras 3a y 3b) presentaron diferencias significativas en su crecimiento en longitud y peso después de 99 días de cultivo.

Con respecto al crecimiento de los organismos alimentados al 9% las diferencias estadísticas se encontraron después de 140 días. En contraste, al realizar el análisis de varianza con los datos del peso húmedo total, las diferencias fueron significativas desde el día 99, a un nivel de significancia de 0.05 (Figuras 4a y 4b).

El mayor crecimiento obtenido fue en los organismos alimentados con *P. maritima* cuya una talla final de 25.92 ± 3.09 mm y peso de 1.87 ± 0.77 g y el menor fue para los individuos con alimento para tilapia (22.35 ± 1.9 mm y 1.42 ± 0.37g (Tabla 1).

En cuanto a tasa de crecimiento, los organismos que crecieron más rápido durante el experimento fueron los alimentados con la almeja al 3 % (39 µm/día) y los de tasa de crecimiento fueron los que recibieron el alimento para tilapia al 6 % y 9% (12 y 13 µm/día respectivamente).

La sobrevivencia no mostró diferencias estadísticas ($p= 0.7173$) en el análisis de varianza (Figura 5).

El índice fisiológico de condición Peso seco de tejidos blandos : Peso húmedo de tejidos blandos se presenta en la Figura 6a. El contenido de humedad está entre 60 y 70 %. Se estimaron diferencias estadísticas en el índice al inicio y el final del experimento. Los valores más bajos se encontraron con los organismos alimentados con la almeja al 3 %.

Al comparar el índice fisiológico (Peso seco de la pulpa : Peso seco de la concha) se observa mayor proporción tejido-concha en los organismos alimentados con el alimento para tilapia que en los alimentados con alimento natural (Figura 6b). Entre raciones el mayor valor se obtuvo con la ración al 9 %.

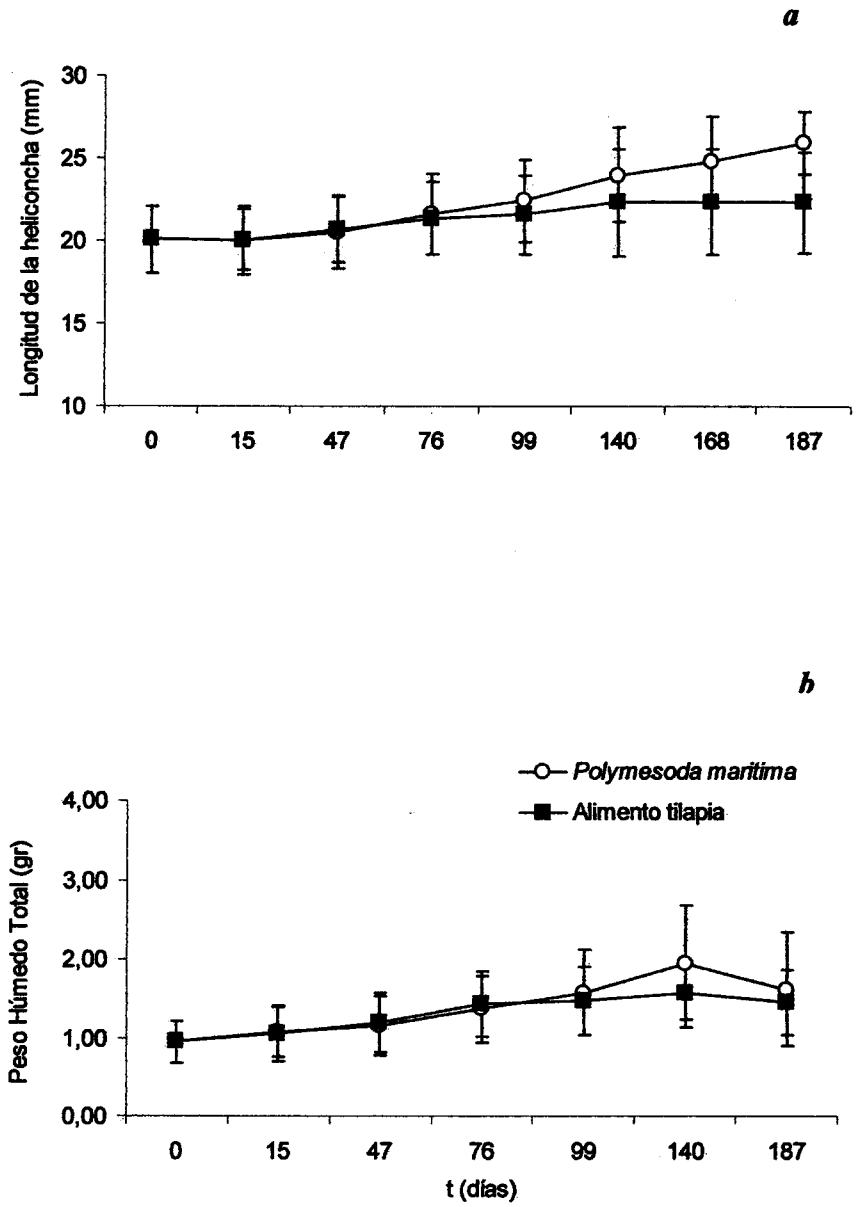

Figura 2. Crecimiento de *Melongena corona bispinosa* en longitud de la heliconcha (a) y peso húmedo total (b) alimentado con *Polymesoda maritima* y alimento para tilapia al 3 %,

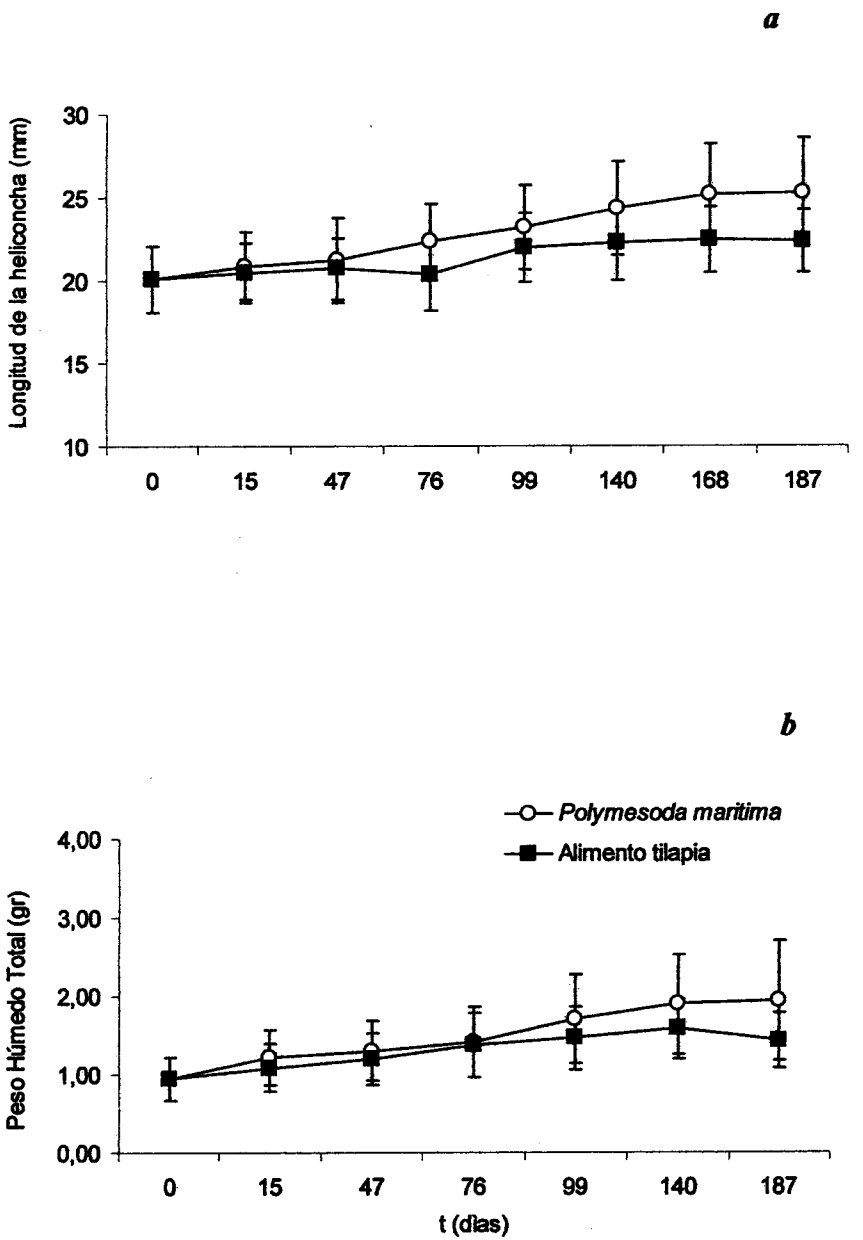

Figura 3. Crecimiento de *Melongena corona bispinosa* en longitud de la heliconcha (a) y peso húmedo total (b) alimentado con *Polymesoda maritima* y alimento para tilapia al 6 %.

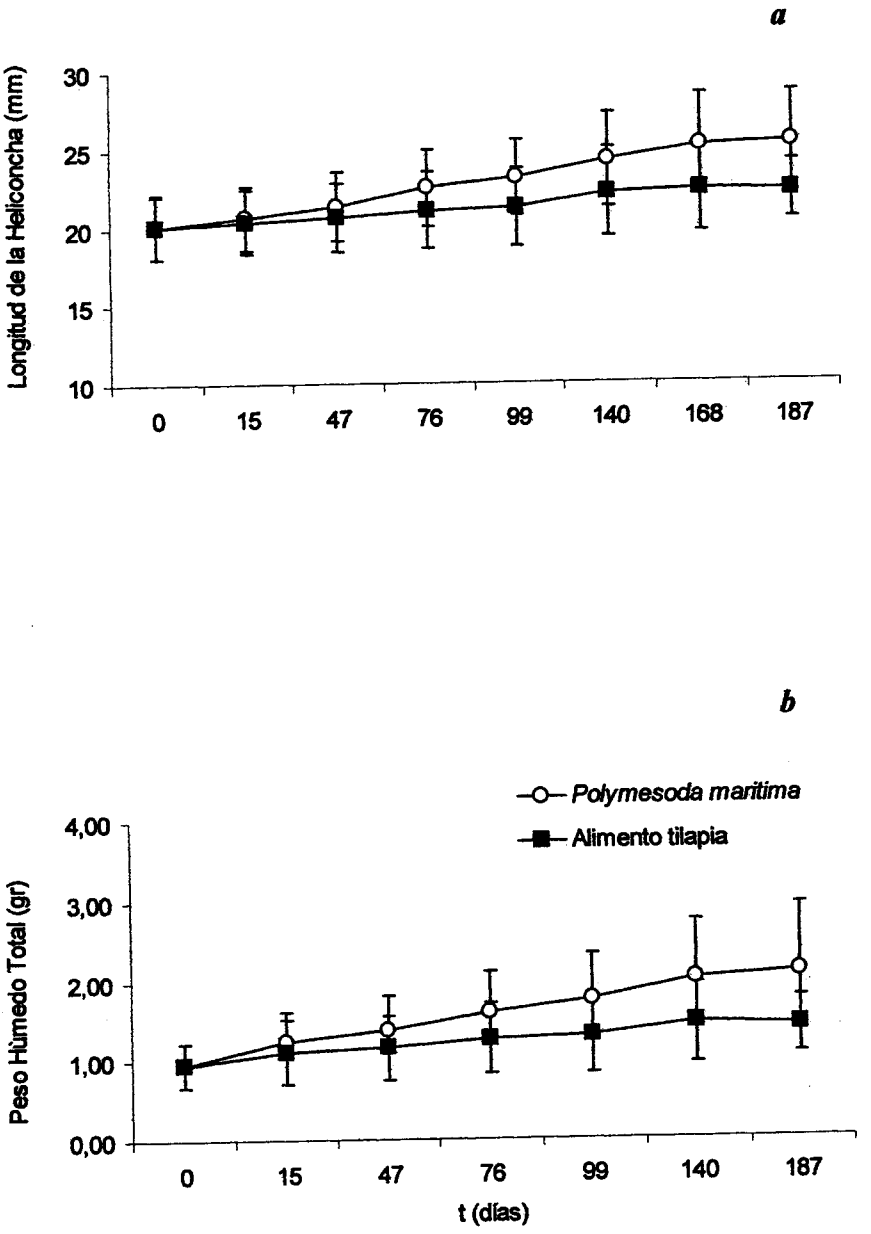

Figura 4. Crecimiento de *Melongena corona bispinosa* en longitud de la heliconcha (a) y peso húmedo total (b) alimentado con *Polymesoda maritima* y alimento para tilapia al 9 %.

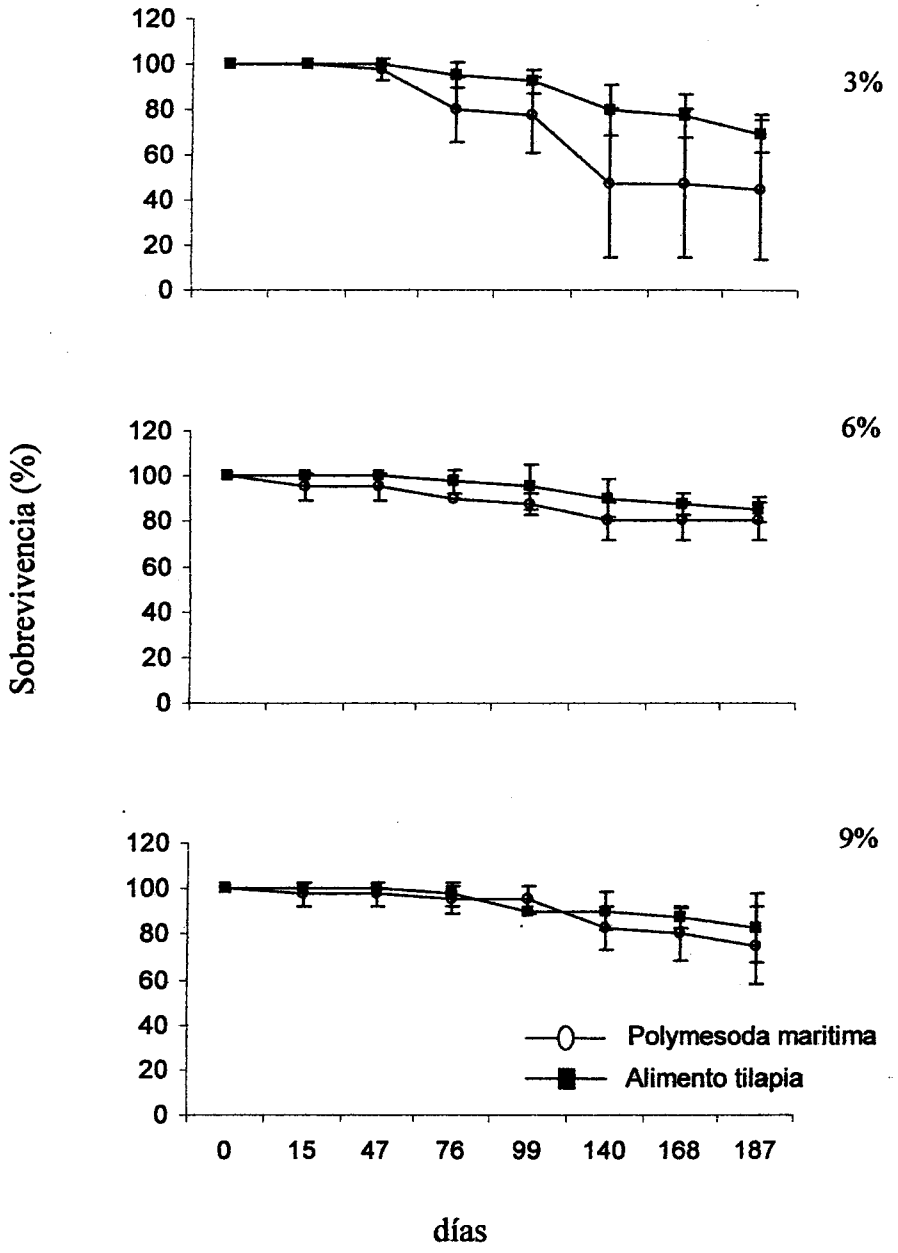

Figura 5. Sobrevivencia de *Melongena corona bispinosa* durante 187 días en condiciones de laboratorio

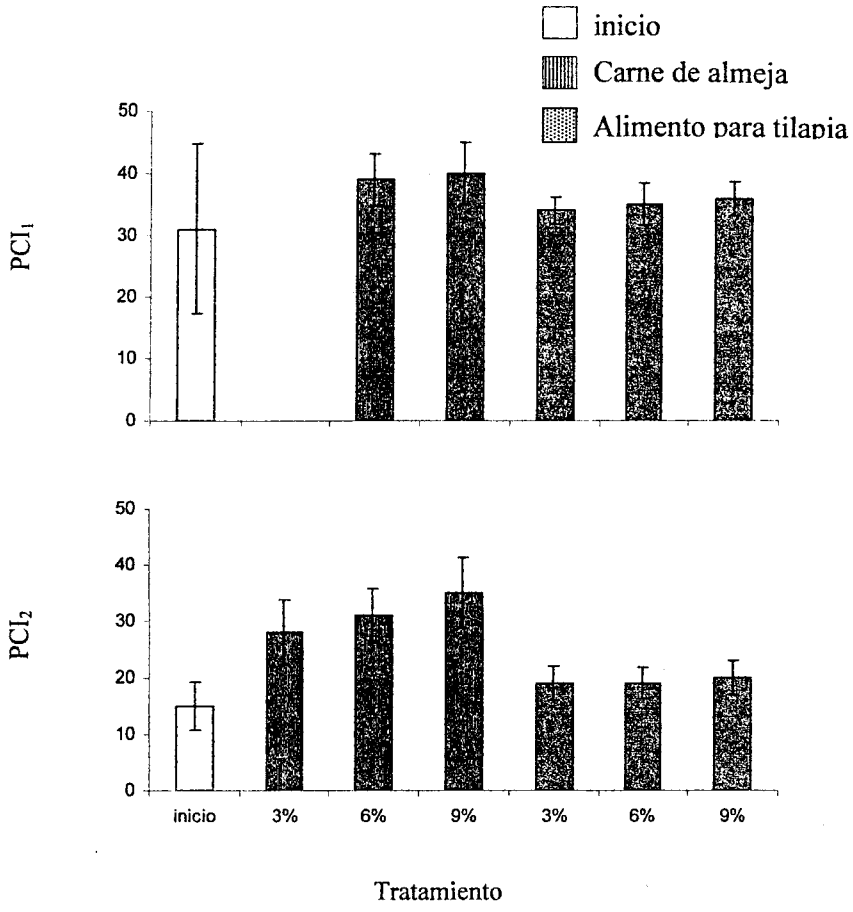

Figura 6. Indices de condición de *Melongena corona bispinosa*, al inicio y al final del experimento alimentado con *Polymesoda maritima* y alimento para tilapia al 3 %, 6 % y 9 % (* no determinado)

DISCUSIÓN

Existe relación lineal entre la talla y el peso de *M. corona bispinosa* por lo que cualquiera de las dos biometrías es útil para estudios de crecimiento. Baqueiro et al. (1992) sugiere que la medida comúnmente usada para determinar crecimiento de gasterópodos es la longitud sifonal. Day y Fleming (1992) sugieren que el efecto de la dieta en el crecimiento se puede confundir con el efecto de otros factores como la temperatura, salinidad, concentración de oxígeno y densidad. En el trabajo, el crecimiento obtenido fue por causa de las dietas porque la temperatura, el oxígeno y salinidad se mantuvieron constantes.

Las curvas de crecimiento por efecto de la ración (3, 6, 9 %) no mostraron diferencias estadísticas, coincidiendo con Knauer et al (1996) quienes no encontraron diferencias en el crecimiento de *Haliotis midae* alimentado con diatomeas y con pellets. Los autores asociaron sus resultados a la variación en las tallas de los organismos al inicio de su experimento; situación no encontrada en este trabajo (tabla1).

La ración utilizada en este estudio se encuentra dentro de los rangos empleados por otros autores como Viana et al. (1993) quienes alimentaron con una dieta artificial y la macroalga *M. pyrifera ad libitum* a *Haliotis fulgens*. Stuart y Brown, (1994) proporcionaron alimento en exceso a juveniles de *H. iris*. Capinpin y Corre (1996), utilizaron alimento artificial al 5 % y alimento natural en exceso para determinar el crecimiento de *H. asinina*. Knauer et al. (1996) alimentaron a *H. midae* con alimento artifical a una ración de 5.5 %. Aldana Aranda et al. (1996) utilizó una ración de 2 g/L de un alimento comercial (Fripakk) para alimentar a post larvas de *S. gigas*.

Las dos etapas encontradas en el crecimiento de *M. corona bispinosa* concuerdan con lo reportado por Viana et al (1996) quienes caracterizan un crecimiento lento de *H. fulgens* durante los primeros 30 días de cultivo y posteriormente una etapa de crecimiento acelerado. Contrariamente, Viana *et al* (1993), señalan dos etapas en el crecimiento de los organismos observando una disminución en la segunda etapa del experimento atribuyéndolo al desconocimiento de los requerimientos alimenticios de *H. fulgens*. Capinpin y Corre (1996) al obtener una tendencia en la disminución del crecimiento de *H. asinina* menciona que es porque el organismo se encontraba en fase de maduración sexual.

La mayor tasa de crecimiento de *M. Corona bispinosa* fue con la carne de almeja (alimento natural). Viana et al (1993, 1996), Stuart y Brown (1994), Capinpin y Corre (1996), encontraron mayor tasa de crecimiento en Haliotis sp alimentados con dietas artificiales que en los abulones que recibieron alimento natural. El menor crecimiento de *M. corona bispinosa* con el alimento para tilapia se debe a que este no es específico, no cubriendo sus requerimientos alimenticios.

En experimentos realizados con melongénidos, Bowling (1994), alimentó a *M. corona* con tejido blando de ostión (*C. virginica)* y de mejillón (*Guekensia demisa*) obteniendo tasas de crecimiento de 60 y 50 µm/día respectivamente. Brito et al (1998) alimentó juveniles recién eclosionados de *M. corona bispinosa* con un alimento granulado y obtuvo una tasa de crecimiento de 9 µm/día. Zetina Zárate y

Aldana Aranda (1998), observaron una tasa de crecimiento de 28.13 µm/día^{-1} al alimentar a juveniles de *M. corona bispinosa* con carne del pez *Epinephelus morio*. En ese trabajo la tasa de crecimiento fue de 31 µm/día.

Otro factor importante en el cultivo de un organismo es la sobrevivencia. Davis y Dalton (1991) obtuvieron una sobrevivencia de entre 80 y 100 % con juveniles cultivados de *S. gigas*. Los resultados obtenidos por Capinpin y Corre (1996) con juveniles de *Haliotis asinina* fueron del 100 %. Los valores obtenidos por estos autores son mayores a los obtenidos en este trabajo, sin embargo el grado de conocimiento de la biología de estos organismos es mayor. Con *M. corona bispinosa*, Zetina Zárate y Aldana Aranda (1998) obtuvieron una sobrevivencia de 26.55 %, Brito Manzano y Aldana Aranda (1998) de 100 % y Bowling (1994) 95 %.

Lucas y Benninger (1985) señalan que los índices de condición estáticos revelan bajas reservas de energía, condiciones estresantes o épocas invernales en moluscos bivalvos. En este sentido, el PCI_1 de los organismos alimentados con la almeja fue el mayor comparado con el de los organismos provenientes del medio (inicio del experimento) y de los organismos alimentados con alimento para tilapia lo que señala una respuesta favorable de los organismos por efecto del alimento, coincidiendo con los resultados obtenidos en el análisis de las curvas de crecimiento.

Mann (1978) menciona que la relación soma : concha (PCI_2) revela el esfuerzo biológico de un organismo como respuesta a condiciones ambientales o períodos de reproducción. El índice de los organismos al inicio del experimento fue el menor (10%) en comparación con el de los organismos alimentados con la *P. marítima* y alimento para tilapia de lo que se deduce una respuesta favorable de los organismos a las condiciones de cultivo.

El inconveniente encontrado al utilizar a la almeja *Polymesoda maritima* como alimento para el cultivo de *M. Corona bispinosa*, es su disponibilidad.

M. corona bispinosa es un organismo que tiene importancia económica, social y ecológica. Este organismo posee características adecuadas para su cultivo, tales como aceptación y aprovechamiento de alimento artificial y buena sobrevivencia en cautiverio. Sin embargo, los estudios realizados hasta el momento no permiten aún su domesticación para el cultivo. Por otra parte, la extracción sin normativa alguna pone en riesgo de una sobreexplotación a las poblaciones naturales.

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Morfometría de una Población Inusual de *Isognomon alatus* (Gmelin, 1791) en la Reserva de la Biósfera Banco Chinchorro y su Relación con el Ambiente

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RESUMEN

La RB. Banco Chinchorro se localiza en aguas oceánicas del Caribe Mexicano, tiene la forma de un atolón y esta separado de la costa de Quintana Roo por un canal de 1000 m de profundidad. Posee 4 islas: dos al norte, una central y la más pequeña en el sur. Posee gran variedad de hábitats que incluyen; una laguna arrecifal poco profunda de 840 km^2 de área con parches arrecifales (microatolones) diseminados a todo lo largo, formaciones coralinas muy desarrolladas en la parte sur y pendientes muy abruptas que exceden los 500 m. La isla central (Cayo Centro) tiene una red de islotes de mangle que ha originado un microsistema lagunar conectados por pequeños canales de baja profundidad. El descubrimiento insólito de una población de *Isognomon alatus* en un canal interno de Cayo Centro de aproximadamente 100 m de longitud, llevó a la investigación de las condiciones ambientales que permitieron ese asentamiento inusual. Se realizaron observaciones bimensuales de febrero a noviembre de 1998, para definir la dimensión ambiental tomando en cuenta 12 parámetros del ambiente y correlacionando el peso, la longitud y la amplitud de la concha. La parte media del canal fue la de mayor abundancia y la parte inicial la de menor abundancia. Las regresiones entre peso y los otros parámetros morfológicos fueron mayores en la parte media alcanzando coeficientes de correlación mayores a 0.8. En relación a los diferentes parámetros, la mayoría presenta valores más bajos en la parte final del canal. Esta comunicación presenta cada uno de los parámetros y su influencia en la variabilidad poblacional de este molusco.

PALABRAS CLAVES: *Isognomon alatus*, morfometría, distribucion

Morphometry of an Unusual Population of *Isognomon alatus* (Gmelin, 1791) in the Chinchorro Bank BR and their Environmental Relationships

The BR Bank Chinchorro is located in oceanic waters of the Mexican Caribbean, has atoll form, and it is separated from the coast of Quintana Roo for a channel of 1000 m of depth. It possesses four islands: two to the north, one in the middle and the smallest in the south. It possesses great habitat variety that includes: a shallow reef lagoon of 840 area km^2 with patches (microatolones) disseminated along its extent, coralline formations very developed in the south part, and very abrupt slopes that exceed 500 m. The central island (Cayo Centro) has a network of mangrove

islands that has originated a lagoon microsystem connected by small, shallow channels. The unusual discovery of a population of *Isognomon alatus* in an internal channel of approximately 100 m of longitude in Cayo Centro, prompted an investigation of the environmental conditions that supported that unusual establishment. Bimonthly observations were undertaken from February to November in 1998, to define the environmental parameters taking into account 12 parameters of the atmosphere and correlating the weight, the longitude, and the width of the shell. The half part of the channel was that of more abundance and the initial part that of smaller abundance. The regressions between the weight and the other morphometric parameters were greater in the half part reaching correlation coefficients greater than 0.8. In relation to the different parameters, most presented lower values in the final part of the channel. This paper demonstrates how each environmental parameter influences the populational variability of this mollusk.

KEY WORDS: *Isognomon* morphometric, growth, distribuciones

INTRODUCCIÓN

Los arrecifes de coral están ampliamente distribuidos en la región Atlántica de México. Bancos arrecifales pequeños y de bajo perfil, están dispersos a través del suroeste del Golfo de México; la costa Este de la Península soporta una estructura geográfica comparativamente continua que oscila entre un incipiente arrecife de borde y un arrecife de barrera. En la región se desarrollan dos sistemas arrecifales en forma de atolones: Arrecife Alacranes fuera de la costa noroeste y Banco Chinchorro, fuera de la costa sureste de la Península de Yucatán (Torruco 1995).

En estos ecosistemas, las distribuciones de las especies marinas pueden ser explicadas por eventos vicarios o por las habilidades de dispersión y los requerimientos ecológicos de los individuos. Estos últimos son los causantes de la presencia o ausencia de ellas en un lugar particular y pueden imitar la distribución de especies a una escala mayor (Ferre-D'Amare 1985). Aún cuando los arrecifes coralinos tienen características muy semejantes en una región, pueden presentar diferencias originadas por un factor simple o por la resultante de la interacción entre varios de ellos (González 1989), tales diferencias son detectadas por algunos organismos. Los moluscos son unos de los grupos capaces de responder a tales diferencias (Jackson 1974).

Entre los moluscos, las especies que pueden sobrevivir en numerosos hábitats tienen también amplias distribuciones geográficas. Por el contrario, las especies que tienen intervalos estrechos, se presentan en hábitats escasos en una región (González 1995). Estas diferencias pueden tener consecuencias evolutivas significativas (Vermeij 1972). Como grupo, los Moluscos forman un componente distintivo y ampliamente distribuido en los arrecifes coralinos y muestran una alta diversidad en estos ecosistemas (Warmke y Abbott 1962).

En este contexto y con el descubrimiento de una población inusual de *Isognomon alatus* en un canal de una isla de Banco Chinchorro, el presente estudio

analiza la distribución espacial de la morfometría de esta especie y su asociación con diferentes factores del ambiente, en un intento de identificar la causalidad de los patrones encontrados.

ÁREA DE ESTUDIO

Banco Chinchorro es un arrecife Oceánico en el Caribe Mexicano, tiene una laguna arrecifal de 840 km^2 con un gradiente de profundidad sur-norte pronunciado, que va de 17 a 1 m en promedio (Torruco y González 2000a). Posee cuatro islas, de las cuales Cayo Centro es la de mayor área. Esta isla presenta un microsistema lagunar de varias lagunetas conectadas entre si por canales estrechos, la mayoría de ellas están rodeadas por árboles de mangle de aproximadamente 20 m, El sitio de estudio se localiza en el canal Ángel, un canal interno que une dos lagunetas: Laguna Rabios y Laguna Chica, la población de *Isognomon alatus* fue encontrada solo en éste canal del microsistema lagunar (Figura 1).

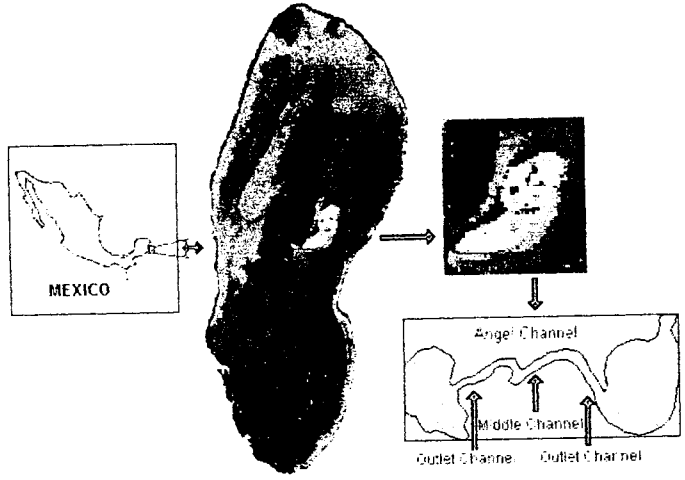

Figura 1. Sitio de muestreo.

MATERIAL Y MÉTODOS

Los organismos fueron colectados de raíces de mangle, obtenidas de la parte media y de ambas desembocaduras del canal. A lo largo de él se tomaron parámetros físicos y químicos y muestras de agua para la determinación de 12 factores del ambiente (Strickland y Parson 1972). Las fluctuaciones de marea se registraron en ciclos circadianos. Los ejemplares colectados fueron limpiados, medidos y pesados.

Los valores obtenidos fueron analizados bajo regresiones de peso *versus* longitud y amplitud, para conocer los descriptores con mejor correlación. Los factores del ambiente fueron analizados mediante una una regresión múltiple paso a paso, tomando en cuenta los atributos de crecimiento de *I. alatus* como variables dependientes y los factores ambientales como independientes (Daniel 1974). Todos los análisis anteriores fueron realizados de manera diferencial para cada segmento del canal. Los factores del ambiente y los valores puntuales de los atributos de crecimiento, fueron analizados en un contexto espacial donde los sitios fueron geoposicionados obteniendo una matriz XYZ, posteriormente se aplicaron técnicas geoestadísticas usando una función de semivariograma lineal con el interpolador kriging (Keckler 1994), utilizando el programa Surfer V.7, con ello se contrastaron cada uno de los patrones espaciales obtenidos (Axis-Arroyo et al. 2001).

RESULTADOS

La mayor abundancia de ejemplares se presentó en el área media y en el extremo de la laguneta que desembocaba al mar. La frecuencia de los intervalos de peso, longitud de la concha y amplitud de la misma se encuentran representados en la Figura 2, donde se muestra una alta relación entre las frecuencias de intervalos semejantes entre la longitud y la amplitud, con altas frecuencias de tallas entre 4 y 10 cm, los ejemplares mayores son escasos. La parte del canal que desemboca a la laguna de Rabios y la que desemboca a la laguna Chica, son las fracciones que marcan un comportamiento unimodal; la fracción de la parte media presenta un comportamiento de frecuencias bimodal. El peso tiene un comportamiento semejante en la parte media y en la desembocadura a la laguneta Rabios, donde se presentan grandes frecuencias de organismos de poco peso, que va decreciendo conforme aumentan su biomasa. La desembocadura a la laguneta Chica una baja frecuencia pero con organismos de todos los tamaños (Figura 2).

La relación entre el peso *versus* la longitud y la amplitud de la concha presentó mayores coeficientes en la parte media del canal (R^2 ⟩ 8), siendo la longitud el atributo con mayor correlación (Figura 3); los parámetros de las regresiones múltiples se encuentran en la Tabla 1, que muestra un coeficiente más alto con el peso en la desembocadura a la Laguna Rabios; en la parte media el mayor coeficiente es para la amplitud y en la desembocadura a la laguneta Chica para la longitud, los intervalos de los coeficientes de determinación va desde el más bajo (0.31) para el peso en la parte media del canal hasta el mayor (0.77) con la amplitud en la misma zona. Los pesos beta de las variables ambientales en relación de los atributos de crecimiento se presentan en la Tabla 2, los valores positivos más altos lo presenta la marea para la desembocadura de la Laguna Rabios y el pH en la parte media y en la desembocadura de la Laguna Chica, contrariamente en estas áreas la marea presenta los valores negativos más altos, mientras que la salinidad tiene los de la desembocadura de la Laguna Rabios.

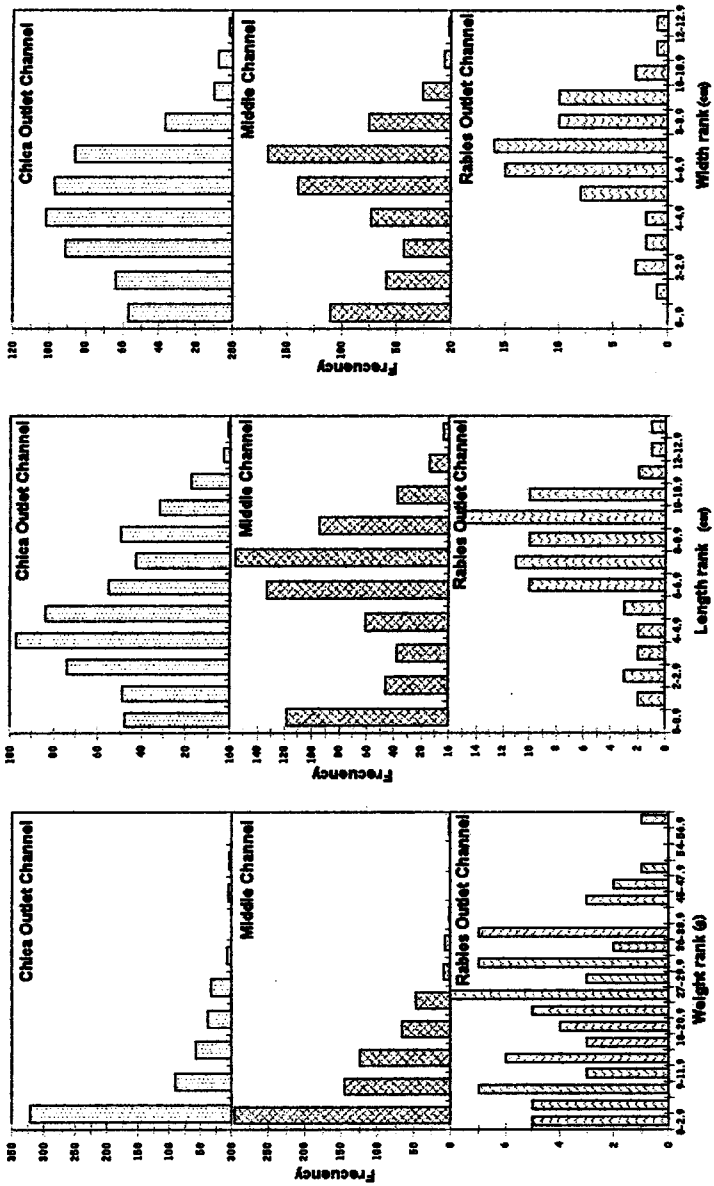

Figura 2. Distribución de pesas, tallas, y de las anchuras para cada segmento del área del estudio.

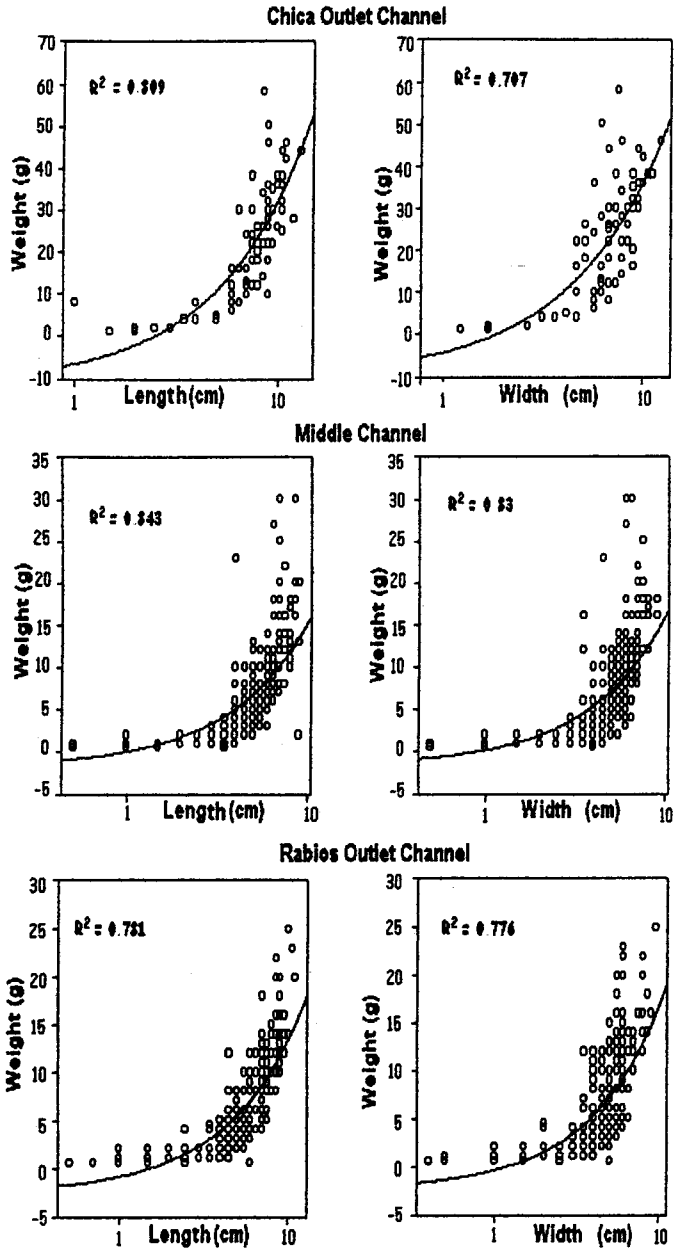

Figura 3. La relación del peso con talla y anchura en cada segmento del área del estudio.

Tabla 1. Parámetros de la regresión múltiple para los diferentes atributos de crecimiento de *Isognomon alatus* en el Canal Angel de Cayo Centro en Banco Chinchorro.

	Entrada del Canal			Canal medio			Salida del Canal		
	Coef. de Correlación Múltiple	Coeficiente de Determinación	Intercepción	Coef. de Correlación Múltiple	Coeficiente de Determinación	Intercepción	Coef. de Correlación Múltiple	Coeficiente de Determinación	Intercepción
Peso	0.74	0.55	156.59	0.56	0.31	-6.44	0.6	0.36	-1.01
Longitud	0.71	0.51	21.43	0.75	0.56	1.96	0.7	0.49	4.58
Amplitud	0.68	0.47	28.45	0.77	0.6	1.98	0.69	0.47	2.92

Tabla 2. Pesos beta de los variables ambientales (independientes) y los atributos de crecimiento (dependiente) de *Isognomon alatus* en el canal Angel de Cayo Centro en Banco Chinchorro.

Atributo	T °C	S °/$_{oo}$	O_2	pH.	Marea	$N\text{-}NH_4$	$N\text{-}NO_2$	$N\text{-}NO_3$	$P\text{-}PO_4$	$Si\text{-}SiO_4$	Ca	Mg
					Entrada del Canal							
Peso	-4.39	-9.83	5.95	-0.43	10.15	1.9	-0.45	-4.27	-2.38	0.43	0.3	0.11
Longitud	-0.55	-1.3	1.11	-0.2	1.04	0.3	-0.05	-0.57	-0.26	0.05	0.04	0.01
Amplitud	-0.46	-1.41	1.08	-0.98	2.03	0.3	-0.06	-0.66	-0.32	0.04	0.06	0.01
					Canal Medio							
Peso	-0.97	0.8	-0.98	5.35	-4.75	-0.34	0.02	0.2	-0.08	0.05	-0.08	0.002
Longitud	-0.21	0.46	-0.55	1.28	-2.9	-0.13	0.004	0.11	0.01	-0.01	0	-0.01
Amplitud	-0.26	0.41	-0.49	1.31	-2.83	-0.11	0.005	0.09	0.01	-0.01	0	-0.01
					Salida del Canal							
Peso	-0.75	0.15	-0.86	4.82	-3.08	-0.29	-0.009	-0.08	-0.28	0.08	-0.06	0.005
Longitud	-0.46	-0.12	-0.29	2.11	-2.43	-0.06	-0.02	-0.1	-0.15	0.03	0	0
Amplitud	-0.36	0.06	-0.24	1.46	-2.15	-0.05	-0.007	-0.006	-0.056	0.01	-0.01	0

Independientemente de la magnitud de los valores, la Tabla 3 muestra la significancia estadística entre esas variables, donde el peso es el elemento con mayor significancia en casi todos los parámetros en la entrada del canal.

Los patrones espaciales se muestran en la figura 4, donde se forman tres grupos que presentan nódulos de alta densidad, uno en la desembocadura de la laguna Chica (Figura 4a), el segundo grupo que presenta valores altos en la parte media (Figura 4b) y los que presentan estos nódulos en la desembocadura de la laguna Rabios (Figura 4c); el peso y la longitud presentan un patrón de alta densidad en la desembocadura hacia la laguna Rabios, mientras que la amplitud presenta valores semejantes en todo el canal Figura 4d)

DISCUSIÓN

En México, *Isognomon alatus* es una especie característica de la porción occidental de la Península (González et al. 1991), íntimamente ligada a los mangles de franja de lagunas costeras con aportes importantes de agua dulce (Pérez-Rodríguez 1969), en Banco Chinchorro se encontró en un área con estas características solo que a 35 km de la costa y con un canal de separación de la costa superior a los 1000 m. La tolerancia a la temperatura y a otros factores ambientales juega un papel importante para la determinación de los patrones latitudinales característicos de cada especie sobre todo en aspectos comparativos de eurotopia y estenotopia (Jackson 1974), las propiedades intrínsecas de las masas de agua: temperatura, nutrimentos, salinidades y el medio circundante pueden ejercer efectos controladores que limiten la libre distribución de la malacofauna (Ward et al. 1978). En el grupo de los moluscos se presentan cambios en la diversidad, que podrían explicarse por la separación y saturación de masas continentales con cambios concomitantes en la potencialidad del aislamiento genético y competencia interespecífica; ademas de factores no biológicos como la estabilidad del ecosistema (Verneij 1972).

Durán-González et al. (1984), comparan las características cromosómicas de poblaciones de Florida, Veracruz y Campeche, encontrando que los especímenes de Campeche tenían 26 pares de cromosomas, comparados a los 28 pares de las poblaciones de Florida y Veracruz. La población de Campeche tiene cinco metacéntricos, seis metacéntricos subalternos y dos cromosomas acrocéntricos, considerando que las otras poblaciones tenían cinco metacéntricos apareados y nueve pares de metacéntricos subalternos para la población de Florida, y cuatro metacéntricos, siete metacéntricos subalternos y tres acrocéntricos apareados para la población del Veracruz, mencionan que estas diferencias cariotípicas pueden haber sido el resultado de la separación geográfica de las poblaciones y su adaptación a condiciones medioambientales diferentes. En consecuencia, esta especie ha tenido dos posibilidades de colonización en el área de estudio.

Tabla 3. Significancia estadística (t_{95}) de las variables ambientales y los atributos de crecimiento de *Isognomon alatus* en el canal Angel de Cayo Centro en Banco Chinchorro.

Atributo	T °C	S °/$_{oo}$	O_2	pH.	Marea	$N\text{-}NH_4$	$N\text{-}NO_2$	$N\text{-}N0_3$	$P\text{-}PO_4$	$Si\text{-}SiO_4$	Ca	Mg
						Entrada del Canal						
Peso	★	★	★	-	★	★	★	★	★	-	-	★
Longitud		★	★	-	-	★	★	★	-	-	-	-
Amplitud	-	-	-	-	-	-	-	-	-	-	-	-
						Canal Medio						
Peso	-	-	-	-	-	-	-	-	-	-	-	-
Longitud	-	-	-	-	-	-	-	-	-	-	-	-
Amplitud	-	-	-	-	-	-	-	-	-	-	-	-
						Salida del Canal						
Peso	-	-	-	-	-	-	-	-	-	-	-	-
Longitud	-	-	-	-	-	-	-	-	-	-	-	-
Amplitud	-	-	-	-	-	-	-	-	-	-	-	-

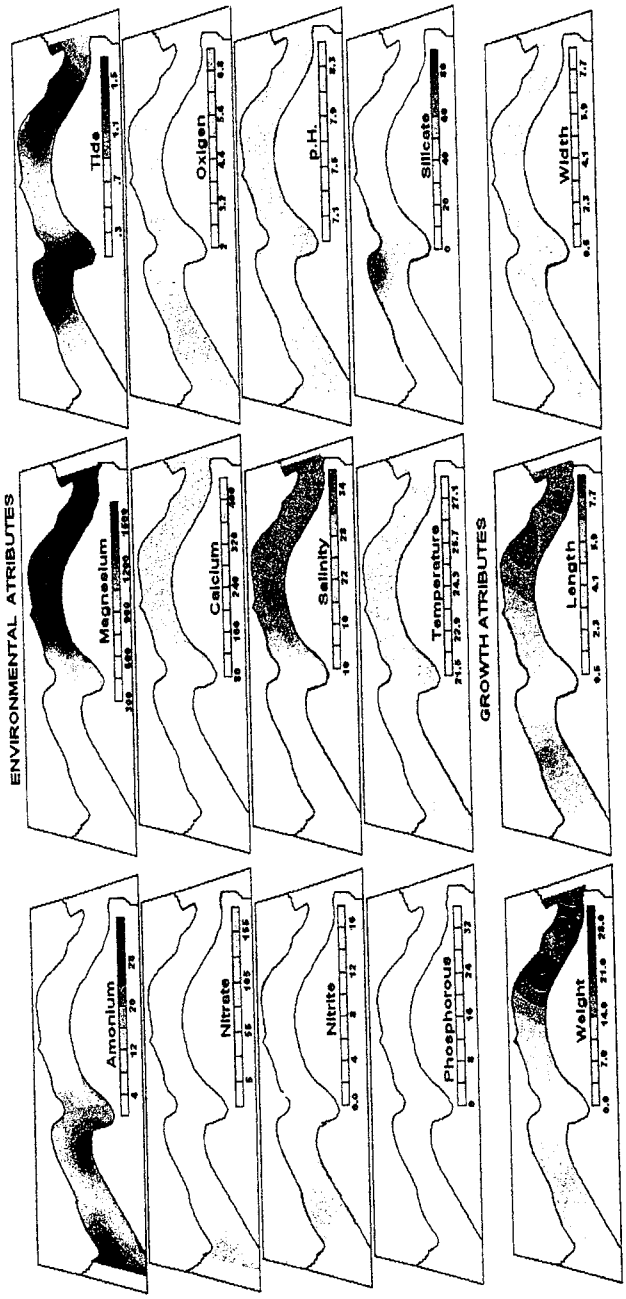

Figura 4. La distribución espacial de los factores ambiental y el crecimiento.

La primera implicaría que las larvas tendrían su fuente de producción en áreas que se localizan en el sur del Banco, ya que la corriente principal viene del Mar del Caimán y con velocidades superiores a los 2 nudos; dado esto, la distancia podría ser enorme, considerando que una larva de molusco en promedio tiene una vida planctónica entre 15 y 40 días (Chia et al. 1984). La segunda posibilidad implica que la especie ha tenido la habilidad suficiente para encontrar corredores y puentes eficientes a lo largo de la Península (Torruco y González 2001), por lo que ha extendido su distribución a lo largo del tiempo hasta esa área de estudio, utilizando las contracorrientes costeras que se hacen presentes en algunas épocas del año (Merino 1986), en este contexto y de ser plausible esta última, las características cariotípicas de la población de Banco Chinchorro, tendrían mayores afinidades con las poblaciones de Campeche.

Las comunidades de mangle de franja son muy productivas a pesar de las bajas concentraciones de nutrientes en las aguas circundantes (Miller y Twilley 1999), como en las comunidades del arrecife de coral, las altas proporciones de producción deben ser mantenidas por las intensas proporciones del reciclaje de nutrientes (Torruco y González 2000b). Miller y Twiley (1999) mencionan la fuerte influencia del amonio de las aguas circundantes en la especie *Isognomon alatus* para la regeneración de nutrientes y el consumo de oxígeno dentro del ecosistema de mangle de franja, y mencionan que podría ser un importante punto metabólico de sostén, para las comunidades que se presentan en las raíces del mangle. La población de la desembocadura a la laguna Chica en Cayo Centro responde significativamente a todo el complejo del nitrógeno, además del fosfato. La otra fracción de la población responde significativamente a la temperatura, salinidad, el calcio y el magnesio; ambas porciones tienen significancia con la marea, es posible que ésta sea el componente que controle los aportes y deficiencias de los nutrimentos mencionados y que con las fluctuaciones que presenta también ejerza una fuerte influencia en la temperatura, la salinidad y el oxígeno. Hacia la parte media, es posible que la misma dinámica de las aguas haga que esta se homogenize por dilución y pierdan significancia todos los parámetros. Así mismo, algunos factores del medio como los vientos y las precipitaciones, hacen que las propiedades intrínsecas de las masas de agua como es la temperatura, la salinidad y los nutrimentos tengan cambios más rápidos, sobre todo tomando en cuenta la poca profundidad del canal (1.3 m en promedio). Algunos nutrimentos como el silicato, muestran nódulos de alta densidad en zonas muy localizadas, donde es posible que exista una acumulación de este elemento por la topografía misma del canal.

Otro factor que puede influir en la distribución es el substrato circundante (Benayahu y Loya 1977, Ohlhorst y Liddell 1988, Novak et al. 1992). Wendt y Alexander (1996), mencionan que la productividad del bysus de *Isognomon alatus* es alta en raíces, rocas y algas muertas y baja en esponjas, mudas y algas filamentosas y que los organismos están fuertemente unidos a raíces, rocas, conchas, algas verdes y algas café muertas. En Banco Chinchorro, solo se le encontró creciendo sobre las raíces de *Rizophora mangle* (L.), con asociaciones ocasionales con esponjas del genero *Cliona*, en la mayoría de las épocas del año, el canal estaba

limpio, con excepción de hojarasca del mangle, que libera taninos en cantidades considerables. Thomas y Dangeubun (1994), mencionan también que en Bermudas se localiza en el mismo substrato preferentemente; sin embargo, las densidades encontradas son mayores que las encontradas en Banco Chinchorro. Ellos encuentran una abundancia de aproximadamente 250 ostras por raíz, mientras que en Banco Chinchorro encontramos 45 ostras por raíz en promedio. La proporción del sexo encontrada en Bermudas fue de 2.6:1 y 6 indeterminados, en Banco Chinchorro, encontramos una proporción de 2:1 con 12 indeterminados. En Bermudas las ostras maduras de ambos sexos estaban presentes a lo largo del año, pero con la máxima actividad en otoño y un pico en primavera, en Banco Chinchorro encontramos un pico a finales de verano. En Bermudas, la biomasa en peso seco promedio fue de 399.3 g/m^2, y el total de producción somática gonadal y de concha fue de 863.9 g/m^2 por año lo que da una tasa de producción de biomasa de 2.2:1, en la zona estudiada, encontramos una relación de 98 g/m^2 en biomasa y una producción total de 268.7 g/m^2, lo que da una tasa de 2.7:1, cinco décimas más alta, lo cual significa que aunque con menor abundancia los organismos son más grandes, con una relación de crecimiento exponencial entre el peso y la concha.

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Population Dynamics for Spiny Lobster *Panulirus argus* in Puerto Rico: A Progress Report

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ABSTRACT

Estimates of growth and mortality parameters for the spiny lobster *Panulirus argus* were estimated from length frequency data collected from Puerto Rico commercial biostatistical program from 1999 through 2000 using the FISAT software package. The corresponding values of L_∞ for female spiny lobsters using ELEFAN I ranged from 185 to 191 mm CL, and K values were 0.23 to 0.25. For males the L_∞ values ranged from 195 to 197 mm CL, and K value was estimated at 0.24 for both years. The length-converted catch curve total mortality Z estimates ranged from 1.32 to 1.35 for males and from 1.25 to 1.85 for females. The Z estimated from Jones length cohort analysis ranged from 1.01 to 1.02 for males and from 1.05 to 1.11 for females. Average exploitation ratios from the two different methods were well above the optimum exploitation rate (E = 0.5) suggesting overfishing. The Beverton relative yield per recruit model analysis for 2000 for males and females implies the Puerto Rico lobster fishery is operating very close to its Maximum Sustainable Yield (MSY) level and that no further increase in fishing effort is advisable.

KEY WORDS: Growth, mortality, *Panulirus argus*

INTRODUCTION

The Caribbean spiny lobster (*Panulirus argus*) is a valuable exploited marine crustacean inhabiting shallow shelf waters off the Caribbean region, the southern United States and Bermuda. In Puerto Rico, spiny lobster is harvested principally by traps and diving. About 15 % of Puerto Rico catch comes from the east coast, 45 % from the south coast and 35 % from the from the West Coast. The spiny lobster has consistently ranked as the most economically important marine shellfish species landed in Puerto Rico. Based on data from the Puerto Rico Department of Natural and Environmental Resources Fisheries Laboratory, for the period 1992 through 1998, spiny lobster value per pound ranged from 4.50 to 9.00 dollars (Matos 1999).

Spiny lobster management in Puerto Rico has been conducted under territorial and federal jurisdictions with a fishery management plan (FMP) administered by the Caribbean Fishery Management Council (CFMC). Indications of overfishing were observed in the US Caribbean during the early 1980s (CMFC 1985). The established regulations are:

i) A minimum size of 89 mm in carapace length;

ii) A prohibition against retaining egg-bearing lobsters;
iii) A requirement to land lobster whole, and
iv) Gear restrictions prohibiting the use of poisons, drugs or other chemicals as well as spears, hooks explosives, or similar devices in harvesting spiny lobsters.

Due to concerns caused by the intensive exploitation of the resource, the Puerto Rico spiny lobster fishery and biological data have been periodically re-examined by the National Marine Fisheries Service (NMFS), Southeast Fisheries Science Center (Bohnsack et al. 1992, Bolden 2001). However, problems with data collection and database management procedures, have so far limited the types of analyses that were possible to provide sound stock assessment of this species.

This study attempts to evaluate the use of length frequency analysis based upon biostatistical data from the Puerto Rico commercial lobster fishery to estimate growth and mortality parameters, and to construct a reliable yield per recruit analysis.

METHODS

Biostatistical data of *P. argus* were collected by port agents from 1999 to 2000. Carapace length (CL) was measured to the nearest 0.1 mm and sex was determined. The sample size per month ranged from 0 to 137 individuals. Biostatistical data were entered into the Trip Interview Program (TIP) developed by the National Marine Fisheries Service (NMFS), Southeast Fishery Science Center. Later, the data were converted and analyzed in Excel. To enhance modal definition for length frequency analysis, samples were pooled trimonthly for each year and assigned a single collection date.

Estimation of Growth Parameters and Mortality

Analysis of growth parameters assumes von Bertalanffy growth: $L_t = L_\infty (1-Le^{k(t-t_0)})$, where L_t is the carapace length at time t, L_∞ is the asymptotic length an individual would reach if it lived indefinitely, and k is the rate at which L_∞ is approached. The growth parameters L_∞ and K were estimated using ELEFAN I from the FISAT software package (Gayanilo et al. 1995). Comparisons of different estimates of growth parameters were done using the empirical equation of Pauly and Munro (1984): phi= Log_{10} K + 2 Log_{10} (L_∞). Recruitment patterns for males and females were estimated using the ELEFAN II from the FISAT program.

Instantaneous total mortality (Z) (Beverton and Holt 1957), fishing mortality (F) and length at first capture (Lc) were calculated using length-converted catch curve (Ricker 1975, Pauly 1984), and Jones length cohort analysis (Jones 1984). These analyses were performed by converting the data of each monthly sample to percent frequency and then weighting by square roots of the sample size. Giving all monthly samples equal weight prevents a single large monthly sample from being a major source of bias or from overly affecting the total annual sample. Since estimates of natural mortality (M) of spiny lobster for Puerto Rico are unknown,

we are using estimates from literature for subsequent analysis (M = 0.34) CFRAMP/FAO Spiny Lobster Stock Assessment Workshop (CFRAMP 1997). Exploitation rates were calculated with the Pauly and Soriano (1986) exploitation rate formula: E=F/Z. Yield per recruit analyses were conducted using Beverton and Holt yield/recruit relative (Y'/R) and biomass/recruit relative (B'/R) models (Beverton and Holt 1957).

RESULTS

Size Distribution

During the period of 1999 - 2000, 2,137 lobsters were measured, of which 1,037 were males and 1,100 females. The size range for males was from 62 mm to 216 mm CL whereas the size range for females was from 60 mm to 152 mm CL. The mean CL for males and females were 103.3 mm and 98.3 mm, respectively. The modes of the length frequency distribution for males and females were 89 mm and 90 mm, respectively (Figure 1). Twenty three percent and 17 % of all females and males, respectively, measured from 1999 to 2000 were below the minimum legal size (89.5mm). Figure 2 shows the recruitment patterns of *P argus* males and females. Year round recruitment with a single peak was observed for both males and females around summer.

Growth and Mortality Parameters

The estimated values of L_∞ for females ranged from 185 to 191 mm CL (Table 1), and K values ranged from 0.23 to 0.25. For males the L_∞ values ranged 195 to 197 mm CL, and K values were estimated at 0.24. Females had higher good fitness indices (Rn) of ELEFAN I.

The length-converted catch curve estimates ranged from 1.32 to 1.35 for males and from 1.25 to 1.85 for females (Table 2). Length at first capture (Lc) for males was around 88 mm and for females it ranged from 86.3 to 87.4 mm. The Z estimated from Jones length cohort analysis ranged from 1.01 to 1.02 for males and from 1.05 to 1.11 for females (Table 2). The exploitation ratios from length converted catch curve were between 0.74 - 0.75 for males and 0.73 - 0.82 for females. Whereas, exploitation rates from Jones length cohort analysis were around 0.66 for males and 0.68 to 0.71 for females. Average exploitation ratios from the two different methods were well above the optimum exploitation rate (E = 0.5) suggesting that Puerto Rico spiny lobster is fully exploited.

The mean fishing mortalities obtained Jones length cohort analysis for fully recruited length groups were around 0.67 - 0.68 for males while 0.71 - 0.94 for females, respectively. Mortality estimates from Jones length cohort analysis were used for the yield per recruit analysis since length catch curve methods tend to overestimate mortality parameters due to variable recruitment and migration of larger specimens (Baisre and Cruz 1994).

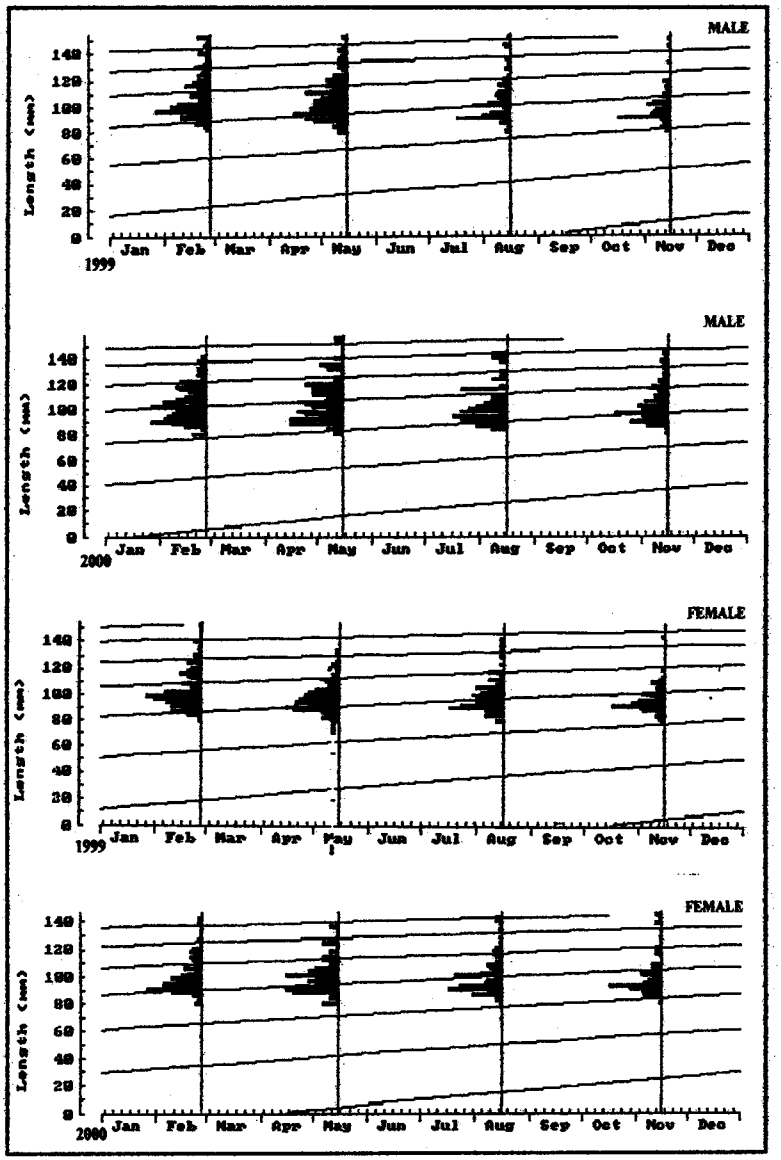

Figure 1. Length frequency distribution of the spiny lobster *Panulirus argus*, male and female, by year and von Bertalanffy growth curves produced by ELEFAN I.

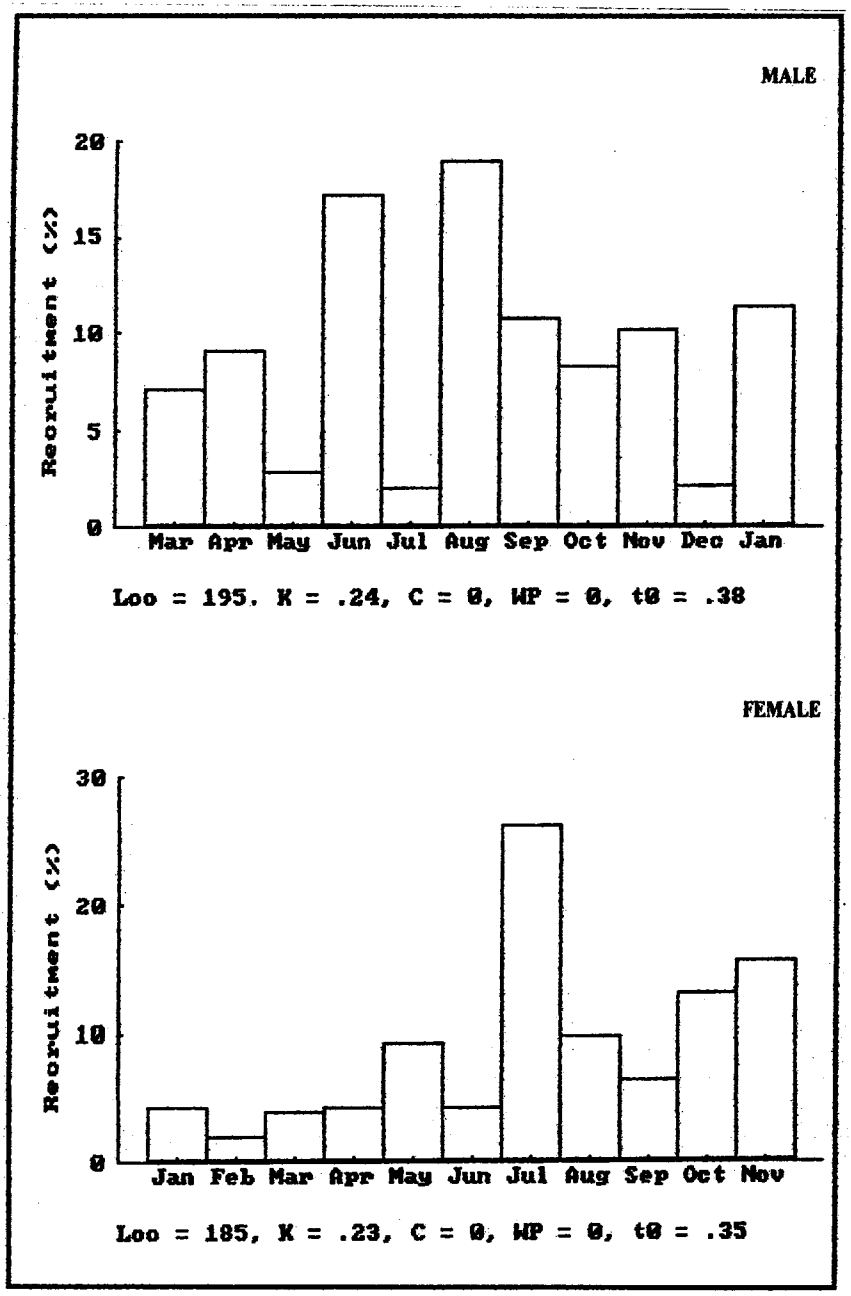

Figure 2. Recruitment patterns for *Panulirus argus*, male and female, for year 2000.

Table 1. Estimates of length (L¥), body growth rate (K), goodness of fit index (Rn), age at birthday (T0) and growth performance index j (phi) by sex for the spiny lobster, Puerto Rico using ELEFAN I.

Sex/Parameters		L¥	K	Rn	T0	j (phi)
Male	1999	197	0.24	0.129	0.38	3.96
	2000	195	0.24	0.138	0.38	3.96
Female	1999	191	0.25	0.142	0.29	3.96
	2000	185	0.23	0.139	0.28	3.89

Table 2. Estimation of fishing mortality (F), exploitation ratio (E = F/Z), and length at first capture (Lc) by sex using Length Catch Curves and Jones length cohort analysis for the spiny lobster, Puerto Rico.

		Length Catch Curve			Jones Length Cohort Analysis				
Sex/Parameter		Z	F	E	Lc	Z	F	E	Lc
Male	1999	1.32	0.98	0.74	88.02	1.02	0.68	0.66	87.96
	2000	1.35	1.01	0.75	88.35	1.01	0.67	0.66	88.05
Female	1999	1.85	1.51	0.82	87.70	1.11	0.94	0.73	87.45
	2000	1.25	0.91	0.73	86.25	1.05	0.71	0.68	86.25

Yield Estimates

The Beverton and Holt relative yield per recruit model for males in 2000 implies that with values of E = 0.66 and Lc = 88.05 mm the current lobster fishery is harvesting approximately near 95.6 % of the potential yield (Figure 3). Likewise, the analysis for females show that with a value of E = 0.68 and Lc = 86.2 mm the fishery is harvesting 94 % of the potential yield in females (Figure 3). The results also indicate that the current levels of fishing pressure have not exceeded the maximum sustainable levels. The E_{MSY} (exploitation rate at its maximum sustainable yield) for males and females (0.69 and 0.72, respectively) have not been surpassed by the current exploitation ratios (0.66 and 0.68).

DISCUSSION

Information on the general life history, as well as on growth rates, size frequencies, mortality rates, abundance indices and other parameters is paramount for effective fishery management of economically important species in Puerto Rico. Previous this study, no specific estimates of growth and mortality parameters existed for spiny lobsters from Puerto Rico.

On the last spiny lobster stock assessment workshop held by the Caribbean Fishery Management Council, the scientific panel attempted to build reliable yield per recruit analysis models using length frequency data from Puerto Rico commercial biostatistical data (Bohnsack et al. 1992). However, reliable estimates of growth parameters such as L_∞ (asymptotic length) and K (body growth coefficient) were unsuccessfully estimated for various reasons: data were limited and carapace measurements were to the nearest one tenth inch, which was too wide an interval to show distinct size frequency peaks.

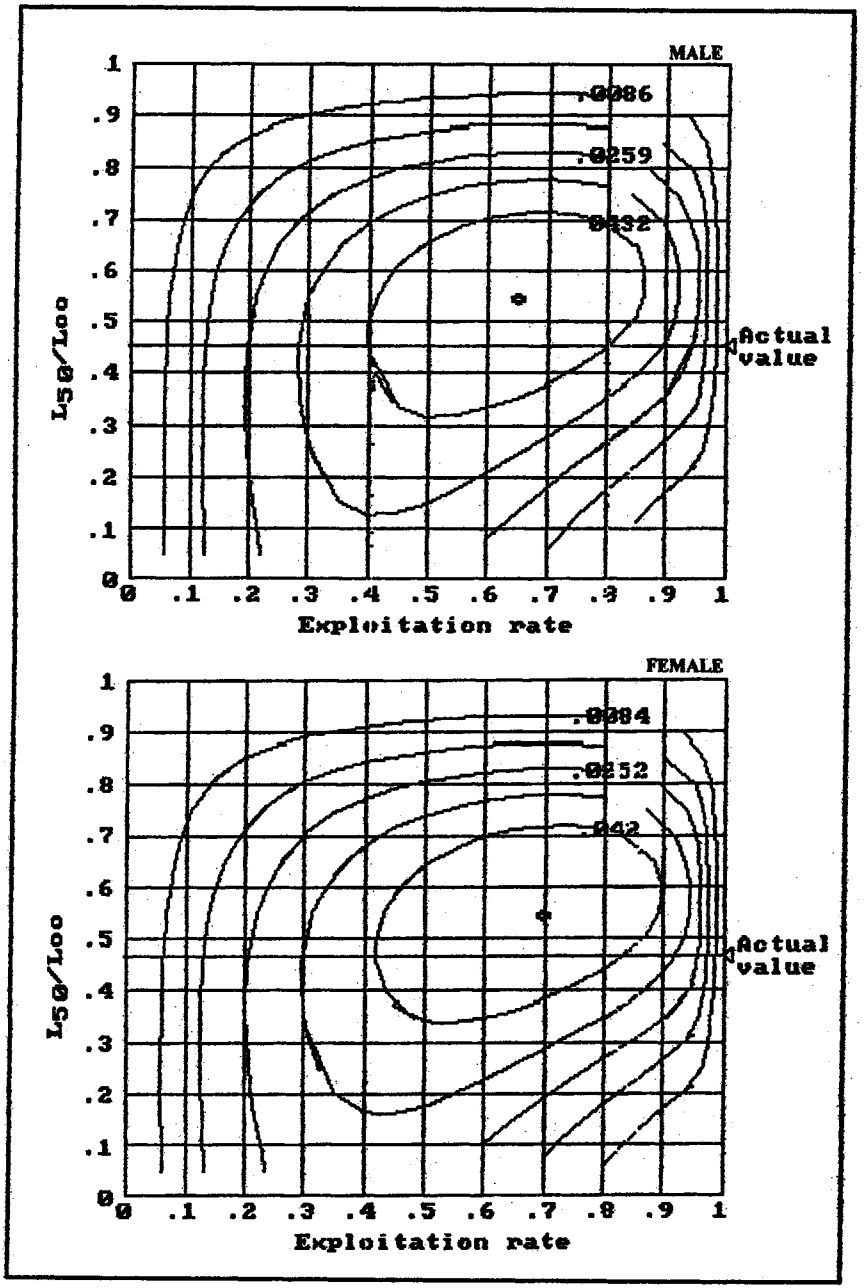

Figure 3. Yield per recruit isopleth for *Panulirus argus*, male and female, as a function of exploitation ratio (E) and size at first capture relative to asymptotic length (L_{50} / L_{∞}).

Growth rate is the most studied aspect of spiny lobster biology. However, accurate growth estimates are problematic due to the difficulty of separating the two main processes that affect spiny lobster growth: molting frequency and growth increment per molt. In general, the average growth rate for *Panulirus argus* of 5 - 8 mm increase in CL per month and there are four molts per year (Munro 1974; Lipcius 1985).

There are also artifacts when fitting spiny lobster growth through a von Bertalanffy growth function. The von Bertalanffy growth model simply describes the average growth of a spiny lobster cohort rather than the growth of an individual lobster which would be represented by a stepwise curve as a consequence of the moulting process (Haughton and King 1992). In addition, the model does not describe growth during larval stages. Nevertheless, it is still widely used to model spiny lobster growth although there is growing evidence that empirical growth models using moult increment and moult interval allow a better data interpretation (Baisre and Cruz 1994, Zetina and Rios 2001).

Growth curves estimated from ELEFAN I represented a rather poor fit to the peaks in the length frequency data. The goodness of fit (Rn) ranged from a minimum of 0.129 to a maximum of 0.142. The relatively poor fit of the growth curves suggested multiple recruitment pulses probably as a result of spawning year all round.

Estimates of growth parameters from elsewhere in the Caribbean indicate that *P. argus* is long lived, slow growing and has low rates of natural mortality (Munro 1974, Clairovin 1980, Lozano et al. 1991, Phillips et al. 1992, Haughton and King 1992, Leon et al. 1995). However, there are several discrepancies when comparing growth rates by gender. Cruz and de Leon (1991), Lozano et al. (1991), Castano and Cadima (1993), and Ivo (1996) estimated higher K values for females, whereas other studies report females with lower growth rates than males (Olsen and Koblic 1975, Waugh 1981, Gonzalez-Cano 1991, Leon et al. 1995, Gonzalez-Cano and Rocha 1995, and Mateo and Tobias 2002).

Table 3 gives estimates of growth parameters for *P. argus* from different parts of the Caribbean. Growth coefficients from *P. argus*, sexes combined, are generally low ranging from 0.16 to 0.45. Estimates of L_∞ have been reported to vary from 154 to 225 mm. The estimate of growth performance index (3.96) from *P. argus* males for year 2000 lie well within a 95 % confidence interval (3.90 - 4.02) of phi (φ) based on a mean of 3.96 (SE = 0.03). Similarly, the 2000 estimate of growth performance index for females using ELEFAN I (3.89) lie well within a 95 % confidence interval (3.77 - 3.91) of phi based on a mean of 3.84 (SE = 0.03).

Mortality estimates in *P. argus* are also difficult to obtain due to the lack of accurate age-based data (Baisre and Cruz 1994). Crustaceans have no permanent hard body parts, such as fish otoliths or molluscan shells, to carry a record of seasonal or annual changes in growth rates allowing actual ageing or validation of indirect ageing methods to take place. Age-based assessments of *P. argus* stocks are therefore hampered because, the calcified exoskeleton is shed at ecdysis leaving

no hard bony tissue from which annual ring markings can be distinguished. Mark and recapture methods often tend to overestimate growth and mortality parameters in panuliruds due to different sources of biases (ie higher probability of recapture of tagged individuals, loss of tags, nonreporting of recaptures, etc) (Baisre and Cruz 1994). As a result, the fitting of normal curves to polymodal length-frequency distributions appears to be the most promising means available. Size frequency distributions in animal populations are often polymodal, each mode representing an individual cohort. By separating these distributions into their component size classes, changes in position of these modes over time allow a population growth curve to be produced (Bhattacharya 1967). In *P. argus,* this method has moderate application due to the variability in individual growth; coupled with a slowing down in rates of growth in the older age classes, especially mature females (Haughton and King 1992).

Likewise, the migratory behavior of the spiny lobster can potentially give biased estimations of mortality. It is generally accepted that lobsters gradually migrate to deeper waters as they grow older. If lobsters migrate from the fishing grounds into deeper waters where they are inaccessible to fish traps and divers, such migrations would be incorporated in the total mortality value Z which therefore would be overestimated as well as the fishing mortality and exploitation ratios (Baisre and Cruz 1994).

Total mortalities (Z) from length catch curves ranged from 1.32 to 1.35 for males and 1.25 to 1.85 for females. These mortality estimates are more in agreement with data using length based methods from other highly exploited lobster populations in the region such as those of the Bahamas: Z = 1.44 (Waugh 1981); Jamaica: Z = 2.19 males, 2.88 females (Haughton and King 1992); Florida: Z = 2.59 (Warner et al. 1977), Z = 4.09 (Lyons et al. 1981), Z = 1.18 (Powers and Bannerot 1984), Z = 1.85 (Powers 1985); Brazil: Z = 1.27 (Fonteles-Filho 1994), Cuba: Z = 1.9-2 (Baisre and Cruz 1994), and St Croix, USVI: Z = 1.24-1.91 males, 0.8-1.58 females (Mateo and Tobias 2002).

However, average Z from Jones length cohort analysis for males ranged from 1.01 to 1.02 while females average instantaneous mortalities ranged from 1.05 to 1.11. These values are similar with other lobster stock assessment studies using length/age structured methods such as in Florida: Z = 1.09 for females, Z = 1.19 for males (Muller et al. 1997); Mexico: Z = 0.95 (Zetina and Rios 1998); St. Kitts: Z = 1.09 (Goodwin et al. 1986) and St Croix, USVI: Z = 0.83-1.13 males, 0.72 - 0.83 females (Mateo and Tobias 2002).

Exploitation rates from males and females calculated from all methods were greater than the accepted optimum level of 0.5 (Pauly and Soriano 1986) and suggest that spiny lobster fishery in Puerto Rico is under heavy fishing pressure.

The main recruitment seasons determined by ELEFAN are in agreement with other studies by Monterrosa (1986) and Boardman (1981) in which spiny lobster recruitment in Puerto Rico occurs year around with maximum seasonal pulses around late summer-early fall.

Table 3. Comparison of length (L∞) and body growth rate (K) by sex using Pauly's equation j (phi) (Pauly, 1984) for the spiny lobster from different areas in the Caribbean

Area	Sex	(L∞)	K	j (phi)	Source
Brasil	M	141	0.34	3.82	Dos Santos et al., 1964
	F	148	0.38	3.92	
St John	M	153	0.44	4.01	Olsen and Koblick, 1975
(USVI)	F	133	0.32	3.72	
Martinique	M	190	0.25	3.96	Clairovin, 1980
	F	188	0.23	3.91	
Bahamas	M	190	0.26	3.97	Waugh, 1981
	F	190	0.23	3.92	
Cuba	M	169	0.22	3.80	Cruz et al., 1981
	F	139	0.31	3.77	
Bermuda	M	204	0.18	3.87	Evans, 1988
	F	192	0.15	3.74	
Cuba	M	142	0.30	3.78	Baez et al., 1991
	F	122	0.3	3.65	
Mexico	M	257	0.2	4.12	Arce et al., 1991
	F	215	0.25	4.06	
Mexico	M	198	0.24	3.97	Gonzalez-Cano, 1991
	F	165	0.22	3.77	
Cuba	M	250	0.27	4.23	Phillips et al., 1992
	F	171	0.39	4.06	
Jamaica	M	210	0.24	4.02	Haughton and King, 1992
	F	195	0.28	4.03	
Nicaragua	M	169	0.23	3.82	Castano and Cadima, 1993
	F	160	0.40	4.01	
Cuba	M	190	0.31	4.05	Leon et al., 1994
	F	174	0.24	3.86	
Cuba	M	178	0.21	3.82	Baez et al., 1994
	F	171	0.21	3.81	
Cuba	M	185	0.23	3.90	Leon et al., 1995
	F	154	0.19	3.65	
Brazil	M	207	0.26	4.04	Gonzalez-Cano and Rocha, 1995
	F	162	0.18	3.67	
Mexico	M	217	0.25	4.07	Gonzalez-Cano and Rocha, 1995
	F	146	0.22	3.67	
Brazil	M	257	0.229	4.02	Ivo, 1996
	F	233	0.236	3.92	
St. Croix	M	192	0.25	3.96	Mateo and Tobias, 2002
(USVI)	F	172	0.22	3.81	
Puerto Rico	M	195	0.24	3.96	Mateo, In press
(2000)	F	185	0.23	3.89	(this study)

Evaluation of different exploitation strategies, in particular the trade-offs between small size at first capture and large size at first capture for *P. argus* males and females was done with the Beverton yield per recruit analysis. This model incorporates estimates of growth and mortality rates to estimate potential yield for any desired combination of fishery effort and minimum size. However, the reliability of this analysis of size and yield is limited by the quality of the parameters. Some parameters are not precisely estimated. This is very important because small changes in some parameters can make large changes in the predicted size at

maximum yield. This is particularly true for the estimates of fishing and natural mortalities, which are the least reliable of all the necessary parameters. It also estimates yield from the available recruitment and does not consider the effect of variable recruitment (Baisre and Cruz 1994).

Results from the yield per recruit analysis suggest there seems to be little potential for an increase in Y/R if effort were increased with the current length at first capture. Likewise, increasing length at first capture Lc with the current level of effort will not result in a significant increase of yield per recruit. The results of the model shows that most of the potential yield might be harvested by maintaining the current fishing effort at the present level or barely reducing it, However, no account is taken of the impact of reduction of spawner biomass on recruitment.

According to the Beverton model, yield is directly proportional to yield-per-recruit over a wide range of fishing mortalities only if it can be assumed that there is no relationship over a wide range of F and E values between the size of the parental stock and its progeny. Thus, the values of F or E needed to produce a maximum yield-per-recruit will tend to generate very low yields, because F_{max} and E_{max} usually reduce the parental stock to a level at which few recruits are produced.

Although the mortality estimates may be subject to considerable errors as consequences of violations of some assumptions made during analyses, the present level of fishing mortality appears to be much greater than the optimum required level for the lobster fishery suggesting that this fishery resource is fully exploited and current management measures must be revised to sustain and probably optimize yield.

Our findings, although preliminary, are in agreement with a recent study done by Bolden 2001 in which suggested a continuing trend toward growth overfishing as first identified by Bohnsack et al. (1992) 10 years ago. When Bolden compared historical biostatistical data from USVI and Puerto Rico from 1983 to 1999, she found that PR spiny lobster populations had smaller mean carapace lengths, frequency distributions centered around a smaller length class, lower fecundity, skewed sex ratios, and a greater portion of the landings being comprised of sublegal sized females compared to USVI. Another interesting finding is that from biostatistical data individual trip information, it was found that there has been a decline in lobster catch rates in Puerto Rico across years.

Management of the spiny lobster in the US Caribbean is complicated by failure to enforce regulations, a lack of local basic information on the biology and ecology of the species, and a lack of management oriented research. Long-term research designed to understand the dynamics of different stocks is usually limited to gathering data and hardly ever reaches the stage of data processing and publication. In certain cases, regulations have no clear biological or economical bases and are not closely enforced. Fishermen cooperation along with fishery researchers and government, which is of major importance for the success of sustained management, has historically depended on political decisions and does not exist for prolonged periods.

Regulations for the Spiny lobster in the US Caribbean have not changed in 17 years (CFMC 1985). The latest NMFS stock assessment studies from Bohnsack 1992 and Bolden 2001, although they provide useful information about the current status of the spiny lobster, their information from the biostatistical data have a low number of observations and have an associated degree of uncertainty. This associated uncertainty reduces the effectiveness with which the fishery may be managed. Thus, it is major importance that fully coordinated research involving fisheries researchers, government, fishermen, and industry be initiated in the near future to obtain critical data to permit the development of sound management strategies. At this actual moment, future yield from the spiny lobster stock seems dependent on effective enforcement of the minimum legal size limit to optimize yield from the available recruitment and prevent substantial further declines in spawning stocks.

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Test of Multi-species Spawning Aggregations

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ABSTRACT

Spawning aggregations are an essential phase in the life history of most commercially important finfish species of the Caribbean including snappers and groupers. These aggregations are under increasing threat from overfishing. This special symposium was designed to examine the ecology of spawning aggregations, the socio-economics of their exploitation, and examples of their effective management. Region-wide similarities in the ecology of aggregations and the threats to them may require consistency in monitoring approaches and management measures.

Belizean fishermen, national fisheries managers, and local and international conservation organizations recognized declines in the endangered Nassau grouper (*Epinephelus striatus*) and have conducted coordinated national monitoring efforts during 2001 – 2003. Data from these field surveys confirm that Nassau grouper stocks are depleted compared to historical records. These surveys also provided strong support for the hypothesis that multi-species spawning aggregations consistently occur at the shelf edge of windward facing reef promontories that jut into deep waters.

With new understanding from nation-wide surveys and unanimous support from conservationists and fishers alike, Belize enacted year-round fishing closures at 11 of these multi-species spawning aggregation sites within new Marine Reserves in November 2002, along with new closed season for Nassau grouper from January through March. This symposium has brought together over 50 aggregation fishers and a total of 450 scientists and managers from around the Caribbean Basin to address the issue of spawning aggregation monitoring and conservation at local and regional scales. The goal of the symposium was to foster shared regional efforts to conserve and manage spawning aggregations throughout the Gulf and Caribbean.

KEY WORDS: Multi-species spawning aggregations, conservation,

Conservación de las Agregaciones de Desove de Múltiples Especies

Las agregaciones de desove son una fase esencial en la historia de la vida de la especie de mayor importancia comercial en el Caribe incluyendo los pargos y meros. Estas agregaciones están bajo amenaza de aumento de la sobre pesca. Este simposio especial fue diseñado para examinar la ecología de agregaciones de desove, la socio-economi'a de su explotación, y para dar ejemplos de un manejo eficaz. A través de la región existen similitudes en la ecología de estas agregaciones y a las amenazas para estas están expuestas requieren consistencia en el tipo de monitoreo y en las

medidas de manejo.

Los pescadores de Belize, los encargados nacionales de las industrias pesqueras, y las organizaciones conservacionistas de índole local e internacional reconoce él decline en el mero de Nassau (*Epinephelus striatus*) una especie que esta puesta en la lista de las especies en peligro. Estas entidades han conducido esfuerzos de monitoreo nacionales coordinados durante 2001- 2003. Los datos de estos muestreos de campo confirman que el stock del mero de Nassau ha sido eliminado cuando se comparó a los expedientes históricos. Estos exámenes también proporcionaron fuerte apoyo a la hipótesis que dice agregaciones de desove de especies múltiple ocurren constantemente en el borde de la plataforma de los promontorios de barlovento del arrecife en ves que en las aguas profundas.

Con la nueva comprensión de muestreos a escala nacional y la ayuda unánime de conservacionistas y de los pescadores, Belice decretó un cierre total a lo largo de todo el año de la pesca en 11 de estas agregaciones de múltiples especies dentro del marco de las nuevas reservas marinas en Noviembre de 2002, Al mismo tiempo decreto una nueva época de veda para el mero de Nassau a partir de Enero y hasta Marzo. Este simposio ha reunido sobre 50 pescadores de las agregaciónes y un total de 450 científicos y administradores de la región del Caribe para tratar la aplicación la supervisión y la conservación de las agregaciones en escalas locales y regionales. La meta del simposio era fomentar esfuerzos regionales compartidos para conservar y manejar las agregaciones de desove a través del Golfo de México y del Caribe.

INTRODUCTION

Fisheries globally are surpassing carrying capacities causing severe depletions; reef fish fisheries within the Gulf and Caribbean are no exception (FAO 1994, Jackson et al. 2001). Coral reefs throughout the world are also under duress and showing declines in diversity and live coral cover. Marine protected areas are now being used to mitigate habitat loss, and to assist in fishery management. In order to provide maximum benefits for fisheries and biodiversity protection however, these protected areas must be supported locally, be placed strategically, managed effectively, supported sustainably, and be linked by ocean currents into mutually replenishing networks.

For the sake of efficiency, marine protected areas, particularly in the tropics were multi-species fisheries dominate, should include critical life stages of many ecologically and commercially important species (Lindeman et al. 2000, Roberts et al. 2001). Spawning aggregations are crucial in the life history of most commercially important reef fishes. Many of the aggregations of snappers and groupers are transient in space and time (Domeier and Colin 1997), and collectively represent 100% of the annual reproductive output for these species (Shapiro 1987). Spawning aggregations serve as important "source sites" for reproduction. As such, gametes are released from these sites into ocean currents from which they can replenish other areas by recruitment. Source sites are particularly important for protection and should be included within marine reserve networks (Roberts 1997). Studies of the

marine connectivity between spawning aggregation sites nursery habitats by ocean currents has become an active area of research, and will help in designing marine protected areas networks that can be mutually replenishing (e.g. Colin 1995, Cowen at al. 2000, Lindeman et al. 2001). Two talks in this symposium (Kjerfve and Paris) will address this issue specifically.

The short duration abundances of fishes that appear at spawning aggregation sites have attracted fishermen to them. As these sites are discovered by fishers, anecdotal information about the timing and location of spawning aggregations have been passed by oral tradition. In some cases, this information is documented by researchers, and is slowly being revealed to biologists and managers (e.g. Claro and Lindeman 2003, Heyman 1996, Johannes 1978, Lindeman et al. 2000). But fishing pressure has caused the depletion of many of these sites throughout the Caribbean Basin, particularly for Nassau grouper (*Epinephelus striatus*) (Sadovy 1994). In Belize, declines have been sharp in recent years. Nassau grouper was harvested from a site at Caye Glory, reaching a peak in the late 1960s when two tons of fish per day were being removed from the area (Craig 1969). Recent surveys indicate that only 21 fish remained at the site (Paz and Grimshaw 2001) indicating dramatic declines. Several studies have documented declines in reef fish spawning aggregations in the Caribbean, particularly groupers, and highlighted the need for their protection (Auil-Marshalek 1994, Beets and Friedlander 1999, Coleman et al. 1996, Johannes 1997, Luckhurst 2002, Sadovy 1994, 1997, Sala et al. 2002).

Until recently, descriptions of spawning aggregations were generally focused on single species (e.g. Aguilar Perera 1994, Carter et al. 1994, Colin 1992, Smith 1992, White et al. 2002). However, recent studies in Belize, and other areas in the Caribbean are revealing what fishermen throughout the Caribbean may have known for generations. Many spawning aggregation sites are utilized by several different species for spawning throughout various times of the year. Studies in Belize have revealed, for example that one multi-species spawning site, Gladden Spit, harbors spawning aggregations of at least 26 different reef fish species (Heyman 1994; Heyman and Boucher, in prep. Heyman et al. 2001, Heyman et al. In prep.). Collaborative studies conducted with nine marine conservation and management organizations in Belize, and with the intimate involvement of fishers revealed at least 13 sites serve as multi-species spawning aggregations (Heyman and Requena 2002). The study further revealed that these aggregations were generally found at the shelf break (25 – 35 m) on windward facing reef promontories that jut into deep (> 500 m) water (Figure 1). This pattern was so robust as to allow prediction of new sites, using geo-referenced, remotely sensed Landsat TM images (Heyman and Boucher In prep.). This collaborative research process, including fishers, and the revealed patterns of the timing and locations of multi-species spawning aggregations, has lead to the declaration of 11 new marine reserves in Belize (November 2002) that protect these areas, and a closed season for Nassau grouper from December through March. These patterns are beginning to be documented in other countries around the Caribbean, using similar techniques (e.g. Claro and Lindeman 2003, presentations in this symposium by Aguilar, Medina-Quej, Tuz-Sulub, and Whaylen). these areas,

and a closed season for Nassau grouper from December through March. These patterns are beginning to be documented in other countries around the Caribbean, using similar techniques (e.g. Claro and Lindeman 2003, presentations in this symposium by Aguilar, Medina-Quej, Tuz-Sulub, and Whaylen).

A recent Caribbean wide survey of marine protected areas in the Caribbean revealed that very few spawning aggregations had been specifically included in marine protected areas (Appledoorn and Lindeman 2003). To date, few efforts have been made to bring fishermen actively into the process of research and conservation of fish spawning aggregations, and their inclusion in marine protected areas. This symposium invited 50 fishers from around the Caribbean Basin to participate, including two from Belize (Young and Cuevas) who will speak to the assembly in support of spawning aggregation protection and the involvement of fishers in this process. The Nature Conservancy, along with local conservation organizations in Belize, has promoted economic alternatives for spawning aggregation fishers, via training in SCUBA guiding, fly fish guiding. These alternatives are helping fishers wean themselves from extractive fishing on aggregations and have helped to build their support for marine protected areas declaration and management.

The symposium will be concluded with the words of the Hon. Minister of Fisheries from Belize, Daniel Silva, who will offer encouraging words for the future and draw participants into action.

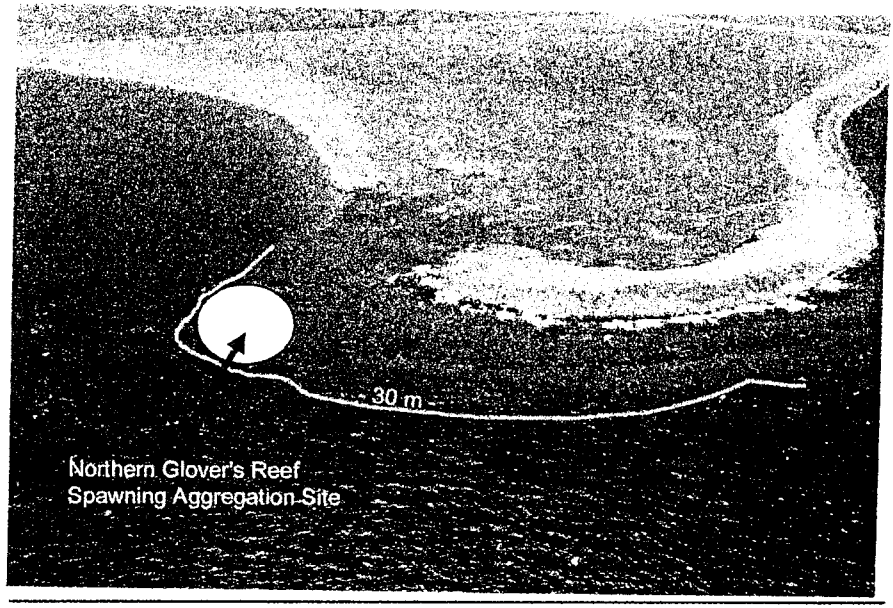

Figure 1. Multi-species spawning aggregation site at northern Glover's Reef Atoll in Belize as described in Sala et al. 2002.

SYMPOSIUM CONTENT

Aguilar, A. - Detection of Fishing Effects on a Nassau Grouper Spawning Aggregation from Southern Quintana Roo, Mexico

Luckhurst, B.E. - Current Status of Conservation and Management of Reef Fish Spawning Aggregations in the Caribbean

Medina-Quej, A. et al. - A Preliminary Survey of the Nassau Grouper (*Epinephelus striatus*) Spawning Aggregation at "El Blanquizal" in the South Coast of Quintana Roo, Mexico

Young, C. and E. Cuevas – Fishermen perspective on spawning aggregation management

Kjerfve, B. et al. – Connectivity of spawning aggregations in the inner Gulf of Honduras

Paris, C.B. et al. - Modeling Larval Transport from Snapper Spawning Aggregations (Lutjanidae) in Cuba

Rhodes, K.I. – Hong Kong Live Reef fish Trade

Tuz-Sulub, A. et al. - Preliminary Characterization of the Space Distribution of Several Species of Groupers (Epinephelinae: Epinephelini) in a Spawning Site in the Campeche Bank, Yucatan, Mexico

Whaylen, L. et al. - Observations of a Nassau Grouper (*Epinephilus stiatus*) Spawning Aggregation Site in Little Cayman, Including Multi-species Spawning Information

Silva, D. – Minister of Fisheries for Belize – Closing Remarks - Political will for management

SYMPOSIUM RESULTS

The symposium provided an opportunity for fishers and managers from around the region to learn about and discuss the physical and ecological dynamics, and the need for management of spawning aggregation sites. Talks on connectivity by Paris and Kjerfve indicated that distant sites around the Caribbean are linked by oceanic currents. Talks by Heyman, Tuz-Sulub, Medina-Quej, and Whaylen underlined that many aggregation sites serve for multiple species. The talk by Belizean aggregation fishers, Young and Cuevas clearly demonstrated understanding of present and past conditions and the need to manage these sites. Leadership from the fishing community in management, and the development of economic alternatives for displaced fishers was a key element of success in Belize. Luckhurst's talk offered a regional look at the bleak status of aggregations around the region. Finally, Hon. Minister Dan Silva offered a note of urgency and action to the session, by announcing the imminent and sweeping legislation for the protection of Nassau

grouper and spawning aggregation sites. He signed the legislation two days after the completion of this Gulf and Caribbean Fisheries Institute Meeting.

DISCUSSION AND RECOMMENDATIONS

Discussions during and after the meetings lead to a series of recommendations as follows:

i) Reduce or eliminate fishing mortality at vulnerable SPAG sites. A sense of urgency should be invoked for management /conservation action,

ii) Incorporate known SPAG sites into planning programs for Marine Protected Areas (MPAs) to provide permanent protection for SPAG sites,.

iii) Develop and implement monitoring programs involving scientists and user groups within the community and using standard protocols to evaluate the effect of management and conservation measures,

iv) Develop community-based management programs for SPAG sites to the fullest extent possible. Full participation in the management process by all of the user groups affected by management measures will greatly increase the probability of success,

v) Provide viable economic alternatives to those user groups who are displaced from SPAG sites as a result of management action, and

vi) Regional networks of protected areas should be designed using principles of connectivity.

In lively discussions following the symposium, participants began work on an implementation plan for this regional strategy, strongly urging the use of electronic media and the Internet to disseminate information about SPAGs. A draft regional policy statement was developed and is online at http://www.gcfi.org/55th_gcfi.htm. Notes from the meeting and a downloadable spawning aggregations monitoring protocol for the Caribbean (Heyman et al. 2002) is available at: http://nature.org/initiatives/marine/work/art9363.html and comprehensive monitoring protocol (Colin et al. 2002) is also available at www.scrfa.org. It was further urged that veteran SPAG fishermen play an increasing role in data collection and conservation process, given their understanding of the ecology and historical perspective on changes in conditions. It was agreed that more tests of the applicability of remote sensing to predict the location of SPAGs in the region are called for. A regional network of marine protected areas, that protect important multi-species spawning aggregations, could contribute to regional fisheries management and help to conserve biodiversity.

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Current Status of Conservation and Management of Reef Fish Spawning Aggregations in the Greater Caribbean

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ABSTRACT

A total of 35 species in ten families are known to form spawning aggregations in the greater Caribbean. The current status of reef fish spawning aggregations by country and species is presented for the region. There appears to be a general declining trend in the landings from most spawning aggregation sites. Principally in the past 10 years, several countries in the region have implemented conservation measures to protect spawning aggregation sites. The majority of these measures involve seasonally closed areas and there have been positive effects demonstrated from active management of spawning aggregations. A number of sites (principally Nassau grouper) have disappeared in the past 25 years and urgent management action is required to address increasing fishing pressure. The elements of a regional conservation and management strategy for spawning aggregations are presented as are suggestions for the dissemination of information about spawning aggregations in the region.

KEY WORDS: Spawning aggregations, Caribbean, management, conservation, status

Estado Actual de la Conservación y de la Gerencia de las Agregaciones de Desovo de Peces de Arrecifes en el Caribe

Se revisa el estado actual de las agregaciones de desove de los pesces de arrecife en el Caribe. En los últimos 10 años más países han puesto las medidas de conservación en ejecucio'n para protejer los sitios de las agregación, la mayoría de estas áreas estan estacionalmente cerradas. Un número de sitios han desaparecido en los últimos 25 años y una acción urgente de manejo es requeridad para poder tratar de eliminar la presión y el aumento de la pesca en estas áreas . Los elementos de una estrategia regional de la conservación y de la gerencia serán discutidos.

PALABRAS CLAVES: Agregaciones de desovo de peces, conservación, Caribe

INTRODUCTION

Reef fish spawning aggregations are documented throughout most of the Caribbean and Central America but appear to be more common in the northern and western portions of this geographical region. The essential element of a spawning aggregation (SPAG) is that it has a relatively high level of predictability in space and time. Domeier and Colin (1997) defined two different types of spawning aggregations, "transient" and "resident" using the following three criteria:

i) The frequency of aggregations,
ii) The longevity of aggregations, and
iii) The distance traveled by fish to the aggregation.

Groupers and snappers form "transient" aggregations with the following characteristics:

i) Fish frequently migrate long distances to the aggregation site sometimes using specific routes (e.g. Nassau grouper; Bolden 2000),
ii) Aggregations typically form for only 1-3 months of the year,
iii) The duration of the aggregation is from several days (e.g. Tiger grouper; Sadovy et al. 1994) to a few weeks,
iv) The formation of aggregations is entrained to the lunar cycle, and
v) Aggregations occur during a limited period of the year (environmental parameters such as water temperature or rate of change of temperature appear to be important factors in the timing of aggregations) (e.g. Red hind; Luckhurst 1998).

In contrast, "resident" aggregations are characterized by their frequency of occurrence (often daily), short travel distances and limited duration (often 1-2 hours). Most "resident" spawning aggregations occur with reef fish species which are generally non-commercial such as parrotfishes (Scaridae), wrasses (Labridae) and surgeonfishes (Acanthuridae). Spawning behaviour of many of these species is described in Colin and Clavijo (1988).

Given these differences in the two aggregation types, there are some generalizations which can be made concerning "transient" spawning aggregations. Both groupers and snappers are comprised of higher trophic level species and the larger species in each of these two families tend to form aggregations. It appears that all reproductive activity takes place in these aggregations as there is no evidence of spawning in these species outside the aggregation (Sadovy 1996). Thus, the total annual reproductive output of the population occurs at the SPAG sites.

The major threat to SPAGs in the greater Caribbean region is overfishing. Although there may be some evidence that habitat damage (e.g. hurricanes impacting on reef habitats) could be a factor, it is clear that overfishing is the factor which needs to be addressed as a priority. Fishing effort at SPAGs typically removes the oldest and largest fish from the population (Coleman et al. 2000). Most grouper species are protogynous hermaphrodites (change sex from female to male) which means that the largest fish in the population are generally males (Shapiro 1987). The removal of a large number of males through aggregation fishing may lead to disruption of the entire spawning pattern of the species (Coleman et al. 1999). A

recent survey of the status of reef fish stocks in the U.S. indicated that 73% of the species considered most overfished are protogynous hermaphrodites (Coleman et al. 2000).

The depletion of reef fish resources which form SPAGs in the greater Caribbean region has both negative ecological and socio-economic impacts, but these effects are not, as yet, well documented. These impacts can potentially be mitigated by the development and improvement of marine resource management measures at both the level of the specific site and at the national level.

RESOURCE MANAGEMENT PRINCIPLES FOR REEF FISH SPAWNING AGGREGATIONS

It is now widely recognized that the management of multi-species coral reef and warm-temperate fisheries using most conventional fishery management tools is unlikely to achieve the level of success desired by resource managers (Coleman et al. 1999). There is rarely a sufficient level of understanding of interspecific and community-level interactions to direct management action at a given species (Lindeman at al. 2000) without negative or unforseen ecological impacts. In the absence of detailed biological information and understanding of the dynamics of the populations of the target species, it is unreasonable and impractical to pursue finely tuned management programs. However, the formation of SPAGs at well-defined times and locations by a number of different species offers a management option which can be both simple and effective. Although the state of knowledge of the dynamics of SPAGs is limited, there exists compelling evidence which indicates that intense fishing pressure at SPAG sites is not sustainable in the long-term (e.g. Gag grouper; Koenig et al. 2000). Therefore, a practical approach to managing SPAGs is to take management / conservation steps to limit fishing mortality to prevent the depletion of the SPAG. Without timely management action, some SPAGs may simply disappear. This is well documented for Nassau grouper at various locations in the wider Caribbean (Sadovy and Eklund 1999).

When fishing mortality of males is high, there may be an insufficient number of males available to fertilize all of the spawning females. This can lead to reduced reproductive output from the population. In addition, the removal of males may cause a greater female-bias in the population sex ratio to develop, further contributing to the disruption of the reproductive process (Coleman et al. 1999). In the case of gonochoristic species such as snappers, the largest females make a disproportionate contribution to the reproductive output of the population (size-fecundity relationships are usually exponential – or, in other words, "bigger females produce many more eggs") (e.g. Red snapper; PDT 1990). The removal of many large females due to aggregation fishing similarly reduces the reproductive output of the population (Coleman et al. 1999). From the foregoing, it is clear that the guiding principle for the management of SPAGs is the reduction of fishing mortality at these sites. At vulnerable sites, the elimination of fishing mortality through

permanent closure of the site may be the only practical management option if the site is to remain reproductively viable.

SUMMARY OF CURRENT STATUS OF SPAWNING AGGREGATIONS BY COUNTRY OR JURISDICTION IN THE GREATER CARIBBEAN REGION

A list of the species documented to form spawning aggregations in the region (Table 1) indicates that there are a total of 10 families and 35 species involved. As expected, the list is dominated by the commercially important groupers (Serranidae) and snappers (Lutjanidae) with eight and seven species respectively. However, the jacks (Carangidae) which are also commercially important in the region, have a number of species listed although relatively few observations have been documented of the formation of SPAGs by these species. The other commercially important families are the grunts (Haemulidae) and the wrasses (Labridae, one species). Virtually all of the species listed in Table 1 may potentially be captured with non-selective Antillian fish traps but there is little directed fishing effort for a number of the reef fish species listed here because they are generally not commercially exploited.

The evaluation of the number of SPAGs and their status in the region (Table 2) is based on the best information available. However, the documentation of SPAGs in the different countries in the region is highly variable. Evaluation of their current status is even more variable. In some instances, there is published information and data on given sites while for a number of others, there is only anecdotal information. With increasing awareness of the importance of SPAGs in the region, the acquisition of information and data should increase substantially.

It is clear from Table 2 that the majority of SPAG sites appear to be suffering declines in landings and that the Nassau grouper in particular has been significantly impacted by fishing pressure with the disappearance of a number of SPAGs in different countries (Sadovy and Eklund, 1999). The only species /sites which appear to be stable are those which have specific management measures in place for SPAGs (principally seasonal area closures). It is not possible to prove cause and effect but these findings strongly suggest that active management of SPAGs (centred on limiting fishing mortality) can be highly beneficial to the populations under exploitation.

Table 1. List of species documented to form spawning aggregations in the greater Caribbean region. The species list is based on published accounts of spawning or documentation by scientific observers of one or more of the criteria associated with spawning aggregations. Not all species included meet the criteria established by Domeier and Colin (1997) to designate a spawning aggregation species but are included on the basis of unpublished scientific observations.

Family	Species	Common Name
Serranidae	*Epinephelus adscensionis*	Rock hind
	E. guttatus	Red hind
	E. itajara	Goliath Grouper
	E. striatus	Nassau grouper
	Mycteroperca bonaci	Black grouper
	M. microlepis	Gag grouper
	M. tigris	Tiger grouper
	M. venenosa	Yellowfin grouper
Lutjanidae	*Lutjanus analis*	Mutton snapper
	L. apodus	Schoolmaster
	L. cyanopterus	Cubera snapper
	L. griseus	Gray snapper
	L. jocu	Dog snapper
	L. synagris	Lane snapper
	Ocyurus chrysurus	Yellowtail snapper
Acanthuridae	*Acanthurus bahianus*	Ocean surgeon
	A. coeruleus	Blue tang
	A. chirurgus	Doctorfish
Haemulidae	*Anisotremus surinamensis*	Black margate
	Haemulon album	White margate
	H. plumieri	White grunt
	H. sciurus	Blue-striped grunt
Mullidae	*Pseudupeneus maculatus*	Spotted goatfish
Scaridae	*Scarus iserti*	Striped parrotfish
	Sparisoma rubripinne	Yellowtail parrotfish
Carangidae	*Carangoides ruber*	Bar jack
	Caranx bartholomaei	Yellow jack
	C. crysos	Blue runner
	C. hippos	Crevalle jack
	C. latus	Horse-eye jack
	Seriola dumerili	Greater amberjack
	S. rivoliana	Almaco jack
Labridae	*Lachnolaimus maximus*	Hogfish
Balistidae	*Canthidermis sufflamen*	Ocean triggerfish
Ostraciidae	*Lactophrys trigonus*	Buffalo trunkfish
	L. triqueter	Smooth trunkfish

Table 2. Summary of current status of spawning aggregations (SPAGs) in the greater Caribbean area by country and species. Only commercially exploited species are listed. Countries with documented spawning aggregations are listed from north to south. Status refers primarily to documented fishery landings but may include fishery independent evaluation of given aggregation sites. Status reflects an overall trend in recent years but may not accurately reflect the current status (2002) as changes can occur rapidly at SPAG sites.

Country/ State	Total SPAG Sites	Species Involved	Current Status (Landings)	Reference / Source
Bermuda	3	Red Hind	Stable	Luckhurst, 1996; MS
	4	Nassau Grouper	Disappeared	Luckhurst, 1996
Bahamas	22	Nassau Grouper	Declines Heavily expl.	Braynen, pers. comm., Ray et al., 2000
Turks and Caicos Islands	5	Nassau Grouper	Lightly exploited	Clerveaux, pers. comm.
Florida	3	Cubera snapper	Declines	Lindeman et al., 2000
25 total sites including :	1	Dog snapper	?	Lindeman et al., 2000
Dry Tortugas	8	Gray snapper	?	Lindeman et al., 2000
Key West area	1	Lane snapper	?	Lindeman et al., 2000
Gulf Coast	4	Mutton snapper	Declines	Lindeman et al., 2000
	2	Schoolmaster snap	?	Lindeman et al., 2000
	1	Yellowtail snap	?	Lindeman et al., 2000
	?	Black grouper	Declines ?	Eklund et al., 2000
	2?	Gag grouper	Declines	Coleman et al., 1996
	?	Scamp	Declines	Coleman et al., 1996
	>4?	Goliath grouper	Protected	Sadovy & Eklund, 1999
Cuba (21 total sites)	10	Cubera snapper	Declines	Claro and Lindeman, in press
	3	Dog snapper	Declines	Claro and Lindeman, in press
	3	Gray snapper	Declines	Claro and Lindeman, in press
	13	Lane snapper	Declines	Claro and Lindeman, in press

Table 2 continued:

Country/ State	Total SPAG Sites	Species Involved	Current Status (Landings)	Reference / Source
	12	Mutton snapper	Declines	Claro and Lindeman, in press
	5	Black grouper	Declines	Claro and Lindeman, in press
	9	Nassau grouper	Declines	Sadovy & Eklund, 1999
	6	Yellowfin grouper	Declines	Claro and Lindeman, in press
	1	White margate	Declines	Claro and Lindeman, in press
Mexico - Quintana Roo	7	Nassau grouper	Declines / 1 Disappeared	Aguilar-Perera and Davis, 1996
Campeche Bank	1	Yellowfin grouper	Heavily expl.?	Tuz-Sulub, in press
	1	Red hind	Mod. expl. ?	
Belize	1	Cubera snapper	Heavily expl.	Heyman, pers. comm.
(13 total sites)	4	Dog snapper	Heavily expl.	Heyman, pers. comm.
	3	Mutton snapper	Heavily expl.	Heyman, pers. comm.
	?	Yellowtail snap.	?	Heyman, pers. comm.
	9	Nassau grouper	Declines /	Paz and Grimshaw,2001
			Disappeared	Sala et al., 2001
	5	Black grouper	Lightly expl?	Heyman, 2001
	4	Tiger grouper	Lightly expl?	Heyman, 2001
	2	Yellowfin grouper	Lightly expl?	Heyman, 2001
	?	Red hind	Lightly expl?	Heyman, 2001
Honduras - Guanaja	1	Nassau grouper	Disappeared?	Fine, 1992; Sadovy & Eklund, 1999
Cayman Islands	6	Nassau grouper	Declines	Bush et al, MS
	5	Tiger grouper	Lightly expl.	Bush, pers. comm.
	2	Mutton snapper	Lightly expl.	Bush, pers. comm.
Jamaica	1	Lane snapper	Heavily expl	Aiken, pers. comm.
Dominican Republic	1	Nassau grouper	Disappeared?	Sadovy & Eklund, 1999

Table 2 continued:

Country/ State	Total SPAG Sites	Species Involved	Current Status (Landings)	Reference / Source
Puerto Rico	4	Red hind	Declines	Matos-Caraballo, 1997
	1	Tiger grouper	Declines	Matos-Caraballo et al,
	3	Nassau grouper	Disappeared	Sadovy & Eklund, 1999
	1	Mutton snapper	Declines?	Garcia-Moliner, 2000
U.S. Virgin Is.	3	Red hind	Stable	Beets & Friedlander, '99
	3	Nassau grouper	Disappeared	Olsen & Laplace, 1976
British Virgin Islands	3	Red hind	Lightly expl.	Eristhee, pers. comm.
	1	Nassau grouper	Lightly expl.	Eristhee, pers. comm.
	2	White margate	Lightly expl.	Eristhee, pers. comm.

SUMMARY OF FISHERIES MANAGEMENT MEASURES RELATED TO SPAWNING AGGREGATIONS IN THE GREATER CARIBBEAN REGION

There have been a number of fisheries management measures implemented for SPAGs in the region (Table 3) but the majority have only been in place for 10 years or less. Bermuda was the first jurisdiction to specifically protect SPAG sites in 1974 (Luckhurst, 1996) followed by other management measures some years later. In many jurisdictions, management and regulations have been put in place "too late", after significant declines in spawning biomass have occurred. Because the understanding of the dynamics of SPAGs and the time frame of depletion has been slow to accumulate, management action has often not been taken with the urgency necessary to redress the depletion of populations. Once the spawning population biomass falls below some threshold value then recovery under management may not occur even after a number of years. The rate of recovery is likely to be species dependent.

The only scientifically documented examples of the presumed effects of management on SPAGs are for the red hind. In three jurisdictions, significant increases in mean size were observed following the seasonal closure of red hind SPAG sites - Puerto Rico (Matos-Caraballo, 2002), U.S. Virgin Islands (Beets and Friedlander, 1999) and Bermuda (Luckhurst, MS). Similar documentation of the beneficial effects of site closures for other species forming SPAGs has not yet appeared in the published literature.

Table 3. Summary of existing fisheries management measures related to SPAGs by species and country or jurisdiction.

Country	Species	Management Action / Year	Remarks
Bermuda	Red hind	Seasonal area closure (May-August) of 2 sites - 1974	Landings declined in following years before stabilization after trap ban
	Red hind	6) Seasonal closure of additional SPAG site -1990 2) Seasonal (May-August) bag limit of 10 fish per boat per day - 1990	1) Increased number of protected sites to 3. 2) To limit sale of fish caught illegally at SPAG sites
	Red hind Black grouper Yellowmouth grouper	Minimum legal sizes for listed species - 1996 Bag limit - 1 fish /boat /day, for black and yellowmouth grouper - 1996	To assist in protection of spawning stock biomass and to aid in population recovery
	Grouper - Red Nassau, Tiger, Yellowfin	No take/no possession - 1996	Protect to allow population recovery of grouper species with low abundance
Bahamas	Grouper and rockfish	Landing of grouper < 3 lbs. is prohibited - 1986	Protect spawning grouper biomass
	Nassau grouper	Seasonal closure of High Cay site,Andros - 1998-2001	Closures for 3 x 10 day periods around full moon
	Nassau grouper	Seasonal closure of 2 sites, Long Island - 1999-2001	Closures for 3 x 10 day periods around full moon
Florida (Riley's Hump)	Mutton snapper	Seasonal closure (May-June) of designated area - 1998-2001	Protect SPAG site
	Snappers - Mutton, Gray, Cubera, Dog, Yellowtail	Permanent closure of designated area - 2001	Protection of multi-species SPAG site
E. Gulf of Mexico	Goliath grouper	Protected species - 1991, no take, no possession	Abundance at SPAG sites has slowly increased
Mexico (Yucatan)	Nassau grouper	No spearfishing at SPAG site Mahahual – 1993	Declines in abundance due to heavy fishing pressure
Belize	Nassau grouper	Seasonal closure at Glover's Reef – 1990?-1998?	Conservation measure
	All aggreg. spp.- groupers and snappers	Permanent closure of 13 SPAG sites throughout the country - 2002?	Unprecedented cooperation between Govt., fishers and NGOs for conservation
Cayman Islands	Nassau grouper	No spearfishing at SPAG sites, no trapping within 1 nm of SPAG Protected Area during spawning season (Nov. 1-Mar. 31) - 1990s? Alternate year fishing strategy starting 2003, bag limit 12 fish/boat/day when in fishing years	Reduction of fishing mortality by gear restrictions/ catch limits and temporal closures

Table 3 continued:

Puerto Rico	Red hind	Seasonal closure of 4 SPAG sites off west coast - 1995	Increase in CPUE and mean size, west coast - 1996-99
U.S. Virgin Is.	Mutton snapper	Seasonal closure of SPAG site in St. Croix - 1995?	No data on efficacy of measure is available
	Red hind	Seasonal closure of SPAG site in St. Thomas - 1990	Mean size increased; sex ratio less skewed - 1997
British Virgin Is.	Red Hind	Seasonal ban (Jan - Mar) on possession of red hind - 1999	Eliminates market for fish taken at SPAG sites

CONCLUSIONS AND RECOMMENDATIONS

Given the disappearance of a number of Nassau grouper SPAG sites and the general declining trend of landings at most SPAG sites in the region, the need for active management and conservation measures is apparent. In the locations where SPAG management has been implemented, there has been a positive impact on stock condition and often in a relatively short time frame. There is growing recognition of the ecological significance of SPAG sites to the balance of coral reef ecosystems and the need to conserve these sites.

The following recommendations are made to mitigate the effects of overfishing of SPAGs. They are mainly derived from the elements outlined for a Caribbean Regional Conservation Strategy for Reef Fish Spawning Aggregations (Luckhurst 2002). The recommendations are generally listed in priority order but should be adapted to the specific conditions found at each site:

i) Eliminate fishing mortality at vulnerable SPAG sites. If permanent closure of a site is not possible then a seasonal closure should be invoked. There should be a sense of urgency for management /conservation action as SPAGs may show sudden and rapid declines under intense fishing pressure.

ii) Incorporate known SPAG sites into planning programs for Marine Protected Areas (MPAs) to provide permanent protection of SPAG sites. This is often the best option for the protection of SPAG sites as it has multiple benefits for the health of the coral reef ecosystem.

iii) Develop and implement monitoring programs involving scientists and user groups within the community to evaluate the effect of management /conservation measures. The demonstration of the positive effects of management to user groups can be a compelling factor in developing support.

iv) Develop community-based management programs for SPAG sites to the fullest extent possible. Full participation in the management process by all of the user groups affected by management measures will greatly increase the probability of success.

v) Provide viable economic alternatives to those user groups who are displaced from SPAG sites as a result of management action.

It is recommended that a network be established of marine resource managers, scientists and fishermen at key sites throughout the region to promote the systematic collection of information and data about SPAGs. This should enhance our knowledge of the numbers and diversity of SPAG sites in the region. The use of a standardized protocol for data collection should be promoted in order to facilitate comparisons amongst sites. The data and information collected through this proposed regional network should be provided to an international umbrella organization such as SCRFA (Society for Conservation of Reef Fish Aggregations) which is developing a global database on SPAGs.

The efficient dissemination of information regarding SPAGs to relevant organizations within the region including government departments, academic institutions and Non-Governmental Organizations (NGOs) could be accomplished by using the Gulf and Caribbean Fisheries Institute (GCFI) website (www.gcfi.org). The annual GCFI meeting could provide the ideal forum to evaluate and coordinate ongoing SPAG-related activities in the greater Caribbean.

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Detection of Fishing Effects on a Nassau Grouper Spawning Aggregation from Southern Quintana Roo, Mexico

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ABSTRACT

In the tropics, spawning aggregations represent ideal opportunities to target commercially important fishes, to the level that intense and effective fishing can eliminate much of the population. The commercially important Nassau grouper forms large seasonal spawning aggregations at specific locations along the coral reefs of the western Atlantic and Caribbean. In the Mexican Caribbean, the effects of the gillnet fishery on the Nassau grouper, taken during its annual aggregations, were analyzed from 1991 to 1997. Fishing effects on grouper mean size and sex ratios were not clear. Mean size for both sexes decreased and later increased apparently in response to both fishing and variable recruitment. The size-selectivity of gillnets against both small and large individuals may have masked the impact of fishing on population size structure. The sex ratio was female-biased for the overall period and remained close to unity for each individual reproductive season, but sex ratio may not be a good indicator of exploitation in this primarily gonochoristic species. However, landings substantially declined and the aggregation disappeared from its traditional site; both of these are suggestive of serious problems. Although several factors could be involved, fishing is strongly implicated as probable cause for these changes. Fishery managers seriously need to consider the establishment of marine reserves as an alternative to protect all the known Nassau grouper aggregations along the southern coast of Quintana Roo, Mexico.

KEY WORDS: Fishing, Nassau grouper, spawning aggregations, Mexico

Determinacion del los Effectos de la Pesca en Agregaciones de Desove del Mero de Nassau a lo Largo de la Costa Sur de Quintana Roo, México

En los trópicos, las agregaciones de desove representan oportunidades ideales para capturar peces de importancia comercial, a grado tal que la pesca intensa y efectiva puede eliminar gran parte de su población. El mero de Nassau, de importancia comercial, forma agregaciones de desove estacionales en sitios específicos a lo largo del arrecife coralino en el Atlántico oeste y Caribe. En el Caribe mexicano, se analizaron los efectos de la pesca con redes sobre el mero de Nassau, capturado durante sus agregaciones anuales, de 1991 a 1997. No fueron claros los efectos de la pesca sobre la talla media y proporción en sexos del mero.

La talla media para ambos sexos disminuyó y luego incrementó, en respuesta tanto a la pesca como a un reclutamiento variable. La selectividad por talla de las redes contra individuos pequeños y grandes quizá haya enmascarado el impacto de la pesca sobre la estructura poblacional por tallas. La proporción en sexos estuvo sesgada hacia hembras durante todo el período y se mantuvo cercana a la unidad para cada estación reproductiva, pero la proporción en sexos quizá no sea un buen indicador de explotación en esta especie primordialmente gonocórica. Los desembarques disminuyeron substancialmente y la agregación desapareció del sitio tradicional, lo que sugiere que existen problemas serios. Si bien, varios factores podrían estar involucrados en tal desaparición, la pesca queda implicada como una causa probable de tales cambios. El manejo pesquero necesita tomar seriamente en consideración el establecimiento de reservas marinas como una alternativa para proteger todas las agregaciones conocidas del mero de Nassau a lo largo de la costa sur de Quintana Roo, México.

PALABRAS CLAVES: Pesqueria, el mero de Nassau, agregaciones de desove, Quintana Roo, México

INTRODUCTION

Traditional subsistence fishing is a widespread human exploitative activity in the tropics. Intense fishing pressure affects the targeted marine organisms (Russ 1991, Jennings and Lock 1996) by reducing their density and abundance (Russ and Alcala 1989, McClanahan 1994), biomass (Jennings et al. 1995), altering sex ratios (Thompson and Munro 1983), and decreasing body mean size and catch rates (Koslow et al. 1988). Intense fishing has severe consequences for commercially important groupers because of their longevity, slow growth, large age at maturity, and their aggregating behavior during reproduction (Ralston 1987, Sadovy 1994; Coleman et al. 1996).

In the western Atlantic, several groupers exhibit an aggregating behavior: Nassau grouper, *Epinephelus striatus* (Smith 1972), Red hind, *Epinephelus guttatus* (Shapiro et al. 1993), Goliath grouper, *E. itajara* (Sadovy and Eklund 1999, Nelson et al., 2001), Tiger grouper, *Mycteroperca tigris* (Sadovy et al., 1994; Sala et al., 2001), Yellowfin grouper, *M. venenosa* (Sala et al. 2001), and Black grouper, *M. bonaci* (Eklund et al. 2000, Sala et al. 2001). They form briefly, seasonal aggregations to spawn at predictable times and places in the coral reefs (Shapiro 1987, Domeier and Colin 1997). Such aggregating behavior and high site fidelity during reproductive seasons may increase chances for their overexploitation (Coleman et al. 1996).

The Nassau grouper, one of the most commercially important, shallow-water grouper in the western Atlantic (Munro 1973, Thompson and Munro 1978, Sadovy and Eklund 1999), concentrates in hundreds or even thousands of individuals at what seem to be traditional spawning aggregation sites in the coral reef (Smith 1972; Olsen and La Place 1979, Sadovy and Eklund 1999). The aggregation forms for a

period of days prior to spawning during full moon days of December and January, and abruptly dissipates after the reproductive season (Colin 1992, Carter et al. 1994; Aguilar-Perera and Aguilar-Dávila 1996, Sadovy and Eklund 1999, Sala et al. 2001). Many reported Nassau grouper aggregation sites in the western Atlantic show severe landing declines (Sadovy 1999), and many have completely disappeared due to overexploitation (Sadovy and Eklund 1999). As a consequence, the Nassau grouper is a candidate for the U.S. Endangered Species List (Sadovy and Eklund 1999) and considered as threatened by the American Fisheries Society (Musick et al. 2000).

In the Mexican Caribbean (eastern Yucatan Peninsula), of the seven Nassau grouper aggregation sites located along the southern coast of Quintana Roo (Aguilar-Perera 1994), one of the most exploited and the only studied is located off Mahahual, close to northern Belize. Fishermen heavily exploited Nassau groupers from this aggregation site for more than 80 years (Aguilar-Perera 1994, Aguilar-Perera and Aguilar-Dávila 1996, Aguilar-Perera 2000, Sosa-Cordero and Cárdenas-Vidal 1996). Current studies on its stock are relatively scarce as to establish fishery management regulations to protect it.

While direct effects of fishing pressure on fishes are known (Russ 1991, Jennings and Lock 1996), and being more critical during spawning seasons of aggregating groupers (Coleman et al., 1996), relatively few is known of the Nassau grouper in the Mexican Caribbean (Aguilar-Perera 2000). Thus, the primary aim of this study was to examine its population structure based on the commercial gillnetting catch and to determine if changes in mean size and sex ratio relate to the effects of persistent and heavy fishery exploitation.

MATERIAL AND METHODS

Nassau groupers were sampled from the commercial catch in Mahahual (18°43' N; 87°42' W), southern Quintana Roo, Mexico, exclusively during reproductive seasons (e.g., spawning aggregations) each December and January from 1991 - 1997 (except January 1994, 1995 and December 1996, due to logistic constrains). For capturing Nassau groupers, the fishermen used gillnets (15 cm in mesh size) that regularly set in the afternoon (1500 hrs) and hauled early in the morning (0500 hrs) the following day. In some cases during mornings, fishermen would remove groupers as the gillnet was hauled, set it back in the water, and haul it again in the afternoon. Gillnets were deployed in the fore reef, perpendicularly to the reef crest, southern to the traditional grouper spawning aggregation site of Mahahual (Aguilar-Perera 1994, Aguilar-Perera and Aguilar-Dávila 1996).

Since sampling was entirely fishery-dependent, there were some constraints in fishing effort that substantially precluded the sampling. Number of boats, fishermen, and gillnets were variable every fishing season. For instance, in December 1991 and January 1992, at least six boats with two gillnets (150 m long, 5 m wide each) were used by fishermen, while in December 1995 and January 1996, only three boats with one gillnet (200 m long, 5 m wide) were used. Such a decrease in fishing effort was explained by the difficulty for the fishermen in easily finding the grouper

aggregation.

At the landing site, grouper total length (TL) and standard length (SL) were measured to the nearest centimeter, and body and gonad weights were recorded to the nearest gram. Fish were sexed either macroscopically by gently squeezing and externally examining their abdomens or microscopically in laboratory, following embedding in paraffin, sectioning at 4-5 μm, and staining in hematoxylin and eosin. The Kolmogorov-Smirnov two sample test (D), t-test (t), χ^2, and ANOVA were used to compare the fish size-frequency distributions, mean size, sex ratio, and length variations between reproductive periods, respectively (Sokal and Rohlf 1995).

RESULTS

The total sample was comprised by 778 Nassau groupers ranging from 39 to 88 cm TL (sexes combined). Of these, 338 (43.4 %) were males (39 to 86 cm TL) and 440 (56.5%) were females (46 to 88 cm TL). A subsample of 412 groupers (52.9 %; sexes combined) ranged from 1.3 to 10.2 kg. Of these, 178 were males (1.3 to 10.2 kg) and 233 were females (1.8 to 9.6 kg). Size-frequency distributions between females and males were not significantly different (Kolmogorov-Smirnov two sample test). Mean total length did not differ significantly between sexes within each reproductive season (t-test; Table 1). However, mean total length for both sexes combined was significantly different between reproductive seasons (ANOVA, $p < 0.0001$). There was a significant decrease in mean total length for males in December 1993, while significant differences for females were found in December 1993 and 1994 (Tukey test, $p < 0.05$). Mean total length for both sexes slightly increased during subsequent reproductive seasons.

Size-frequency distributions, sexes combined, showed a slightly shift to smaller sizes between December and January within a single reproductive season (Figure 1). In December 1991, mean size was 58.1 cm, while in January 1992 there was a mean size of 59.21 cm. However, size-frequency distributions were not significantly different. In contrast, in December 1992 and January 1993, size-frequency distributions were significantly different (Kolmogorov-Smirnov: $D = 0.226$, $p < 0.01$). Mean size in December 1992 (57.7 cm) was significantly smaller than that of January 1993 (60.8 cm; t-test, $p < 0.01$).

The overall sex ratio of females ($n = 440$) to males ($n = 338$) was 1.3:1, which was significantly biased towards females (χ^2, $p < 0.001$). Nonetheless, during most reproductive seasons, the sex ratio was close to unity (1:1), except for December 91-January 1992 ($n = 224$, χ^2, $p < 0.001$) and December 1995-January 1996 ($n = 61$, χ^2, $p < 0.01$), where a female-biased ratio for the former and a male-biased ratio for the latter were significant. Sex ratios for each reproductive season are shown in Table 2.

Table 1. Mean observed total length (TL, cm), standard deviation (SD) and percentage, for Nassau grouper female and male by reproductive season (December 1991 - January 1997).

Reproductive season		Female				Male			
		Mean	SD	N	%	Mean	SD	N	%
December 91-January 92		59.2	5.371	147	33.4	58.2	5.992	77	22.7
December 92-January 93		59.3	5.614	167	37.9	58.6	5.043	126	37.2
December 93		55.4	4.106	60	13.6	54.7	4.277	57	16.8
December 94		57.5	3.733	39	8.8	58.1	3.279	31	9.1
December 95-January 96		60.8	6.825	20	4.5	58.5	5.329	41	12.1
January 97		60.0	6.218	7	1.6	58.3	2.732	6	1.7
Grand Mean/Total	58.7	5.433	440		57.8	5.176	338		

N = number of fish

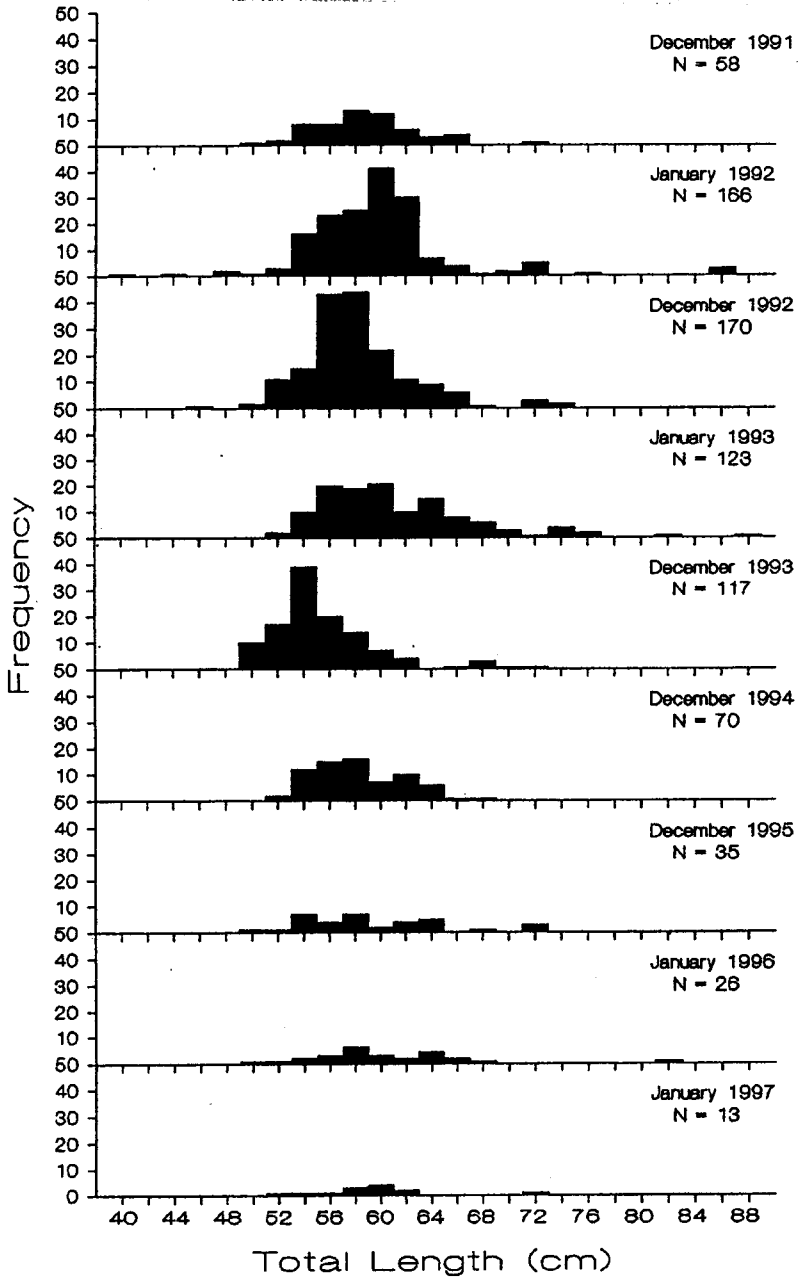

Figure 1. Length-frequency distributions of male and female Nassau grouper, *Epinephelus striatus*, taken from the spawning aggregation by the gillnetting fishery of Mahahual, Quintana Roo, Mexico (from Aguilar-Perera, 2000).

Table 2. Nassau grouper, *Epinephelus striatus*, sex ratios for each reproductive season and fish aggregation arrival dates to the traditional aggregation site at Mahahual, Quintana Roo. Sampling was conducted around full moon days only.

Reproductive season	N		Sex ratio	Sampling	Full moon day	Grouper arrival date
	F	M	F : M			
Dec 91-Jan 92	147	77	1.9:1*	23-26 Dec; 19-25 Jan	21 Dec/19 Jan	23 Dec/19 Jan
Dec 92-Jan 93	167	126	1.3:1	10-15 Dec; 6-12 Jan	10 Dec/ 8 Jan	19 Dec/6 Jan
Dec 93	60	57	1:1	28-31 Dec	27 Dec	28 Dec
Dec 94	39	31	1.2:1	18-21 Dec	17 Dec	18 Dec
Dec 95-Jan 96	20	41	0.48:1**	6-9 Dec; 5-8 Jan	16 Dec/7 Jan	6 Dec/5 Jan
Jan 97	7	6	1.1:1	21 Jan	23 Jan	21 Jan

F = female, M = male. N = number of fish. Dec = December, Jan = January. Significant, female-biased (*). Significant, male-biased (**).

DISCUSSION

Nassau grouper mean size trend was not a good indicator of fishing effects because of the influence of annual recruitment variability. Females and males were similar in size, not only for the overall study, but also during each reproductive season. However, there was a decline in mean size for females during December 1993 and 1994, and for males during December 1993. An apparent increase in mean size for both sexes was observed during December 1995 and January 1997. It is possible that a combination of persistent fishing pressure and grouper annual recruitment variations could account for such differences in mean size. Moreover, during last months of the study sample size was so small (around 13 individuals), due to grouper landing decline, that it could confound mean size comparisons with the previous reproductive seasons. There were no more elements as to conclude that the mean size fluctuations could be solely due to fishing pressure.

According to Carter et al. (1994), in Belize the Nassau grouper mean sizes for both sexes were similar within a given area, or at a specific aggregation site; thus it is possible to detect size decline in areas of higher exploitation. When the exploitation is very high, juveniles (< 30 cm TL) largely comprised the catch (Sadovy and Eklund 1999). In Belize, Nassau grouper mean sizes of exploited aggregations were smaller (> 42 cm standard length [SL]) than those of non-exploited aggregations (52 cm SL) (Carter et al. 1994). In the Mexican Caribbean, although mean sizes apparently declined, juveniles were not present in the commercial catch, and mean size for both sexes was greater than that of groupers from Belize. In a previous study in Mahahual, Mexico, Sosa-Cordero and Cárdenas Vidal (1996) found that mean size between females and males was significantly different during 1991 - 1990, with females slightly larger than males. However, they concluded that their results were preliminary, with shortcomings derived from a small sample size (180 individuals only).

In the present study of Mahahual, juvenile absence from catches could be due to either gillnet selectivity for larger sizes (> 30 cm) or the presence of only mature groupers. However, a couple of individuals (< 30 cm) were observed in the coral reefs close the aggregation site. One interesting aspect found in this study, in relation to mean size, is that the size-specific Nassau grouper catchability (i.e., the extent to which a stock is susceptible to fishing) with gillnets would potentially be equivalent for both sexes, meaning that the fishery was not size-selective for a particular sex.

Sex ratio was not a good indicator of fishing effects. The overall sex ratio of Nassau grouper in the Mexican Caribbean was significantly female-biased (1.3:1), but when viewed for each reproductive season it was close to unity, with two exceptions (December 1991 - January 1992; December 1995 - January 1996). The gillnet fishery reflected a significantly overall female-biased sex ratio. However, most reproductive seasons reflected a uniform sex ratio. Compared to other Nassau grouper populations around the western Atlantic, the sex ratio in this study was among the closest to unity, while the most female-biased (4:1) was reported in heavily exploited areas of Cuba (Claro et al. 1990).

In general, the sex ratio is female-biased in exploited populations, while in lightly or relatively non-exploited populations is close to unity, suggesting that the normal sex

ratio in non-fished adult populations is approximately 1:1 (Sadovy and Colin 1995, Sadovy and Eklund 1999). However, care is needed when assessing sex ratios at aggregations because of possible gear selectivity, differences between the sexes in time spent at aggregation sites or migration patterns (Sadovy and Eklund 1999). In the Mexican Caribbean, differences between sexes in time spent at aggregation sites could have affected the estimation of sex ratio. According to Bardach (1958), males may precede females to spawning sites. This may explain the sudden appearance of a male-biased sex ratio observed in the Mexican Caribbean during the December 1995 - January 1996. Sosa-Cordero and Cárdenas-Vidal (1996) also documented a male-biased sex ratio (1: 1.5) in Mahahual during 1990-91.

While the mean size trend and sex ratio were not good indicators of fishing effects on the Nassau grouper from Mahahual, the aggregation disturbance (i.e., disappearance) and landing declines (Aguilar-Perera and Aguilar-Dávila 1996) were indicative of serious problems. Such situation is similar to that of the rest of the Nassau grouper aggregations in the western Atlantic (Sadovy and Eklund 1999). In this sense, concerns about the possibility of overexploitation of the Nassau grouper from Mahahual are high (Aguilar-Perera 2000). Fishing at this aggregation site started in the 1920s, but it attained commercial importance in the 1950s, when Nassau grouper landings obtained by hook and line for one season reached about 24 t (Aguilar-Perera 1994). The average weight of the groupers caught from 1991-1997 was 4 kg (Aguilar-Perera, 2000); thus, 24,000 kg represents around 6,000 individuals. In 1988, 4 t (1000 individuals) were caught in 1988 using spearfishing only (Aguilar-Perera 1994), and 2 t (500 individuals) in 1992 using gillnets (Aguilar-Perera and Aguilar-Dávila 1996). However, in 1997 less than 100 kg (25 individuals) were caught with gillnets only. It is important to mention that not only the fishing gear used, but also the number of fishermen varied along this period of 50 years.

During the 1990 - 1991 season, a grouper aggregation comprised by 1,000 groupers was found at the traditional site (Aguilar-Perera 1994), but eventually no longer appeared at this site, and only sparse fish groups (2 or 3 of less than 100 individuals) were found at the deep fore reef (15 m), moving from south to north following the deep fore reef contour (Aguilar-Perera and Aguilar-Dávila 1996). Such a progressive decline in fish abundance at this aggregation has greatly diminished the fishermens' ability to exploit it. Moreover, in late 1996 the Mexican Fishery Department applied a severe fishing ban, which not allowed the fishermen to exploit the Nassau grouper during the aggregation.

In the western Atlantic, of the more than 60 Nassau grouper aggregation sites known, many (25 %) no longer form (Sadovy and Eklund 1999). Since these aggregations are found at predictable places and times in short periods, removed with a variety of fishing gears, and heavily exploited for more than 50 years, they are especially susceptible to heavy fishing pressure, and consequently to overexploitation. In the Mexican Caribbean, as in many areas of the western Atlantic, the fishermen mainly exploit Nassau groupers during the reproductive (i.e., aggregating) season (December and January). For more than 80 years, the grouper

aggregation from Mahahual was exploited with different types of fishing gears (Aguilar-Perera 1994), including hand lines, spearguns, and gillnets (Aguilar-Perera and Aguilar-Dávila 1996). Spearfishing (Sluka and Sullivan 1998) and fish traps (Thompson and Munro 1978) are more devastating for larger and smaller groupers, respectively, because both gears are highly size-selective. In the Mexican Caribbean, gillnets selected a vast array of Nassau grouper sizes (39 cm to 88 cm TL) according to the mesh size used (e.g., 15 cm).

Fishing effects are more striking on fishes that aggregate to spawn (Coleman et al. 1996), since they show high site fidelity and concentrate their annual reproductive activity during aggregations. Heavy selective pressure concentrates on mature Nassau groupers susceptible to capture from easily located spawning aggregations. Since heavy fishing on these aggregations is one of the main causes of fish depletion and stock collapse, a complete protection for them is strongly recommended as a management strategy in the western Atlantic (Sadovy 1999). Such protection needs also to be enforced during non-aggregating seasons, with additional management regulations, such as: minimum sizes, gear restrictions and quota limits (Sadovy, 1994). Furthermore, comprehensive studies on biological, fishery, and socio-economic aspects are important for an effective management (Sadovy 1994, Aguilar-Perera 1994). In the Mexican Caribbean, new research for the aggregation site off Mahahual (including the other known sites along the southern coast of Quintana Roo), must rely on using the side-scan sonar technology and geographic information systems (GIS) for habitat mapping, and telemetry (ultrasonic tagging) to determine the Nassau grouper home range and potential aggregation site sharing along the Mexican coast (including Belize).

Recently, a management alternative increasingly accepted to protect spawning areas involves establishing "no-take" (or fully protected) marine reserves (Jennings 2001, Roberts et al. 2001). Any identified and documented spawning area represents a known "source" of larvae for the replenishment of local populations, while the adjacent areas could be "sinks". Thus, both should be protected as a marine reserve (Roberts 1998). Density and biomass of larger groupers in the Florida Keys and the Bahamas were significantly greater in marine reserves than in heavily exploited areas (Chiappone et al. 2000). Nassau grouper size, reproductive output (number of eggs per hectare), and average biomass inside a marine reserve in the Bahamas were significantly greater than those of outside (Sluka et al. 1997). Since the Nassau grouper migrates considerable distances to reproduce (Bolden, 2000), a network of marine reserves (including spawning sites) is recommended for conservation and management purposes. In addition to establishing reserves for the Nassau grouper in the Mexican Caribbean, it could be important to evaluate the nonextractive value of this grouper as a tourist attraction through diving, offering the fishermen an alternative to obtain economic revenue. In this sense, very interesting perspectives have proposed in Belize (Sala et al. 2001) and Turks and Caicos (Rudd and Tupper 2002).

Avoiding fishing pressure on the Nassau grouper spawning aggregations, establishing a network of "no-take" marine reserves, and applying additional

management regulations during non-aggregating periods, need to be strongly enforced to assure that potential recruits could incorporate via either pelagic (eggs and larvae) or benthic (adults) stages to replenish grouper populations not only in the Mexican Caribbean, but also in adjacent countries (e.g., Belize and Honduras) within the Mesoamerican Barrier Reef System.

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Estudio Preliminar de la Agregación del Mero *Epinephelus striatus* en "El Blanquizal" en la Costa Sur de Quintana Roo, México

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RESUMEN

En la costa sur de Quintana Roo, se reconoce actualmente de siete a ocho sitios de agregación del mero *Epinephelus striatus*, que acude anualmente para realizar el desove durante tres a cuatro días antes y después de la fecha de luna llena en Diciembre, Enero y Febrero. Con el fin de obtener información básica sobre un nuevo sitio de agregación reproductiva conocida como Blanquizal, cercano a Punta Gavilán, dentro del polígono del área protegida "Parque Nacional Arrecifes de Xcalac", se efectuaron muestreos durante el evento Diciembre de 2001 y Enero de 2002. Por estimaciones visuales (SCUBA) se observaron grupos de meros, que hacen un total de 200 a 400 individuos en el sitio. La captura de meros se llevó acabo con cordel y anzuelo por un número muy reducido de pescadores; la captura estuvo compuesta por individuos con talla promedio 64.77 (cm LT) y peso promedio de 4588 (g). La proporción por sexos fue de 1.96 H:1M. Además de describir ambos, el evento de agregación 2001-2002 y las características generales del sitio, se hacen comparaciones con la información publicada de sitios en la región y el Caribe. La necesidad de reconocer las características ecológicas de este nuevo sitio de agregación hace necesario la continuidad de las investigaciones, con el fin de tener las bases para un manejo mas adecuado del recurso y lograr que sea perdurable su explotación.

PALABRAS CLAVES: Mero, *Epinephelus striatus*, agregación reproductiva, Caribe Mexicano, desove.

A Preliminary Survey of the Nassau Grouper *Epinephelus Striatus* Spawning Aggregation at "El Blanquizal" in the South Coast of Quintana Roo, Mexico

In southern Quintana Roo, currently are acknowledged seven to eight sites where spawning aggregations of the nassau grouper, *Epinephelus striatus,* takes place every year. There, this species aggregates during three-four before and after the full moon dates of December, January and February. In order to obtain the first

information on a new spawning aggregation site, locally known as "El Blanquizal", nearby to other traditional site: Punta Gavilán, both pertaining to the marine protected area "Parque Nacional Arrecifes de Xcalac" we conduct a preliminary survey during the event December 2001-January 2002. Through visual censuses using SCUBA, several groups of groupers were observed an a total number of 200 to 400 individuals was estimated in the site. Concurrent fishing activity was low, and the only fishing gear was hook and line, baited with small and alive haemulid fishes. The catch was comprised of individuals having mean size of 64.77 (cm LT), and mean weight of 4,588 (g). A sex ratio 1.96 H:1M was observed. A first general description of both, the aggregation event and the site is made, and our outcomes are also compared with data available from other sites in the region and the Caribbean Basin. The need to further understanding of ecological features of this new aggregation site are the main reasons for continue this research. The latter will provide proper basis for the resource management in order to attain a long-term exploitation.

KEY WORDS: Groupers, *Epinephelus striatus*, spawning aggregation, Mexican Caribbean, reproduction

INTRODUCCION

México presenta aproximadamente unos 10,500 kilómetros de litoral marino, estas costas son bañados por los Océanos Pacífico, Atlántico y el Mar Caribe, encontrándose presentes mas de 100 lagunas costeras (Marín-Guardado 2000). Lo heterogéneo de su litoral se debe a factores latitudinales y oceanográficos presentes en cada una de estas áreas (Castro 1998). Una de estas áreas se localiza en la Península de Yucatán, que presente en su parte occidental al Mar Caribe, donde Quintana Roo es el único estado de México que es bañado con estas aguas. Una característica importante de esta región, es que corre paralelo a sus costas una estructura arrecifal en forma más o menos continua, extendiéndose desde el extremo norte de la Península hasta la Bahía de Chetumal en el sur, cubriendo una distancia aproximada de 350 km, la cual no considera los arrecifes de Cozumel y Banco Chinchorro (Jordán 1979); y que se extiende otros 300 km frente a la costa de Belice. Esta gran estructura forma lo que se conoce actualmente como el Sistema Arrecifal Mesoamericano, el segundo más grande del mundo después del arrecife de Australia. Los arrecifes coralinos son considerados como el biotopo de mayor productividad biológica de todos los conocidos, tanto en el mar como en la tierra y por tal motivo en ella se ejerce la explotación de sus recursos, abarcando una gran cantidad de organismos como corales, moluscos, peces y elasmobranquios. Debido a la fragilidad de este ecosistema, se debe de cuidar y monitorear continuamente con el fin de implementar planes de manejo con el propósito de hacer sustentables la productividad de sus pesquerías.

En Quintana Roo (Q. ROO), la explotación de los recursos pesqueros la realizan cerca de la costa y en su mayoría es de tipo artesanal, están encaminados a

especies de gran valor comercial como son la langosta espinosa *Panulirus argus*, caracol rosado *Strombus gigas* y camarón *Syciona brevirostris* y *Penaeus brasiliensis* (Sosa-Cordero et. al. 1993). Actualmente estos recursos se encuentran en niveles máximos de presión pesquera y están sobreexplotados.

En la zona sur de Q. ROO, son de gran importancia los dos primeros recursos, sin embargo existe una tercer pesquería que abarca al grupo comúnmente llamado escama, que representa una actividad de gran importancia para la comunidad asentada en la costa. Con respecto a este grupo se pueden mencionar algunas características habituales: son especies que pueden ser capturadas durante casi todo el año, aunque existe un periodo estacional principalmente para el verano y otoño en que se agrupan y forman cardumenes para llevar acabo la reproducción. Realizan migraciones hacia el sur penetrando a la laguna arrecifal durante la noche para alimentarse y es durante este espacio donde se lleva acabo el mayor volumen de captura por medio de trampas de atajo conocidas como trampas de corazón y cola. Entre los principales géneros y especies capturados de escamas podemos mencionar; a los pargos (*Lutjanus* sp.), meros (*Epinephelus* sp.), abadejos (*Mycteroperca* sp.), chacchi (*Haemulon* sp.), mojarra blanca (*Gerres cinereus*), macabi (*Albula vulpes*), lisa (*Mugil cephalus*).

Una de las principales pesquerías que se llevan acabo en el sur de Q. ROO, esta centrada a los organismos pertenecientes a la familia Serranidae, son individuos que presentan gran talla, son apreciados por su importancia comercial y pesquera, se encuentran ampliamente distribuida en la región del mar caribe, son considerados depredadores activos, juega un papel importante en la demanda alimenticia de la población y representa ingresos muy importantes para la comunidad pesquera de cada región. Los miembros más pequeños de esta familia son colectados para la industria del acuario (Paz y Grimshaw 2001). Su pesquería es multiespecifica, siendo una de las mas importantes el mero *Epinephelus striatus*, las capturas de esta especie alcanzan su máxima intensidad durante los eventos de luna llena de diciembre y enero de cada año, cuando se lleva acabo la reproducción de la especie en algunos puntos específicos del sur de Quintana Roo, México.

La explotación pesquera del *E. striatus*, ha originado un declive comercial de sus capturas desde las pasadas décadas, a causa del mal manejo de su pesquería, lo que a causado que actualmente este en la lista roja de especies amenazadas (Auil-Marshalleck 1993, Sadovy 1993). Una razón de este declive en casi toda la región del Caribe y México, viene siendo la sobreexplotación selectiva sincronizada hacia los sitios de agregación reproductiva, la cual ocurre durante la primera luna llena de diciembre y enero de cada año y por tal motivo muchas de estas agregaciones en el mar caribe han llegado o están en el colapso total, a la sobreexplotación y la desaparición de la especie en lugares tales como Puerto Rico, Isla Vírgenes US, Isla Caimán, Bermuda, Republica Dominicana, Belice y México (Sadovy 1993, Aguilar-Perera y Aguilar-Dávila 1994, Sadovy y Eklund 1999, Paz y Grimshaw 2001).

El mero *E. striatus*, es un pez común de los arrecifes coralinos del atlántico oeste y mar caribe (Sadovy y Eklund 1999). Son organismos que se encuentran en las regiones cercanas a la costa hasta los 100 m de profundidad, en los arrecifes

coralinos, manglares, pastos marinos y estuarios. Es un organismo depredador de vida solitaria que se puede alimentar de invertebrados y peces, de larga vida que logra alcanzar tallas por arriba de los 800 mm de longitud total y que pueden vivir hasta cuatro décadas (Randall 1965, Silva Lee 1974; Sadovy y Eklund 1999).

La reproducción es compleja dado que el pez presenta hermafroditismo protogíno, es decir, las hembras maduras cambian de sexo (Smith 1959, Shapiro 1987, Claro et al. 1990). Es durante este periodo cuando se reúnen para realizar el dosove, la mayor parte de la captura comercial proviene precisamente de tales agregaciones (Johannes 1978). Las agregaciones están compuestas por el agrupamiento de organismos adultos que van de 2000 a 3000 organismos (Colin 1992).

En la zona sur de Q. ROO, es el único sitio conocido en México en donde se lleva acabo las agregaciones del mero *E. striatus*, se cuenta con un registro histórico desde mediados de los 50', en donde se tiene documentado que las capturas la realizaban con redes agalleras, anzuelo y con arpón; se han reconocido en la actualidad que existen mas de 7 sitios de desove de gran importancia (Aguilar-Perera 1994). A pesar que ya se cuentan con algunos estudios previos sobre las agregaciones de esta pesquería, es escaso aun el conocimiento en cuanto al aspecto biológico y a su hábitat. En la actualidad sólo se tiene bien estudiado un sitio de agregación en todo el sur de Q. Roo, este punto viene siendo la zona conocida como Mahahual (18° 43'N y 87° 42'W) ya se han obtenido un estudio descriptivo y reseña histórica sobre la pesca tradicional en la agregación de esta especie (Aguilar-Perera 1994), de igual forma se han generado trabajos sobre la agregación reproductora de esta especie en Mahahual, Q. Roo (Aguilar-Perera et al. 1994, Aguilar-Perera y Aguilar-Dávila 1997) y de manera preliminar un estudio sobre la agregación del mero en la zona conocida como Mahahual y Xahuaxol (Sosa-Cordero y Cardenas-Vidal 1992).

Conociendo de antemano que sólo hay reportes bien documentados de un solo sitio de agregación, nos vimos en la necesidad de trabajar un nuevo sitio en la zona sur del estado, con el simple fin de comparar nuestros resultados con los obtenidos por Aguilar-Perera y Aguilar-Dávila. El área de trabajo estuvo comprendida en el "Polígono Parque Marino Arrecifes de Xcalac", en el punto conocido como Punta Gavilán, sin embargo estamos dando a conocer un nuevo sitio de agregación del mero *E. striatus* en la zona sur del estado conocida como el Blanquisal, este trabajo brindara en primer termino un estudio descriptivo y preliminar sobre la situación reproductiva durante el invierno de 2001 - 2002, la investigación incluye aspectos biológicos como distribución de frecuencias por tallas, proporción por sexos, relación longitud-peso, la realización de un video sobre el sitio de agregación y comentarios sobre las características ecológicas de la zona desove. Sin embargo hay que reconocer que es el primer trabajo que se esta realizando en esta zona, la continuidad de investigar este sitio en los próximos años nos dará un panorama mas real sobre la biología reproductora, la ecología de su hábitat, la conducta animal y su pesquería; con todos estos puntos a resolver en un futuro, se podrán llevar a cabo planes de manejo sobre la especie con el simple fin de que sea perdurable por

mucho tiempo.

Ubicación el Area de Estudio

El establecimiento del Área natural protegida propuesta como Parque nacional "Arrecifes de Xcalak", México, Quintana Roo, México; se ubica en la zona sur del estado de Quintana Roo dentro del municipio de Othón P. Blanco en la Península de Xcalak (Figura 1). Sus limites extremos están definidos por el paralelo 18° 30' 00" N, al sur por el limite internacional entre México y Belice, al este por el mar caribe y al oeste en su porción sur por la zona costera dentro de la linea que delimita la Zona Federal Marítimo Terrestre y en la porción norte incluyendo al Sistema Lagunar Río Huache hasta el trazo del proyecto de la carretera Mahahual-bacalar chico. Abarca una superficie de 17,377 ha de las cuales 13,340 ha corresponde a ecosistemas marinos y 4,037 ha a ecosistemas de humedales incluyendo lagunas perennes e intermitentes. El sitio conocido como el Blanquizar, se encuentra localizado aproximadamente a 1000 metros de la orilla de playa, en el paralelo 18° 19' 25" N y 87° 48'24" O, se realizó un polígono con el fin de detallar mejor el sitio de trabajo.

MATERIAL Y METODO

Trabajo de Campo

Para este propósito se cubrió la estación de desove de Diciembre de 2001 y Enero de 2002, que comprendió los días de luna llena de cada mes. Durante este periodo se efectuó el muestreo de ejemplares obtenido de las capturas comercial y de observaciones submarinas de la agregación en el arrecife coralino comprendida en el Polígono "Parque Marino Arrecifes de Xcalac" en el sitio de captura conocido como el Blanquizal.

Se realizaron medidas biométricas de adultos reproductores de *E. striatus* que se obtuvieron por medio de las capturas comerciales realizadas en el área de muestreo, hay que mencionar que la captura de este recurso se lleva acabo por medio de la línea o anzuelo del # 1, no se capturo ningún otro organismo por otro método. Por medio de este mecanismo se logro obtener la Longitud Total (LT), Longitud estándar (LS), el Peso Eviscerado (WE) y el Sexo de cada organismo. La duración del muestreo en cada uno de los meses trabajados estuvo en relación con la permanencia de la agregación en la zona de trabajo, por lo que en promedio de cada uno fue de siete días.

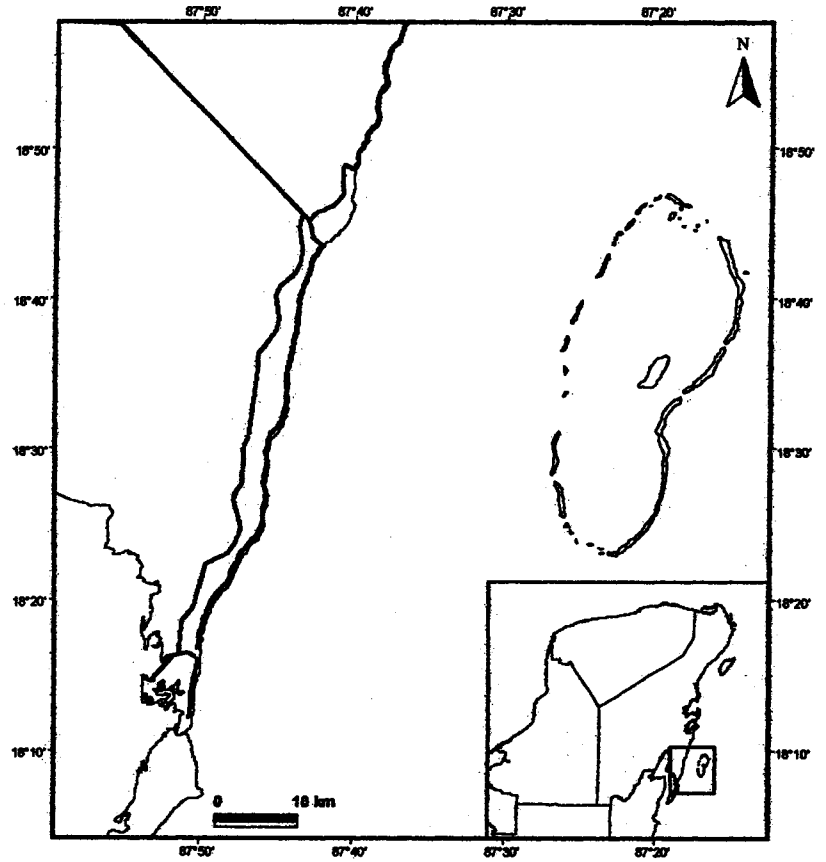

Figura 1. Área natural protegida propuesta como Parque nacional "Arrecifes de Xcalak"

Observaciones Submarinas

De igual manera se realizaron muestreos *in situ* por medio del buceo SCUBA, en la zona agregación en el arrecife coralino, en cada una de las inmersiones realizadas durante los días de trabajo se contaba el número organismo, se filmo la zona de trabajo con ayuda de dos cámaras submarinas, se ubico geográficamente con ayuda de un GPS el sitio de la agregación y se caracterizo la topografía del parche arrecifal.

No se logro obtener ninguna muestra biológica extra como otolitos (para determinar la edad) y gónadas (para determinar el estadio de maduración por medios histológicos), debido principalmente a que ya estaba vendido.

RESULTADOS

Características de la Zona de Agregación

La zona de agregación del mero *E. striatus*, localizada en el polígono "Parque Marino Xcalac" se encuentra en el arrecife anterior a una distancia aproximada de 1000 metros de la línea de costa, mar adentro (Figura 1). Esta se encuentra cerca de un parche coralino de gran tamaño y alto relieve, esta zona tiene una profundidad promedio de 30 m, el parche coralino presenta una altura de 8 metros, existiendo fracturas dentro del mismo parche ocasionando que se formen canales (formación tipo canales y macizos) con presencia de arena en la parte central de los mismos, en la parte lateral de este parche existían grandes áreas de arenales, este lugar es conocido por los pescadores como el blanquizar. Debido a las características de este parche, se presentaba corales de gran importancia como *Montastrea sp.*, *Agaricia sp.* esponjas marinas y corales blandos.

Una de las observaciones realizadas durante el evento reproductivo del mero en esta importante área de trabajo, durante el buceo SCUBA, es que la agregación empezó dos días antes de la luna llena, llegando en un principio algunos organismos adultos de gran tamaño, contabilizando en un inicio menos de 100 individuos, posteriormente a la luna llena se logro contar en promedio un total de 250 a 350 organismos en este sitio, este mismo patrón se presento durante los dos muestreos realizados (Diciembre de 2001 y Enero de 2002). El momento justo del desove no se pudo observar debido posiblemente a que este ocurre en el atardecer del día o inicio de la noche, y que nuestros muestreos realizados en estos sitios se llevaban acabo al medio día, sin embargo si se logro observar cambios de color de los organismos pasando de típicos a bicolor después de la luna llena.

Esta zona de agregación ha sido explotada de manera regular en los últimos años, en esta área de Xcalak, sin embargo el sitio original en donde se capturaba el mero reconocido como Punta Gavilán, se encuentra localizado a mas de 4 km hacia el norte del lugar en donde llevo acabo la agregación este año, parece ser que en el sitio original hubo agregación, pero fueron pocos los organismos que estuvieron presentes, observándose que el sitio conocido como el Blanquizar, fue el lugar donde se llevo acabo la agregación y el desove mas importante, ya que siete días después de la luna llena de febrero, el día 4 y 5 del 2002, se logro ubicar un cardumen por los pescadores de la localidad de 2000 a 3000 organismos en la zona de estudio, a una profundidad de 30 a 35 m y a 70 m del parche coralino estudiado, debido a lo anterior se podría considerar como una zona de agregación significativa de esta especie en el sur de Q. Roo y para el Caribe en general, si consideramos el número de organismos que estuvo presente en esta ultima agregación ya que no ha sido reportado para ninguna otra zona en Quintana Roo en los últimos años.

Datos Meristicos y Proporción por Sexos

Durante los dos eventos de luna llena trabajados para la agregación del mero *E. striatus* en el Polígono Parque marino arrecifes de Xcalak, en el área conocida como Blanquizar, se logro obtener un total de 206 organismos, de los cuales

correspondieron a 134 hembras, 71 machos y un organismo juvenil. La proporción por sexos obtenida en este trabajo correspondió a 1.91 hembras: 1 Macho, lo cual hace referencia a que gran parte de la captura obtenida en este año de trabajo, correspondió aproximadamente a una relación de dos hembras por macho.

Tabla 1. Datos meristicos obtenidos durante el muestreo de mero *E. striatus*, en el polígono Parque Marino Xcalak, durante la agregación efectuada en los meses de Diciembre 2001 y Enero 2002, en Xcalak Quintana Roo, México.

	Hembras		Machos		Total	
	Longitud	Peso	Longitud	Peso	Longitud	Peso
Promedio	65.14	4714.04	64.44	4397.64	64.77	4588
Desviación. estándar	7.79	1843.14	6.66	1491.23	7.63	1745
Mínimo	49	2400	53.1	2000	49.0	2400
Máximo	84.5	9700	82.5	8700	84.5	9700
# organismos	133	133	70	70	203	203

En la Tabla 1, podemos observar los datos merísticos obtenidos durante esta investigación, esta fue dividida por sexo y total, de los 206 datos disponibles solo tres organismos no fueron incluidos en esta tabla, un macho, una hembra y un juvenil, esto debido a que no se obtuvieron los pesos de los dos primeros y fueron desechados para el análisis, por lo que respecta al juvenil, este represento la talla más pequeña obtenida en la investigación con una longitud de 37.8 cm LT y con un peso eviscerado de 1,200 g. Regresando un poco con la tabla 1, se puede observar que las hembras presentaron significativamente tallas promedio mayores respecto a los machos y fueron mas abundante durante la investigación.

En cuanto a la Figura 2, podemos mencionar la distribución de tallas para los tres grupos encontrados en la investigación, en donde podemos observar que las hembras presentaron la mayores frecuencias durante el trabajo y a la vez la mayor tallas. En la Figura 3, se observa la frecuencia por tallas para todos los organismos muestreados, en donde se detalla que los organismos encontrados dentro del intervalo de 55 - 60 cm fueron los mas comunes y los mas factibles a ser capturados durante la agregación reproductiva del mero en Diciembre de 2001 y Enero de 2002 en la zona del Blanquizal.

El análisis de regresión longitud-peso, fue efectuado por separado para los dos sexos y el total; por tal razón en la Figura 4, observamos los datos obtenidos de la relación longitud total (LT) y peso eviscerado (PE), en machos, con una n=70 organismos durante los dos meses de trabajo. La Figura 5 se detalla la relación LT-PE, en hembras con una n=133 organismos y en la Figura 6, se demuestra los datos LT-PE, de todos los organismos muestreados con un total de 203 organismos, de acuerdo a nuestros pendiente encontrada en cada una de las graficas presentada, nos hace referencia que su crecimiento es de tipo alométrico.

El esfuerzo pesquero observado en esta zona de trabajo, fue poco, ya que solo se pudo observar una embarcación de fibra de vidrio trabajando en esta época, con un total de tres pescadores, el arte utilizado por los mismo fue la línea y el anzuelo, la carnada utilizada fue el Chacchi (*Haemulon sp.*), se noto la presencia de dos

lanchas mas pero por la falta de cultura en la captura de esta especie, se retiraban del lugar, sin haber capturado ningún organismo. La explotación de este recurso, inicia desde las 8 de la mañana con la obtención de la carnada viva, posteriormente se dirigen al pesquero, y empieza la captura del mero hasta las 2 de tarde, regresan a la playa a comer y si queda tiempo vuelven por tarde por dos a tres horas, esto fue percibido durante los dos meses de explotación de este recurso, la extracción total para cada mes de trabajo fue de una tonelada, lo cual nos da un panorama de que la agregación en esta zona de estudio es muy importante, que debe de monitorease para los siguientes años venideros, con el de hacerlo manejable y sustentable para la comunidad de Xcalak.

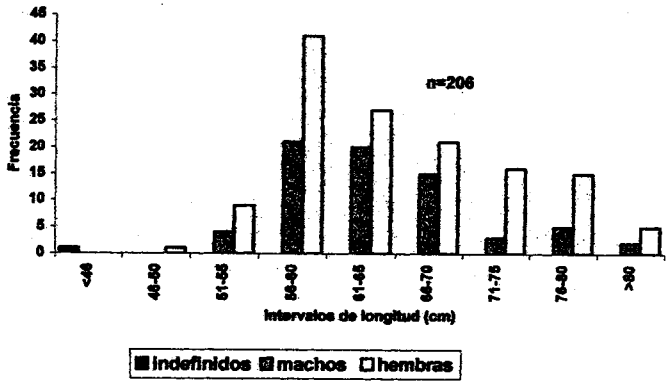

Figura 2. Distribución de frecuencias por tallas para el mero *E. Striatus*, por sexo encontrado en el polígono Arrecifes de Xcalak

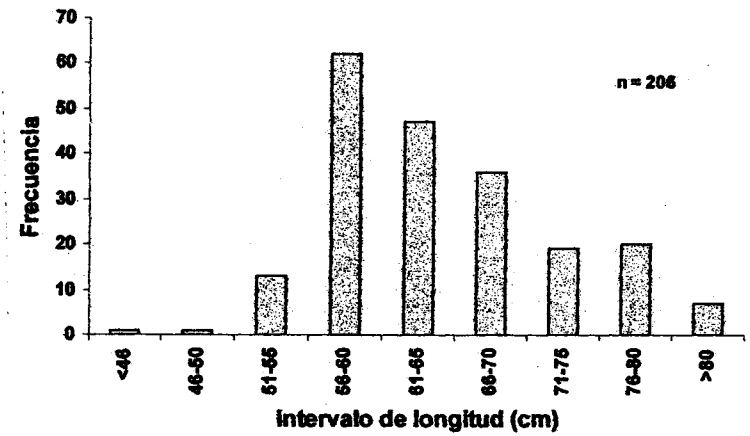

Figura 3. Distribución de frecuencia por tallas para el total de organismos muestreados del mero *E. striatus*, en el área del Blanquizal, Xcalak, Q. ROO,México.

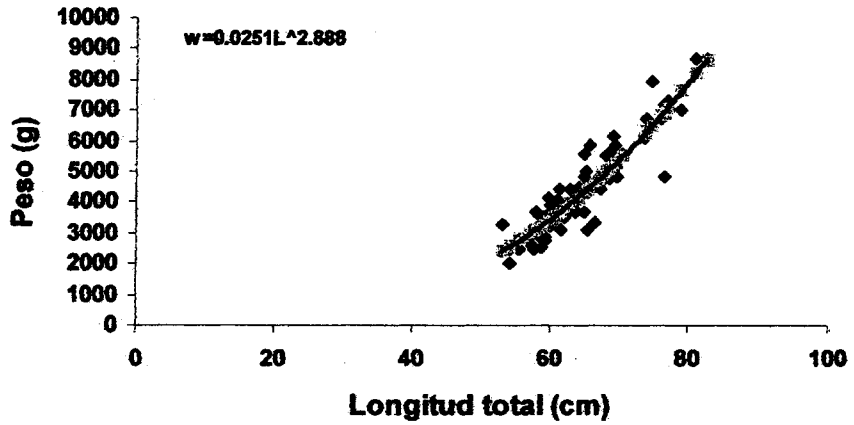

Figura 4. La relación longitud total-peso eviscerado del mero *E. striatus* (machos), en el área de agregación del blanquizar, Q. Roo, México.

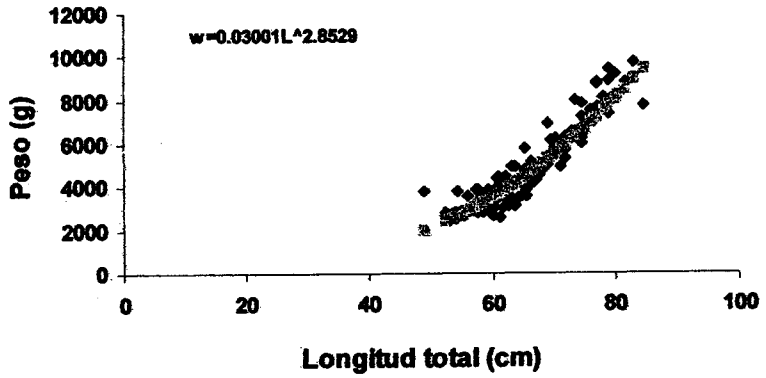

Figura 5. La relación longitud total-peso eviscerado del mero *E. striatus* (hembras), en el área de agregación del Blanquizal, Q. Roo, México

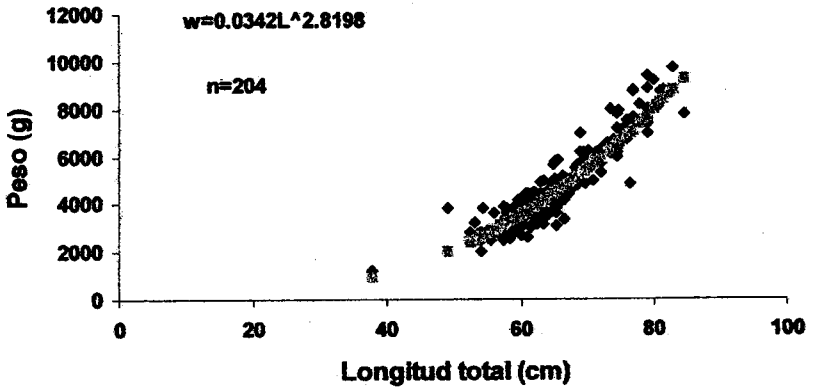

Figura 6. La relación longitud total-peso eviscerado del mero *E. striatus* (total), en el área de agregación del Blanquizal, Q. Roo, México .

DISCUSION

En Quintana Roo, la explotación del mero *Epinephelus striatus*, es conocida desde principios de 1910 por los pescadores antiguos, en donde utilizaban el arte del cordel y el anzuelo como método de captura en el área conocida como mahahual Q. Roo (Aguilar-Perera 1994). Durante mucho años esta zona de agregación fue la mas importante zona de captura de *E. striatus*, sin embargo debido a las características de la zona, por presentar poca profundidad y debido al uso indiscriminado de artes no permitidos como redes, arpón y explosivos durante un tiempo, provoco que esta agregación disminuyera año tras año o desapareciera en un periodo. Se logro en un principio capturas importantes como las 24 toneladas obtenidas en 1960 hasta las 3 toneladas capturadas en 1991 (Aguilar-Perera et al. 1994). Por tal razón el decremento del producto en los últimos años ha sido en mas del 80%, este panorama nos hace reflexionar en que estamos provocando la desaparición de este importante sitio agregación en el sur de Quintana Roo. Esto mismo esta ocurriendo en ciertas zonas de Belice, en donde pronostican la desaparición de sitios de agregación dentro los próximos 10 años (Sala et al. 2001).

La agregación localizada en el "Polígono Parque Marino Arrecifes de Xcalak", conocida por los pescadores como el Blanquizal, cae dentro del panorama propuesto, en que se dice que tales sitios de agregación se encuentra localizados cerca de las proyecciones arrecifales, hacia mar adentro del propio contorno general arrecifal (Colin et al. 1987). Por tal motivo este sitio de agregación se encuentra localizado a unos 1000 m de la línea de costa, la estimación en un inicio en la época reproductora, se logro contar por medio del buceo SCUBA, a un total de 100

organismos hasta alcanzar aproximadamente 350 individuos a finales de este evento, en cada uno de los meses del muestreo, sin embargo los mismos pescadores a principio de febrero de 2002, lograron ubicar un cardumen de 2000 a 3000 organismos, a tan solo 70 m de la zona de captura y a una profundidad de 40 metros, esto nos da una idea que la agregación es importante desde el punto de vista ecológico. Con los datos obtenidos por la pesca con línea y anzuelo, se logro encontrar, que hay una relación Hembra:Macho, por arriba de un orden de magnitud por parte de las hembras, esto quiere decir que hay mas hembras en los sitios de agregación que machos, esto también a sido observado por varios autores en el caribe (Colin et al. 1987, Sosa-Cordero y Cardenas-Vidal 1992, Aguilar-Perera et al.,1994, Sandovy y Eckland 1999, Paz y Grimshaw 2001). De igual forma se conoce que las hembras en este sitio presentaron las tallas mas grandes referente a los machos, presentando una tendencia igual en varios sitios del caribe (Colin et al. 1987, Paz y Grimshaw 2001).

A pesar que este es un primer esfuerzo en cuanto a la obtención de datos de tallas y pesos, podemos mencionar que las tallas encontradas y los pesos, corresponde a un recurso subexplotado, ya que abarcaron tallas de 49 a 84.5 cm de LT (Thompson y Munro 1983). El rango de tallas encontrado en mahahual y Xahauaxol, estuvieron entre un rango de 52 a 76.5 cm de LT, las tallas promedios encontrada en este sitio del blanquizar estuvo entre los 64.77 cm LT, mientras que en otras regiones del caribe y de la costa sur de Q. Roo están por debajo de este rango (Colin et al. 1987, Sosa-Cordero y Cardenas-Vidal 1992, Aguilar-Perera et al. 1994, Sandovy y Eckland 1999, Paz y Grimshaw 2001).

En vista a lo anterior hace la necesidad de implementar un plan de manejo adecuado, es necesario continuar con el estudio, este análisis preliminar, ya que nos proporciono resultados sorprendentes, ya obtuvimos un panorama de cómo se esta distribuyendo la frecuencia de longitud en este hábitat y la proporción por sexo de la agregación. La falta de estudios biológicos, oceanográficos y sociales, son fundamentales para un buen plan de manejo sustentables, y que a la vez sirva de base a los otros sitios de agregaciones de la zona sur de Q. Roo.

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Modeling Larval Transport from Snapper (Lutjanidae) Spawning Aggregations in Cuba

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ABSTRACT

Historical spawning aggregations of mutton (*Lutjanus analis*), lane (*L. synagris*), cubera (*L. cyanopterus*), dog (*L. jocu*), and gray (*L. griseus*) snappers on the insular shelf of Cuba are examined in terms of the probability of larval dispersal from the source populations to coastal habitats in the Mesoamerican region and different ecological provinces of the island of Cuba. In particular, we examine how dispersal and recruitment vary intra- and inter-annually with oceanographic regimes, shelf configuration, and spawning sites. Our modeling approach is based on a coupled biophysical model incorporating a high-resolution ocean circulation model (MICOM), a Lagrangian scheme with larval sub-grid turbulent motion, larval sensory capabilities, and the availability of settlement habitat. Sequential runs centered on particular months and lunar phases were used to estimate the likelihood that each spawning event contributes large numbers of larvae to foreign downstream populations or to neighboring populations on the complex Cuban shelf. The model results are discussed with regard to historical data. This innovative approach of estimating larval dispersal from spawning aggregations can enhance stock-based conservation recommendations and optimize the design of marine reserve networks.

KEY WORDS: Larval transport, snapper, spawning aggregations, Cuba

Modelando el Transporte Larval desde las Agregaciones de Desove de los Pargos (Lutjanidae) en Cuba

Se analizan las agregaciones históricas de desove de los pargos (*Lutjanus analis, L. synagris, L. cyanopterus, L. jocu y L. griseus*) de Cuba, en términos de la probabilidad de dispersión de las larvas desde el origen de la población hacia los hábitat costeros de la región mesoamericana y las provincias ecológicas de la isla de Cuba. Se investigó en particular, la variación anual e interanual de la dispersión y el reclutamiento en relación con el régimen oceanográfico, la configuración de la plataforma y los puntos de desove. Nuestro modelo biofísico incorpora un modelo de circulación oceánica de alta resolución (MICOM), un esquema Lagrangian con

turbulencias de rejilla secundaria para describir el movimiento de las larvas, las capacidades sensoriales de estas y la disponibilidad de hábitat para el asentamiento. Se ejecutaron varias secuencias del modelo centradas en determinados meses y fases lunares, y fueron utilizadas para estimar la probabilidad de contribución de larvas de cada evento de desove hacia poblaciones distantes de otros países, u otras zonas de la plataforma cubana. Los resultados del modelo se analizan a la luz de los datos históricos. Esta forma innovativa de análisis de la dispersión de larvas desde las agregaciones de desove, puede contribuir a los esfuerzos de conservación basados en las poblaciones, y además ayudar en la optimización de la red de reservas marinas.

PALABRAS CLAVES: Transporte larval, pargos, agregaciones de desove, Cuba

INTRODUCTION

The snapper family (Pisces: Lutjanidae) include Caribbean-wide, reef fish species known for forming predictable spawning aggregations. Historically, large groups of snappers have been spawning periodically at specific sites within the insular shelf of Cuba (Claro and Lindeman 2003). The snapper fishery is the principal finfish fishery in Cuba with the lane snapper as primary fishing target, being mostly fished in the Golfo de Batabanó in the southwest of Cuba. Mutton snapper catches rank second with largest catches in the northeastern coast. Large decreases in catches from as early as 1975 have been reported (Claro et al. 2002a) and may be attributed from fishing in spawning aggregations.

The Cuban platform consists of a main continental island with many smaller islands. The geomorphology of the Cuban shelf is very distinct in that it has a large and shallow insular shelf surrounded by fringing keys and reefs forming a series of lagoons, while the shelf edge is abrupt and formed by a series of submerged terraces (Claro et al. 2002b). The Cuban platform can be divided in four wide shelf regions separated by areas of narrow shelves: the North West (NW), North Central (NC), South East (SE) and South West (SW).

The reproductive strategy of snappers is species-specific and rather complex. Spawning aggregations occur at promontories (e.g. Cabo Cruz, C. Corrientes), at the shelf edge (Cayo Bretón), or even in the inner-shelf (Golfo de Cazones). A single or multiple sites may be shared by several species simultaneously or with different inter- and intra-specific spawning schedules. Spawning occurs during a narrow window in time (usually of a couple of months) and centered on a lunar phase (Table 1). However, intra-specific variations in peak spawning occurs among regions (Claro and Lindeman 2003). In addition, snapper have highly variable within and among species planktonic larval durations (PLDs), ranging from 15 - 48 days (Lindeman et al. 2000).

Marine reserves have been suggested as a tool to conserve economically and ecologically valuable species fish species like snappers. However, snappers may require particular protection since they are highly vulnerable to fishing activities during spawning (Luckhurst 2002). Thus, information on the potential larval

pathways likely to occur from specific spawning aggregations may serve to guide reserve design for maximum effectiveness at ensuring population replenishment. Only studies that incorporate accurate information on the currents, physical forcing, spawning locations, and larval behaviors can make such predictions.

Table 1. Subset of spawning aggregation sites for larval transport modeling. * - peak spawning month (modified from Claro and Lindeman 2003)

Spawning Site	Coordinate	Species	Spawning Peak	Moon
		Southeast region		
Cabo Cruz	19°49'24" 77°44'36	Lane snapper	June	Before full
		Mutton snapper	May*-June	Full to 4
		Cubera and gray snapper	July*-August.	Full
Cayo Bretón	21°07'36" 79°31'24"	Cubera snapper	July-August.	Full
		Dog snapper	July*-August.	Full
		Lane snapper	June*-July	Before full
		Southwest region		
C. Diego Pérez	22°02'00 81°30'25	Lane snapper	May*	Before full
C. San Felipe	21°55' - 83°36'	Mutton snapper	May*	Full to 4
		Lane snapper	May-June*	Before full
		Spiny lobster	Feb.-May	Full
Cabo Corrientes	21°44'43" 84°32'05"	Nassau grouper	Dec.-Jan.	Full
		Mutton snapper	May-June*	Full to 4
		Cubera and Dog snapper	July*-August	Full
		Northwest region		
Corona de San Carlos	22°54'24" 83°36'12"	Mutton snapper	May-June*	Full to 4
		Gray and cubera snappers	July*-August.	Full
		North-Central region		
Punta Hicacos-Mono	23°17' 81°05'	Mutton snapper	May-June*	Full to 4
		Lane snapper	May-June*	Before full
C. Caimán Grande	22°45'12" 78°52'48"	Mutton snapper	May-June*	Full to 4
		Lane snapper	May-June*	Before full

APPROACH AND METHODS

Data Source

It is important to recognize two major sources of information regarding those spawning aggregations. First, information may come from patriarch fishers, which knowledge of the spawning sites (e.g. where and when) is usually associated with observations of adult biology. Fishers can in fact become the most credible of advocates for the protection of those sites (e.g. Riley's Hump, Florida; Banco Chinchorro, Mexico). Another source of information comes from local scientists. They take a critical part in keeping track of historical data and in studying the ecology of local fish populations as well as the physical attributes of the region (e.g. Claro et al. 2002c).

Spawning Aggregations Sites

The spawning sites on the insular shelf of Cuba were reported by Claro and Lindeman (2003) and listed in Table 1 for the mutton (*Lutjanus analis*), lane (*L. synagris*), dog (*L. jocu*), cubera (*L. cyanopterus*), and gray (*L. griseus* (gray) snapper. Six major spawning aggregation sites were selected for the mutton snapper (one in the NW and the SE, two in the SW and the NC) as well as for the lane snapper (two in the SE, SW, and NC). The cubera, dog, and gray snappers were treated as a species complex because they share both locations and peak spawning times; for this species complex, four major spawning aggregation sites were selected (one in the NW and the SW, two in the SE).

Larval Transport Model

Spawning output dispersal and larval trajectories from known spawning sites within the insular shelf of Cuba (Table 1) was simulated for several species of snapper (*Lutjanus analis* (mutton), *L. synagris* (lane), *L. jocu* (dog), *L. cyanopterus* (cubera), and *L. griseus* (gray)). For this purpose, we used the high resolution (9 km mesh) Miami Isopycnal Coordinate Ocean Model (MICOM) and a variety of larval behavior scenarios (e.g. passive and active; Cowen et al. 2003) to compute a range of likely transport outcomes under varying winds and currents associated with seasonal conditions. Larval behavior incorporated to the model is based on observed biophysical retention mechanisms (i.e. ontogenetic vertical migration in low flow regions; Paris and Cowen In review) as well as on known swimming (Stobutzki and Bellwood 1999) and sensory capabilities (Kingsford et al. 2002). These factors served to define a Retention Zone (RZ) for pelagic larvae of which the boundaries correspond to the geographical extent of the biophysical mechanisms experienced by snapper larvae (see Sponaugle et al. 2002) and were set within 9 - 18 km of the suitable settlement habitat. Mortality at the end of the transport scenario occurs at 100% for simulated larvae that are found outside the RZ. Larval transport is performed under various levels of larval behavior. For example, in the quasi-passive scenario, transport is passive throughout the pelagic phase and the recruits are those particles that are at found within the RZ at the end of the PLD. In the active

scenarios, the onset of active behavior occurs at day 7, 14, or 30 of the pelagic phase, whereby simulated larvae are allowed to be retained if they are found within the RZ. Otherwise, they continue their trajectories until they reach a RZ or until the end of the PLD, whichever comes first. Finally, Spawning Production (SP) is simulated using sequential runs of 3-day frequency around a moon phase and during peak spawning months.

RESULTS AND DISCUSSION

Sensitivity Analysis

Sensitivity analysis was performed on the onset of active behavior and on the width of RZ around settlement habitat. The percentage of SP recruiting locally decreased exponentially with delay of active behavior, while the width of the RZ did not have a significant effect on recruitment levels. Similarly, the export levels (% SP non-locally recruiting) decreased with delay of active behavior, especially for close-by locations (e.g., Bahamas, Cay Sal Bank). For more distant locations (e.g. Mexico, Jamaica, Florida), the export levels were constant for the early onset of active behavior (day 7 and 14), but decreased drastically in the quasi-passive scenario.

Local Recruitment

Results indicate that most of the spawning aggregations benefitted their own region (self-recruitment), except for the mutton snapper spawning aggregation site from the NW which was mostly a source to the NC region. It was also clear that some regions were more productive than others. For example, the SE sites contributed to most of the local recruitment of the cubera-dog-gray complex, while the SW and NC sites were more important in terms of local recruitment for the mutton snapper. The NW region was consistently a poor source of local recruitment for all the species, which corroborated with lowest historical catches by region (Claro et al. 2002c). There were also site differences within a region, where some sites represented a better source of local recruitment than others (e.g. in the SW region, Cabo San Felipe produces more local recruits than Cabo Corrientes).

Export by Region

Results indicate that export is about an order of magnitude lower than local recruitment. In general, sites from the northern regions may be connected to the southern Bahamas, and may contribute to a significant part of the replenishment for the mutton snapper populations of Cay Sal Bank. Sites from the SW region are connected to Mexico, Cayman, and Jamaica, and to a lesser extent to Belize, while those from the SE are connected to Hispaniola and the eastern Bahamas. Despite the proximity of the Florida Keys from the NW sites, none of the spawning aggregations seemed to contribute to the Florida Keys snapper populations. There are, however, interspecific differences in the exports.

Preliminary Conclusions

i) Temporal variability such as a lag in spawning schedules leads to spatial variability in recruitment,
ii) Spawning production from the insular shelf of Cuba contributes mostly to local recruitment to the insular shelf of Cuba – total export is an order of magnitude lower than local recruitment,
iii) Spawning aggregations are sources of recruitment to the region -the NW region is an exception to self-recruitment – consistent with lowest historical catches by region & the geomorphology of the shelf,
iv) The larval transport model is sensitive to the onset of active behavior in terms of recruitment but not in terms of dispersal distances - early larval behavior increases survival for both local recruitment and export. The quasi-passive scenario produces such low level of recruitment that it hampers detection of any possible spatial variation in recruitment levels.
v) Estimating larval dispersal from spawning aggregations can enhance stock-based recommendations and optimize design of marine reserves, and
vi) The sustainability of snapper populations in Cuba may largely depend on the conservation of the spawning aggregations.

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Caracterización Preliminar de la Distribución Espacial de Varias Especies de Mero (Epinephelinae: Epinephelini) en un Sitio de Desove en el Banco de Campeche, Yucatán, México

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RESUMEN

"Bajos del Norte" es un área ubicada a 137 millas náuticas al NE del Puerto de Progreso, en la parte central del Banco de Campeche. Esta zona esta compuesta por formaciones, con carácter arrecifal, que emergen de la plataforma marina hasta alcanzar profundidades entre 5 a 20 m, formando pequeñas "cordilleras" y "montañas" submarinas. En marzo y mayo de 2002 se realizaron viajes a "Bajos del Norte", a bordo de una embarcación pesquera, con el objetivo de estudiar el comportamiento reproductivo de los meros en la zona. *In situ*, a través de métodos directos (observaciones submarinas) e indirectos (captura comercial), se analizó: la distribución de los organismos y su estado de desarrollo sexual utilizando criterios macroscópicos de las gónadas. Además, parámetros ambientales como profundidad, temperatura, corriente, transparencia, salinidad, oxígeno disuelto, y fase lunar fueron registrados en el sitio. Once especies de mero (géneros *Cephalopholis*, *Epinephelus* y *Mycteroperca*) fueron identificadas por censo visual y/o en la captura comercial. En particular una de las cordilleras conocido por los pescadores como "Bajo Chico" presentó las mayores densidades y estadios de madurez sexual más avanzados para *M. venenosa*, *M. bonaci*, *M. tigris*, *E. striatus* y *M. interstitialis*. Aunque no se observó *in situ* la emisión de gametos, la alta densidad de organismos observados y la presencia de ovocitos hialinos en sus gónadas, permite suponer que este sitio corresponde a un área de desove. Así *E. guttatus* se encontró agregado principalmente en la cresta arrecifal a una profundidad promedio de 27 m; *E. striatus*, *M. tigris y M. venenosa* se agregaron preferentemente en la pendiente de la cordillera a profundidades entre los 35 y 40 m, mientras que *M. interstitialis y M. bonaci* ocuparon el lecho marino a una profundidad de 55 m.

PALABRAS CLAVES: Meros, Agregaciones de reproducción, Banco de Campeche.

Preliminary Characterization of the Space Distribution of Several Species of Groupers (Epinephelinae: Epinephelini) in a Spawning Site in the Campeche Bank, Yucatan, Mexico

"Bajos Del Norte" is an area located 137 nautical miles northeast of Progreso Port, in the central part of Campeche Bank. This zone is composed by formation, with reef characteristics, which emerge from the marine platform reaching depths between 5 and 20 m, forming a small range of submarine "mountains" (*cordilleras*). In March and May of 2002 trips to "Bajos de Norte" were made on board a fishery boat with the objective of studying the reproductive behavior of groupers in the zone. *In situ*, through direct methods (submarine observations) and indirect (commercial catch), we analyzed the distribution of the organisms and its state of sexual development using macrocospic criteria of its gonads. In addition, environmental parameters such as depth, temperature, current, transparency, salinity, dissolved oxygen, and lunar phase were recorded for each site. Eleven species of groupers (genera *Cephalopholis*, *Epinephelus* and *Mycteroperca*) were identified by visual census and/or in the commercial catch. One of these "cordilleras" known by the fishermen as "Bajo Chico" displayed the greater densities and advanced stages of sexual maturity for *M. venenosa*, *M. bonaci*, *M. tigris*, *E. striatus* and *M. interstitialis*. Although the emission of gametes was not observed *in situ*, the high density observed of organisms and the presence of hyaline oocytes in its gonads, suggests that this site corresponds to a spawning area. Thus *E. guttatus* aggregated mainly in the reef crest at an average depth of 27 m; *E. striatus*, *M. tigris* and *M. venenosa* preferred the reef slope to depths between 35 and 40 m, whereas *M. interstitialis* and *M. bonaci* occupied the marine bed at a depth of 55 m.

KEY WORDS: Groupers, Spawning aggregation, Campeche Bank.

INTRODUCCIÓN

Muchas especies de peces tropicales, asociados con arrecifes de coral, se agregan en lugares y épocas específicos para llevar a cabo la emisión de sus gametos y poder así reproducirse. Estas especies comprenden al menos a 11 familias de los peces arrecifales más abundantes, destacando entre ellas la Serranidae, Lutjanidae, Labridae, Scaridae, Acanturidae, Caesionidae, Mugilidae, Siganidae entre otras (Domeier y Colin 1997). Estas agregaciones típicamente se forman en sitios con características particulares en su geomorfología, topografía e hidrología, que en conjunto contribuyen facilitando el comportamiento reproductor y el desove de los individuos adultos y la dispersión y sobrevivencia de los huevos fecundados (Russell 2001). Los estudios sobre este tipo de agregaciones de reproducción de peces son escasos debido a que son eventos de corta duración que ocurren en lugares muy remotos, muchas veces con condiciones climáticas desfavorables y cuando ocurren en sitios de fácil acceso estas agregaciones han sufrido grandes estragos en sus

poblaciones debido a la sobreexplotación por la pesca (Domeier y Colin 1997). En el Atlántico Oeste, varias especies de serránidos (meros) forman agregaciones de desove que van de centenares a miles de individuos, en áreas especificas y relacionadas con las fases lunares. Se tiene el reporte de agregaciones de reproducción típicas para *E. adscensionis* (Colin et al. 1987), *E. guttatus* (Colin et al. 1987, Shapiro et al. 1993a,b, Sadovy et al. 1994), *E. itajara* (Colin 1994), *E. striatus* (Smith 1972; Olsen y Laplace 1979, Colin et al. 1987, Colin 1992, Aguilar-Perera 1994, Carter et al. 1994, Sadovy y Colin 1995, Aguilar-Perera y Aguilar-Dávila, 1996), *M. bonaci* (Carter 1989, Carter y Perrine 1994, Eklund et al. 2000), *M. tigris* (Sadovy y Domeier 1994) y *M. venenosa* (Bannerot en Domeier y Colin 1997).

En el Banco de Campeche la explotación comercialmente de varias especies de mero conforman la segunda pesquería en importancia económica para la región (INP 1997). Al menos 21 especies de meros de los géneros *Cephalopholis, Epinephelus* y *Mycteroperca* se encuentran distribuidos en esta área de gran importancia pesquera (Colás-Marrufo et al. 1998, Tuz-Sulub 1999). A pesar del reporte de la reproducción de algunas de estas especies en zonas del Banco de Campeche, como *E. morio, M. bonaci* y *M. microlepis* (Brulé et al. 1999, Renán 1999, Colás-Marrufo y Brulé 2000, Renán et al. 2001), no se tiene ningún reporte documentado de la formación de agregaciones de reproducción de meros en esta área. Más aun, para los litorales mexicanos solamente existe un reporte acerca de la formaciyn de agregaciones de reproducción, la cual es la del mero *E. striatus* que ocurre en el estado de Quintana Roo, en aguas del Caribe Mexicano, en época de invierno (Aguilar-Perera 1994, Aguilar-Perera y Aguilar-Dávila 1996). Sin embargo, el trabajo conjunto con pescadores yucatecos de la flota tecnificada, ha permitido llevar acabo los primeros estudios que están dando pauta para la determinación de sitios donde podrían ocurrir agregaciones de desove en el Banco de Campeche (Tuz-Sulub et al. En prensa). El propísito del presente trabajo fue determinar y caracterizar la ocurrencia de agregaciones de reproducción de meros en una zona del Banco de Campeche.

MATERIAL Y MÉTODOS

En marzo y mayo de 2002 se participó en dos salidas de pesca comercial a Bajos del Norte a bordo de la embarcación pesquera *Cherna 10*, propiedad de la Sociedad Cooperativa de Producción pesquera "*Jurisdicción de Cooperativas*" del puerto de Progreso, Yucatán. Los pescadores profesionales de ésta embarcación se dedican a la captura de peces de escamas en ésta zona, durante los meses de febrero hasta mayo en periodos que incluyen los días cercanos a la luna llena ya que en estos, los volúmenes de captura de ciertas especies de meros como *E. guttatus, M. venenosa, M. tigris, M. bonaci* y *E. striatus* son más abundantes. "Bajos del Norte" (23°10'- 23°27' N y 88°40' - 88°59' O) corresponden a una zona de bajos fondos, con características arrecifales, localizada en la plataforma continental yucateca a 137 millas náuticas al Noreste del puerto de Progreso. Durante todas las salidas de pesca

se exploró una pequeña cordillera conocida por los pescadores como "*Bajo chico*", en la cual han registrado capturas masivas de algunas especies de meros, la posición exacta de la cordillera fue registrada con ayuda de un GPS (Figura 1).

Con base al estudio presentado por Domeier y Colin (1997), se utilizaron los métodos directos e indirectos sugeridos para poder caracterizar los principales factores ambientales de la zona y determinar si los meros presentes en los sitios explorados formaban agregaciones de reproducción.

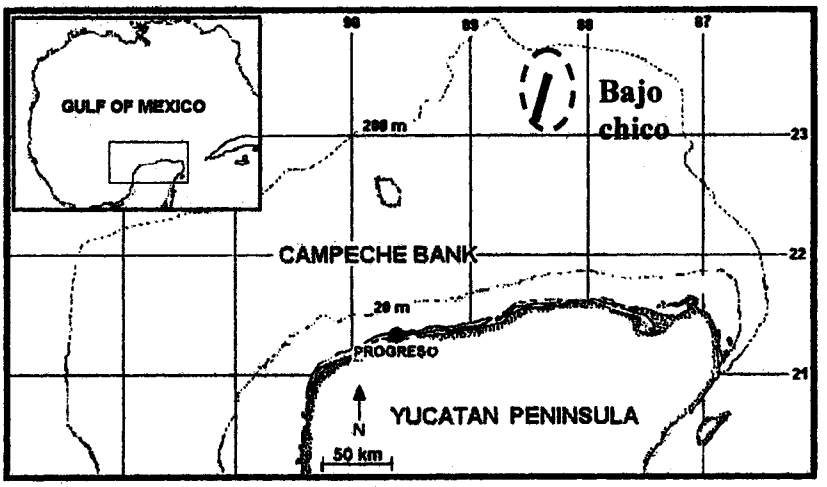

Figura 1. Ubicación geográfica de la región de los *Bajos del Norte* en la plataforma continental de la Península de Yucatán (Banco de Campeche), en particular la ubicación del Bajo Chico

Métodos Directos

Por buceo autónomo, con equipo Scuba, se caracterizó el tipo de fondo y de cobertura del sitio utilizando la técnica de videotransecto y los Grandes Grupos Morfofuncionales (GGMF) descritos por Osborne y Oxley (1997) para arrecifes de coral. Se identificó a las especies presentes con base en sus patrones de coloración, se estimó el número de individuos de cada una de ellas, y se observó el patrón de coloración y comportamiento de los organismos, para todo lo anterior se realizaron una o dos inmersiones diarias, por la mañana y/o tarde. Fotografías y filmaciones submarinas fueron tomadas con cámaras automáticas de 35 mm y 8 mm, respectivamente. Las impresiones y grabaciones fueron utilizadas en laboratorio, para analizar con mayor detalle, la estructura del substrato y el comportamiento de los organismos. Además se registraron los parámetros de temperatura del agua, a proximidad del fondo, por medio de un sensor térmico digital y la profundidad con

ayuda de un profundímetro manual, el oxigeno disuelto, salinidad y conductividad fueron determinados con ayuda de un multianalizador Ysy 85/25; se estimó la transparencia y velocidad de la corriente de manera cualitativa; los vientos dominantes se registraron diariamente a través de los reportes meteorológicos radiotransmitidos por la Cámara Nacional de la Industria pesquera (CANAIPES).

Métodos Indirectos

Se analizaron las capturas comerciales realizadas durante los días de pesca en la zona. Los organismos fueron capturados con arpón entre las 10:00 y 15:00 horas, a profundidades entre 25 y 30 m, durante inmersiones diarias realizadas con la ayuda de una compresora de aire. A bordo de la embarcación, se identificaron a las diferentes especies capturadas y el porcentaje relativo de cada especie en los volúmenes de captura.

Por otro lado, los ejemplares de cada especie fueron medidos (longitud total: Lt y longitud furcal: Lf), pesados (peso total: Pt y peso del pez eviscerado: Pe) y sus gónadas fueron extraídas y analizadas macroscópicamente. El sexo y el estado de desarrollo sexual de estos organismos fueron determinados utilizando siguientes criterios macroscópicos, modificados de Sadovy y Colin, (1995) (Tabla 1).

RESULTADOS

Características de la Zona

El área conocida como *Bajo Chico* esta formada por una cordillera submarina con una extensión 9 millas de longitud por un amplitud de 1 km. aproximadamente, con una orientación de Norte a Sur (23° 17'N- 88° 40' O a 23° 09'N -88° 45'). El sitio exacto donde ocurren las agregaciones se ubica en la parte norte de esta cordillera en los 23° 17' 30'' N y los 88° 40' 46''O. El área de este sitio tiene una extensión aproximada de 2 km^2 y profundidades que van de los 27 m en la parte mas alta y 55 m en su base, presenta una pendiente o ladera muy pronunciada con una inclinación de 75° aproximadamente. El sustrato es principalmente de tipo arrecifal, de formación reciente, ya que no presentan gran complejidad estructural, con una cobertura viva con mas del 9 % de su superficie. En esta cobertura predominaron el grupo de los corales masivos (55 %), principalmente del genero *Montastraea*; el grupo de Octocorales (17 %), principalmente del genero *Plexaura*; el grupo de esponjas (8 %) y el grupo de suelo calcáreo (4 %). La velocidad de la corriente en el área fue casi nula lo que permitió tener una visibilidad al 100 %. La salinidad reportada fue entre los 34.5 y 36.5 ‰, con temperaturas que oscilaron entre los 16.1°C y los 17.4°C. El porcentaje de saturación de oxigeno fue registrado entre el 87.5 y 91 %. En los días de muestreos los vientos dominantes provenían del Sur-Sureste con velocidades entre 20 y 45 km/h, los días de muestreo incluyeron los de luna llena y anteriores y posteriores a ella (Tabla 2).

Tabla 1. Clases sexuales para la determinación de sexo y estado de desarrollo sexual en especies de serránidos, Epinephelinae:Epinephelini. (Modificado de Sadovy y Colin (1995) para el desarrollo sexual y la sexualidad de *E. striatus*).

Clase Sexual	Características macroscópicas
Hembra en Maduración	Gónada densa y granulosa al tacto, con la mayoría de sus ovocitos en vitelogénesis, Ovocitos Opacos visible a simple vista; Pared gonádica gruesa.
Hembra en Desove	Gónada turgente y granulosa, con gran porcentaje de ovocitos hialinos a simple vista y una alta vascularización en la delgada pared gonádica.
Hembra en postdesove	Gónada Flácida, con resto de ovocitos opacos y hialinos a simple vista, Cavidad central muy notoria.
Macho en emisión	Gónada compacta de color pálido y homogénea al tacto, Presencia de esperma en interior de la gónada o en emisión directa
Indeterminado	Gónada muy reducida, de coloración rosácea, donde nos se distingue la presencia de ningún tipo de ovocitos ni de contenido espermático.

Descripción de las Especies

Se identificó a ocho especies de meros distribuidos en la zona del *Bajo Chico*: *C. cruentata*, *C. fulva*, *E. adscensionis*, *E. guttatus*, *M. bonaci*, *M. interstitialis*, *M. tigris* y *M. venenosa* (Tabla 3). Ejemplares de M. *venenosa*, *M. bonaci* y *M. tigris* presentaron un comportamiento gregario y patrón de coloración típicas de agregación en días de luna llena y posteriores a esta. *M. venenosa* particularmente, presentó la mayor densidad, con un conjunto de varios centenares de individuos en los cuales se observaron dos patrones de coloración: ejemplares con una coloración pálida en todo el cuerpo y los bordes de las aletas dorsal, anal y caudal de color oscuro, y ejemplares que presentaban la parte del dorso del cuerpo y cabeza con una coloración oscura y el vientre de color pálido claro. Este conjunto de individuos fue observado en las laderas de la cordillera a profundidades entre los 30 y 45 m. Un grupo de 8-12 individuos de *M. bonaci*, todos con talla mayores a 90 cm, fue observado en la base de la cordillera a una profundidad de 55 m, los organismos mayores presentaban bandas oscuras en los bordes principalmente de las aletas caudal y dorsal. Dos ejemplares de *M. tigris*, observados en el inicio de la pendiente de la cordillera a 30 m de profundidad, presentaron una coloración particular, la cabeza de color pálida-amarilla, aletas pectorales negras y una mancha blanca en la parte posterior del abdomen. Se observaron algunos ejemplares de *E. striatus* y *M. intertitialis* con tallas mayores a los 55 cm distribuidos en las laderas de la cordillera sin coloración llamativa o diferente a la habitual. El 15 de marzo de 2002 a 13 días de la luna llena, en toda la cordillera no se observó la presencia de ningún ejemplar de las especies antes mencionadas.

Análisis de las Capturas Comerciales

Las capturas comerciales de meros realizadas en la zona estuvieron constituida principalmente por *M. venenosa*, tanto en numero de individuos como en volumen

de peso eviscerado. En orden de importancia le siguieron *M. bonaci* en peso eviscerado y *M. tigris* con el número de individuos. También se observó una captura menos significante de *E. guttatus*, *E. striatus*, *M. interstitialis* y un solo ejemplar para *M. phenax* y *E. itajara* (Tabla 4).

Sexo y Estado Gonadal de los Organismos Capturados

Se analizaron un total de 508 individuos de las especies de *M. venenosa*, *M. tigris*, *M. bonaci*, *E. guttatus*, *E. striatus* y *M. interstitialis*, en orden de importancia, obtenidos de la captura comercial. Todos los individuos capturados en el lugar de pesca fueron analizados. Para *M. venenosa*, *E. guttatus*, *M. tigris* y *M. bonaci*, se observó siempre que entre el 85 y 95 % de los ejemplares analizados eran adultos que estaban sexualmente activos (Tabla 4). La diferenciación sexual se caracterizó con las hembras en etapas finales de ovogénesis (ovocitos opacos y hialinos visibles a simple vista en sus ovarios) y los machos con testículos llenos de esperma y/o con emisión visible. Los pocos organismos en los cuales no fue posible determinar el sexo fueron considerados como sexualmente inmaduros y en su mayoría fueron ejemplares con las menores tallas.

DISCUSIÓN

A través de las observaciones *in situ* y el análisis de las capturas comerciales para el área de *Bajo Chico* se determinó la distribución de 11 especies de meros de los géneros *Cephalopholis* (2 especies), *Epinephelus* (4 especies) y *Mycteroperca* (5 especies). Las altas densidades encontradas para varias de estas especies y la presencia de ovocitos hialinos visibles macroscópicamente en la mayoría de las hembras analizadas nos permitieron determinar que el área de *Bajo chico* corresponde a un sitio de agregaciones de reproducción para varias especies de mero. Este último aspecto es considerado uno de los indicadores indirectos de gran importancia para la determinación de agregaciones de desove, según Domeier y Colin (1997). Además observaciones personales nos permiten suponer que *Bajo Chico* es igual un sitio de desove para otros grupos de peces como Lutjanidos, Carángidos y Elasmobranquios. Este aspecto, de la distribución especial compartida por diferentes especies en un mismo sitio de reproducción, ha sido reportado para varias especies de meros y pargos en otros lugares, por ejemplo en las Islas Vírgenes (Beets y Friedlander en Sadovy 1996), Belice (Carter 1989) y en Bermuda (Thresher 1984).

Tabla 2. Especies de meros y sus densidades estimadas y parámetros fisicoquímicos, fase lunar y vientos dominantes registrados *in situ*, para el *Bajo Chico* durante días de marzo y mayo de 2002. m: matutino, v: vespertino. Cc: *Cephalopholis cruentata*; Cf: *C. Fulva*; Ea: *Epinephelus adscensionis*; Eg: *E. guttatus*; Es: *E. striatus*; Mb: *Mycteroperca bonaci*; Mi: *M. interstitialis*; Mt: *M. tigris*; Mv: *M. venenosa*.

Fecha	Hora Buceo	Especies observadas	Ind. Obs.	Prof. (m)	Temp. (°C)	Salinidad (ppt)	Oxigeno (% saturación)	Vientos/vel.
15 / 03 / 2002*	m	NINGUNA	00	27	17.4	34.6	82.5	SE/35 km/h
26 / 03 / 2002**	m/v	Cc, Eg,Mv, Mb,Mi, Mt	100-200	30-50	16.1	36.0	85	S-SE/ 25 km/h
27 / 03 / 2002**	m	Cc, Cf, Eg, Mv, Mt	200-500	45	16.5	—	—	SE/ 30 km/h
28 / 03 / 2002***	m	Cc, Ea, Eg, Mv, Mb, Mt	>1000	35-45	16.3	—	—	SE/ 20 km/h
01 / 05 /2002****	m/v	Ea, Eg, Es Mb, Mi, Mt, Mv	200-500	40-55	16.8	36.5	89.5	S-SE/ 45 km/h
02 / 05/2002****	v	Cc, Eg, Mv, Mb, Mi	100-200	30-35	17.1	36	90.5	S-SE/ 35 km/h
03 / 05/2002****	m	Cc, Mv, Mb,Mi, Mt	<100	30-35	17.1	36	90	S-SE/ 35 km/h

*1 dia posterior a Luna nueva (14/03/2002).
** dias anteriores a Luna llena.
*** Luna llena de Marzo de 2002.
****Dia posteriores a la Luna llena de Abril (27/04/2002).

Tabla 3. Volúmenes de Capturas comerciales de meros, en números de individuos y volumen de peso eviscerado y las características macroscópicas observadas en sus gónadas. Eg: *E. guttatus*; Ei: *E. itajara;* Es: *E. striatus* Mb: *M. bonaci*; Mi: *M. interstitialis*; Mp: *M. phenax;* Mt: *M. tigris*; Mv: *M. venenosa.* OO: Ovocitos Opacos; OH: Ovocitos Hialinos; ME: Machos en Emisión; IN: Individuos Indeterminados Inmaduros.

Fecha de pesca	Especies Capturadas	Numero de ejemplares	Peso vivo (eviscerado)	Características Macroscópicas
15 / 03 / 2002	NINGUNA	0	0	——
26 / 03 / 2002*	Mv, Mb, Mt	143	431 kg	OO, ME, IN
27 / 03 / 2002*	Mv, Mt, Es	124	395 kg	OO,ME,IN
28 / 03 / 2002*	Mv	68	178 kg**	OO,OH,ME,IN
01 / 05 /2002*	Mv, Mb, Mt, Eg,Ei	98	375 kg	OO,OH,ME,IN
02 / 05/2002*	Mv, Mb, Mi, Es, Mp	44	122 kg	OO,OH,ME,IN
03 / 05/2002*	Mv, Mb	31	98 kg	OO,OH,ME,IN

* Predominaron los ejemplares de *M. venenosa* en las capturas.

** El esfuerzo de pesca fue reducido a 1/3 por causas mecánicas.

Tabla 4. Determinación del sexo, longitudes y pesos de los individuos capturados durante marzo y mayo de 2002 en Bajo Chico. Eg: *E. guttatus*; Ei: *E. itajara;* Es: *E. striatus* Mb: *M. bonaci*; Mi: *M. interstitialis*; Mp: *M. phenax;* Mt: *M. tigris*; Mv: *M. venenosa.*

Mes	Especie	Total de ejemplares	Machos	Hembras	Indeterminados	Longitud Total (Max.-Min.)	Peso Eviscerado (Max.-Min.)
	Mv	326	18	306	2	86.5-41.5 cm	9100-1100 g
Marzo / 2002	Mb	4	1	2	1	96-117 cm	18800-4250 g
	Mt	4	2	2	0	61-42 cm	3150-900 g
	Es	1	0	1	0	82.5 cm	10500 g
	Mv	155	20	128	7	82-43 cm	9250-1350 g
	Mb	7	1	3	3	107-67 cm	17800-4500 g
Mayo / 2002	Mt	5	1	4	0	51.5-46 cm	1850-1100 g
	Eg	3	0	3	0	45-41 cm	1500-950 g
	Es	1	0	1	0	74 cm	8750 g
	Ei	1	0	0	1	105 cm	17550 g
	Mp	1	0	0	1	54 cm	1550 g

Las características geológicas descritas por otros autores para sitios de desove, como en Belice (Carter 1989, Carter y Perrine 1994), Florida (Eklund et al. 2000), y Puerto Rico (Shapiro et al. 1993a, Sadovy y Domeier 1994) en general, son descritos como sitios arrecifales con características típicas como la presencia de una cresta arrecifal, un arrecife posterior y una pendiente arrecifal; en el caso de *Bajo Chico* se identifican características homologas, ya que se identifica una cresta y una pendiente o ladera. Por otra parte la mayoría de los sitios de desove ocurren a unas decenas de kilómetros de la costa y generalmente paralela a ella, y en el caso nuestro el sitio se ubica a más de 200 kilómetros y es perpendicular a la línea de costa (Shapiro et al. 1993a, Carter y Perrine 1994, Sadovy y Domeier 1994, Eklund et al. 2000). Así también se pone de manifiesto la presencia de grandes complejidades arrecifales dominadas principalmente por corales duros y blandos y esponjas (Shapiro et al. 1993, Sadovy y Domeier 1994). En este aspecto la dominancia de los géneros *Montastrea sp* y *Plexaura sp*, coincide con lo descrito por Sadovy y Domeier (1994) para un sitio de agregación de *M. tigris* en la isla Vieques de Puerto Rico. La temperatura del agua en sitios de agregación influye para la formación de ellas, ya que se ha visto que es uno de los factores clave en la inducción del desove de los gametos (Russell 2001). Los limites reportados por algunos autores se encuentran por debajo de los 25°C (Sadovy y Domeier 1994, Domeier y Colin 1997); en nuestro caso las temperaturas registradas están muy por debajo del limite, además de que son de las mas bajas encontradas en otros lugares del Banco de Campeche (Arrecife Alacranes) y otros sitios de *Bajos del Norte* (Tuz-Sulub 1999, Tuz-Sulub et al. En prensa). Por otro lado las mayores densidades y los estados mas avanzados de maduración gonádica se registraron en días posteriores a la luna llena, lo que coincide con lo reportado por Domeier y Colin (1997) para varias especies de serránidos. La variación de las densidades observadas con relación a los días previos y posteriores a la luna llena nos permiten suponer que los organismos llegan al sitio antes de ella y se van en días posteriores, la probable migración de meros a los sitios de reproducción ha sido descrita para *E. striatus*, que ha registrado desplazamientos de hasta más de 200 km para llegar a ellos (Colin 1992, Carter et al. 1994).

En particular, *M. venenosa* presentó las mayores densidades y características macroscópicas que nos permiten definirla como una agregación de reproducción del tipo transitoria, tal y como lo describen Domeier y Colin (1997). La densidad estimada en varios centenares de individuos de esta especie en *Bajo Chico* es muy superior a las observaciones preliminares hechas en Bahamas y estimada entre 50 - 75 individuos por Colin (1992). La época de ocurrencia de este fenómeno en aguas yucatecas es de manera similar a la que presentan las poblaciones de *M. venenosa* en Jamaica, Puerto Rico y Cuba (Bullock y Smith 1991, García-Cagide y García 1996) las cuales se reproducen entre los meses de febrero y junio. El patrón de coloración exhibido por *M. bonaci* y *M. tigris*, reportados como de diferenciación sexual (Cabtree y Bullock 1998, Sadovy y Domeier 1994), así como la densidad observada de varios individuos y la presencia de ovocitos hialinos en las gónadas de ejemplares capturados, nos permiten también suponer que esta especie forma

agregaciones de reproducción en esta zona. Por otra parte la presencia de ovocitos hialinos en ejemplares de *E. guttatus*, *E. striatus* y *M. interstitialis* nos hace suponer que estas especies podrían estar reproduciéndose en *Bajo Chico* o en sitios cercanos a este. El periodo de mayor actividad de reproducción de *M. bonaci* es reportado en el Banco de Campeche entre diciembre y febrero (Renán 1999, Renán et al. 2001) y entre enero y marzo en aguas de Florida (Cabtree y Bullock 1998). En *M. tigris* esta actividad ocurre entre diciembre y abril en Puerto Rico (Sadovy y Domeier 1994). Las otras especies en desove encontradas en Bajo Chico durante el periodo de muestreo, coinciden con la época de reproducción descrita por Domeier y Colin (1997) para otras poblaciones del Mar Caribe. Esta época comprende el periodo de fin de invierno-inicio de primavera entre los meses de enero a junio.

Los volúmenes de captura estuvieron dominados en mas del 90 % por ejemplares de *M. venenosa*, siendo esta la "especie blanco" de los viajes comerciales realizados por la embarcación del Cherna 10 a el sitio analizado durante los meses de febrero a mayo (Manzano-Hú Comm. pers.).

No se conoce mucho acerca de donde, como y cuando ocurren las agregaciones de reproducción, este trabajo pone de manifiesto las primeras descripciones de estos fenómenos en la plataforma yucateca, en particular para *M. venenosa*, *M. bonaci* y *M. tigris*, sin embargo es indispensable realizar estudios espacio-temporales más completos en esta zona. Hasta el momento solamente la embarcación antes mencionada y exclusivamente entre febrero y mayo explota las agregaciones que ocurren en *Bajo Chico*. La localización precisa de los hábitats críticos donde se forman las agregaciones de reproducción, el periodo durante el cual éstas ocurren, y el seguimiento continuo de estos fenómenos son informaciones de suma importancia para pretender alcanzar un manejo sustentable y la protección de especies de peces de alto valor comercial y muy vulnerables a la explotación pesquera, como son los meros.

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Observations of a Nassau Grouper (*Epinephelus striatus*) Spawning Aggregation Site in Little Cayman, Including Multi-species Spawning Information

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ABSTRACT

The precipitous decline in mass spawning aggregations of Caribbean grouper and snapper species has been well documented. One-quarter to one-half of the known Caribbean aggregation sites are now inactive due to the ease with which aggregating species are caught. Historically, five spawning locations have been documented in the Cayman Islands. Today, three of these sites are dormant or commercially extinct. In January 2002, an expedition was led by the Reef Environmental Education Foundation (REEF) to Little Cayman Island to document a recently discovered spawning aggregation of Nassau grouper (*Epinephelus striatus*) on the island's west end. A team of divers conducted visual and video surveys on the aggregation site and on nearby reefs for ten days surrounding the full moon. Size and abundance estimates, color phase, and courtship and spawning behavior were documented. The Nassau grouper at the aggregation site shifted from mostly white belly phase early in the aggregation cycle to predominately dark phase in the middle of the cycle to mostly bicolor phase at the end. Toward the middle of the aggregation cycle the number of animals reached a maximum of approximately 5,200 fish. Courtship behaviors were documented each night and spawning was witnessed on four nights beginning five days after the full moon. Courtship coloration and behavior were documented in ten additional fish species. Five of these species were seen spawning. Hook and line fishing occurred daily on the aggregation. The Cayman Islands Department of the Environment reported a total catch of 1,934 Nassau grouper during the 10-day project, with an average landed size of 61.9 cm and a female to male sex ratio of 1:1.6 for all landed fish (39% females).

KEY WORDS: Spawning aggregations, Nassau grouper, *Epinephelus striatus*

Observaciones de un Sitio de Freza del Nassau Grouper (*Epinephelus striatus*) en Little Cayman, Incluyendo Información de la Freza Multi-especie

La declinación empinada en agregaciones frezando de las especies del Caribe del grouper y del snapper se ha documentado bien. Casi una mitad de los sitios del Caribe sabidos de la agregación están inactivo ahora debido a la facilidad con la cual la especie que es típicamente solitaria puede ser cogida mientras que se junta. Históricamente, cinco localizaciones de grouper se han documentado en las islas de Cayman. Hoy, tres de estos sitios son inactivos o comercialmente extintos. En enero de 2002, la Fundación Ambiental de la Educación del Arrecife (REEF) condujo una expedición a Little Cayman a documentar la recientemente descubierta agregación frezando del Nassau grouper (*Epinephelus striatus*) en el extremo del oeste de la isla. Un equipo de buceadores condujo encuestas visuales y de vídeo sobre la representación en el sitio de la agregación y los arrecifes próximos por diez días que rodeaban la luna llena. Las estimaciones del tamaño y de la abundancia, la fase del color, y el comportamiento del courtship y del grouper fueron documentados. Los grouper de Nassau en el sitio de la agregación cambiaron de puesto a partir sobre todo de la fase blanca del vientre temprano en el ciclo de la agregación a la fase predominante oscura en el centro del ciclo sobre todo a la fase bicolor en el extremo. Hacia el centro del ciclo el número de animales alcanzó un máximo de aproximadamente 5.200 pezes. Los comportamientos de courtship fueron documentados cada noche y la freza fue atestiguada por 4 noches que comenzaban 5 días después de la luna llena. La coloración y el comportamiento de courtship fueron documentados en diez especies adicionales de los pescados. La freza de cinco de estas especies fue documentado visualmente. La pesca del gancho y de la línea ocurrió diariamente en la agregación. El Departamento del Ambiente de Little Cayman divulgó un retén total del Nassau grouper de 1.934 durante el proyecto de 10 días, con un tamaño aterrizado medio de los 61,9 cm y una hembra al cociente masculino del sexo de 1:1.6 para todos los pezes aterrizados.

PALABRAS CLAVES: *Epinephelus striatus*,

INTRODUCTION

Nassau grouper (*Epinephelus striatus*) are large sized, long lived fish within the family Serranidae, subfamily Epinephalinae. The distinguishing characteristics of this species include a large black saddle near the caudal fin and five dark bars along the body. Sexes do not exhibit differences in color or shape. However, as with other serranids, Nassau grouper can rapidly blanch their color in response to entering cleaning stations, movement from one habitat to another, or predator/prey interactions (Colin 1992, Carter et al. 1994). Nassau grouper have an average life span of 16 years (Sadovy and Ecklund 1999), can reach a length of 91 cm TL, and

weigh up to 25 kg (Olsen and LaPlace 1979, Domeier and Colin 1997). Originally thought to be protogynous hermaphrodites, evidence now suggests that Nassau grouper are gonochorisitic with the capacity to change sex (Sadovy and Colin 1995, Sadovy and Eklund 1999). Sexual maturation is reached at approximately 1.87 kg (Sadovy et al. 1994b) or 40 – 45 cm, which is between four and seven years old (Sadovy and Eklund 1999). Their geographic distribution includes North Carolina to Florida, Gulf of Mexico, Bahamas, and the Caribbean to Venezuela (Bohlke and Chaplin 1993, REEF 2002). Historically, Nassau grouper were also found in Bermuda but the species has become locally extinct due to harvest pressure (Luckhurst 1996). Adults are normally solitary and territorial and live on coral reefs and rocky bottoms.

Several species of grouper, including Nassau grouper, are known to migrate to specific sites during the winter full moons in order to reproduce in mass aggregations (Domeier and Colin 1997, Bolden 2000, Sala et al. 2001). The benefits of aggregating to spawn include reduction of egg predation, increased genetic exchange, and higher fertilization rates (Domeier and Colin 1997, Bolden 2000, Sala et al. 2001). Spawning aggregation (SPAG) locations are typically at a reef promontory near a drop-off (Colin et al. 1987, Colin 1992). The environmental and social triggers that cause fish to aggregate are not well understood, although studies have suggested changing lunar light conditions, water temperature, currents, learned behavior, geomorphology, or a combination of multiple factors (Colin et al. 1987, Carter 1989, Tucker et al. 1993, Domeier and Colin 1997, Sadovy and Eklund 1999, Paz and Grimshaw 2001). While females have been seen repeatedly spawning in one evening, it is not known if the same fish aggregate in every aggregation month or even each year (Sadovy and Eklund 1999).

Five Nassau grouper spawning aggregation sites existed on the Cayman Islands: one each on the southeast corners of Little Cayman and Cayman Brac and three on Grand Cayman (Tucker et al. 1993). Of the total Nassau grouper currently harvested per year in the Cayman Islands, it is estimated that fishermen take 90% or more from aggregations (P. Bush, pers comm). This intense harvest has resulted in the commercial extinction or complete disappearance of 3 of these sites. The east end SPAG on Little Cayman had been fished since 1903 (Colin et al. 1987). In 1987, four days before the full moon in January, fishermen landed 1,000 Nassau grouper from Little Cayman's east end SPAG in one evening (Colin et al. 1987). In 1995, this site no longer contained an aggregation. The east end SPAG on Cayman Brac had also been fished for nearly 100 years (Colin et al. 1987). Between 1984 and 1991, the aggregation was dormant. In 1992, an aggregation was found approximately 1.2 km north of the dormant Cayman Brac site and was intensively fished the following four years (1993-1996). Since 1996, catches from this site have sharply declined (P. Bush pers. comm). Tucker et al. (1993) documented the three Grand Cayman spawning aggregations for five consecutive seasons (1987-1991) and found declines in harvest yield during this time in at least one site. Since Tucker et al.'s study of Grand Cayman SPAGs (1993), one has disappeared (southwest corner), one has become commercially extinct (northeast corner), and the third

(Twelve Mile Bank) yields a variable amount of Nassau grouper but is fished by only a few fishermen (P. Bush, pers comm).

In 2001, fishermen discovered aggregated Nassau grouper on the west end of Little Cayman Island. That year, fishermen harvested 2,000 Nassau grouper during the aggregation. In the winter of 2002, the Reef Environmental Education Foundation (REEF) coordinated an expedition to document this new aggregation site. REEF staff and volunteers collected information on the size and spatial extent of the aggregation over the course of the January/February aggregation cycle, as well as behavior of aggregating fishes. In this paper we present the results of this expedition.

METHODS

Study Area

The Cayman Islands are a British Crown Colony located in the western Caribbean. The three islands, Grand Cayman, Little Cayman, and Cayman Brac, lie between 19° 15' and 19° 45' N latitude and between 79° 44' and 81° 27' W longitude. Little Cayman lies approximately 145 km to the east-northeast of Grand Cayman and is about 10 km from Cayman Brac. The island is oriented in a northeast to southwest direction. The fringing reefs that surround most of the island contain shallow reef crests (rubble ramparts) as well as mid-shelf and shelf-edge fore reefs (Blanchon and Jones 1997). The aggregation site documented in this study was located at the terminus of the southwestern end of the island's shelf. The area features a sloping drop-off extending 0.6 km from shore to the 15 m depth contour (delineating the shallow terrace) and then continues as a deeper terrace to approximately 24 m. Benthic habitat of the shelf edge between 24 and 33 m featured low relief ridges and plateaus, interspersed with wide (30 m) sand patches. At 33 m the shelf edge precipitously drops off to a sheer wall. The area's currents are complex and range from slack to estimated speeds of three knots. Surface water temperature during the project was 26°C. Horizontal visibility ranged from 20 – 30 m.

The west end aggregation site was initially believed to be a new area for grouper reproduction on the island. However, anecdotal information from local fishermen now indicates that grouper historically aggregated at this site as recently as the 1960s.

Field Observation

Field work was conducted in January/February 2002 on Little Cayman Island. Underwater observations began the day before the full moon (dbfm) and lasted ten days (January 27 – February 5). A team of seven divers documented activity at the west end aggregation site each night, beginning the evening of the full moon (January 28). In addition, staff from the Cayman Islands Department of the Environment (CIDOE) and local dive operators accompanied the core team of

observers on several evenings. The team entered the water 10 to 72 minutes before sunset (mbs) each night and remained in the water approximately 40 minutes. In an attempt to minimize the impact of the divers' presence on the groupers' activities, the divers maintained positions approximately 7 m from the bottom and 10 m from dense aggregations of fish. Dives averaged 30 m in depth. Five members of the team estimated the number of individual Nassau grouper present, estimated color phase composition, and recorded the presence of distended abdomens and courting/spawning behavior. On the evenings when spawning was observed, divers reported the time of each gamete release. Because the amount of overlap of releases observed between divers is unknown, the maximum number reported by a given diver is presented here. Observations on the presence and activity of other fish species were also recorded. Two additional divers took underwater video using digital video cameras without lights.

The dimensions and size of the aggregation were estimated using topographic reference points and point counts of individuals. Each night, density estimates were obtained from multiple divers and then an average was calculated. Estimates were generated using counts within visually determined 3.3 m^3 'quadrats'. Multiple estimates were made for both the plateau and the shelf edge to generate mean values.

In addition to the observations made on the aggregation site each evening, five members of the team conducted multiple daytime visual surveys on reefs around Little Cayman using the Roving Diver Technique (RDT; (Schmitt and Sullivan 1996). During RDT surveys, the divers recorded all fish species encountered and relative abundance categories for each [Single (1), Few (2-10), Many (11-100), Abundant (> 100)]. Divers also recorded information on the size, depth, color phase, presence of a distended abdomen, group size (if traveling with others), and direction of movement (if any) for all sighted Nassau grouper.

Fishermen were present on the aggregation site each day of the project but most rarely fished on the aggregation after sunset. The total number of boats at any given time ranged from one to thirteen and each boat carried two fishermen. All fishing was artisanal hook and line. No special license was needed; however, Cayman Island law only permits Caymanians to fish aggregation sites during grouper spawning season. CIDOE sampled catches throughout the aggregation period to obtain length and sex of aggregated Nassau grouper. CIDOE also collected daily landing numbers.

RESULTS

A total of 67 visual RDT surveys were conducted on 14 reefs around the island (Figure 1) during daytime hours, representing 60 hours of survey time. A total of 176 fish species were documented, including four species of grouper in the genera *Epinephelus* and *Mycteroperca*. Sighting frequency (%SF) of the four species during the visual surveys were 79.1 % (tiger grouper – *M. tigris*), 62.6 % (Nassau grouper), 41.7 % (yellowfin grouper – *M. venenosa*), and 13.4 % (black grouper –

M. bonaci). These values were similar to those calculated for 153 RDT surveys collected during summer months of 2000 and 2001 from Little Cayman reefs (REEF 2002). However, the mean 2000/2001 summer % SF value for Nassau grouper was 80.3 %, considerably higher than what was encountered during the aggregation period. The complete data summary for the RDT data can be accessed from REEF's Website (REEF-GMP 2002).

The aggregation site (Figure 1; Site A1) was surveyed for nine nights beginning on the full moon (January 28).

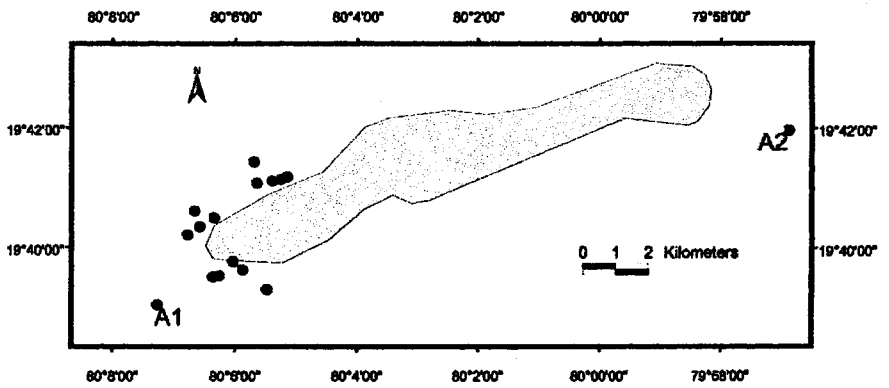

Figure 1. Map of the study area, indicating location of west end aggregation site (A1), the historical east end aggregation site visited on February 4 (A2), and the 14 reef sites surveyed during the day (indicated by dots).

Aggregation Characteristics

The average estimated number of Nassau grouper present at the aggregation site ranged from 408 on the 8th day after the full moon (dafm), the last evening the aggregation was documented, to 5,200 individuals 2 dafm. During the aggregation cycle, a total of 1,934 Nassau grouper were harvested from the aggregation site. The mean estimated numbers present on the aggregation each night and the total catch reported each day are shown in Figure 2.

Staff from the CIDOE recorded total length of 275 Nassau grouper, representing approximately 14 % of fish landed. Based on the individuals sampled, the average TL of harvested fish was 61.9 cm (47 - 86 cm), which equates to an 8+ year old fish (Sadovy and Eklund 1999). Approximately 22 % of the catch (431 fish) was sexed. The female to male sex ratio varied through time; the aggregation was dominated by males early and late in the aggregation cycle with females dominating just prior to the peak of spawning activity (Figure 3). The average female to male sex ratio was calculated to be approximately 1:1.6 (39 % females, 166 females and 265 males). A sub-sample of those sexed was also measured and little difference was found between males and females (67.5 cm and 72.3 cm mean TL in females and males, respectively).

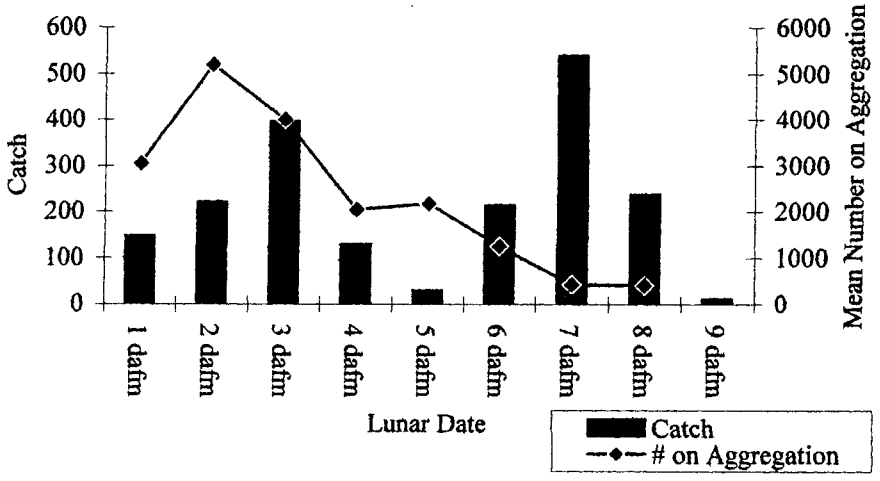

Figure 2. Daily catch and mean number of Nassau grouper visually estimated at the aggregation

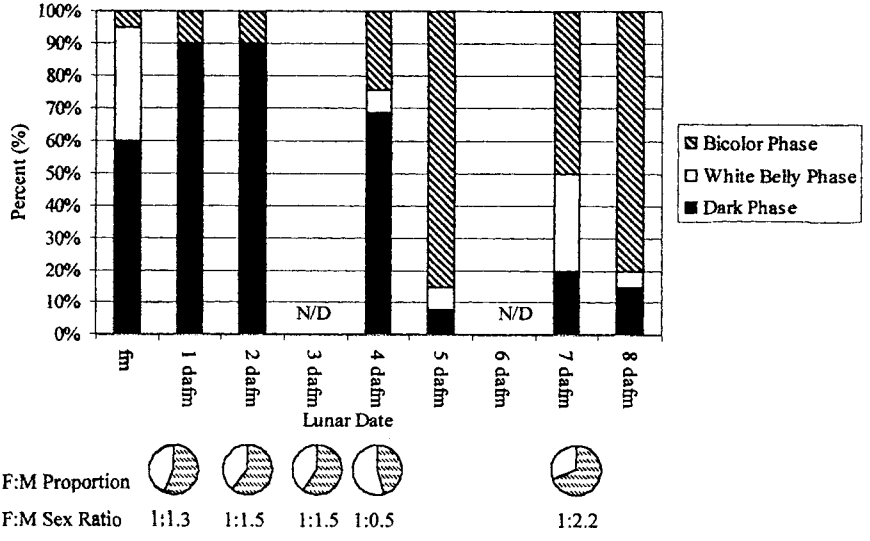

Figure 3. The shift in color phases during the aggregation cycle and the sex ratios based on catch data. Bars indicate the proportional color phase composition at the aggregation site. Pie charts show the proportional sex composition, based on landed fish, with the corresponding sex ratio (female:male) below each pie. Within each pie, hash marks are male and white is female.

Nassau Grouper Movements and Coloration

Characteristics and Behavior on Reef Sites — During daytime dives early in the aggregation cycle (1 dbfm – 4 dafm), approximately half of the Nassau grouper displayed courting colorations (white belly and dark) and had distended abdomens. Most fish with distended abdomens were in white belly phase. The majority (65 %) of all individuals seen were traveling in a directed manner along the shelf edge between 19 and 38 m. Of those in transit, most individuals were traveling in groups of two to eight individuals. The direction of travel was evenly split between going southwest (toward the location of the aggregation site) and going northeast. Most of the migrating individuals were seen at sites on the northwest side of the island. On two occasions, individual grouper were observed changing color phases while in transit; one barred phase changed to bicolor phase and one dark phase changed to barred phase.

Surveyors documented the largest number of grouper 2 dafm, with 27 fish seen during one dive. By the 5th dafm, the number of Nassau grouper seen during daytime dives decreased, and those that were seen were all in the barred (normal) color phase and were not migrating. Mean TL for all Nassau grouper observed during daytime dives was 42 cm, ranging from 26 cm to 60 cm. The smallest individual seen migrating was 32 cm.

Coloration Shifts and Behavior on the Aggregation Site — During the initial days of observation (full moon – 4 dafm), surveyors documented a consistent pattern of crepuscular movement and shift in dominant color phases. Throughout each evening during this time, the composition of color phases shifted to predominantly dark phase as sunset approached and the entire aggregation would move from hovering 1 – 6 m above the plateau to over the shelf edge (Figures 4a and 4b). Bicolor phase fish constituted less than 10 % of the fish present between the full moon and 4 dafm. Barred phase fish were observed on or near the bottom along the perimeter and interior of the aggregation. When present, white belly phase fish were always near the bottom of the aggregation near the substrate.

Interactions between individuals during this time period were rare, but when they occurred, the interaction appeared to be a herding or courting activity in which one dark phase individual was closely followed and partially surrounded by a few other fish (often bicolor phase). The closest pursuers would sometimes nudge the leader on the belly.

As the lunar phase approached 5 dafm, the herding activity became common and the grouper moved more rapidly. In addition, bicolor phase fish dominated (85 % of fish present) and the aggregation concentrated over the shelf edge (Figure 4c, Figure 3).

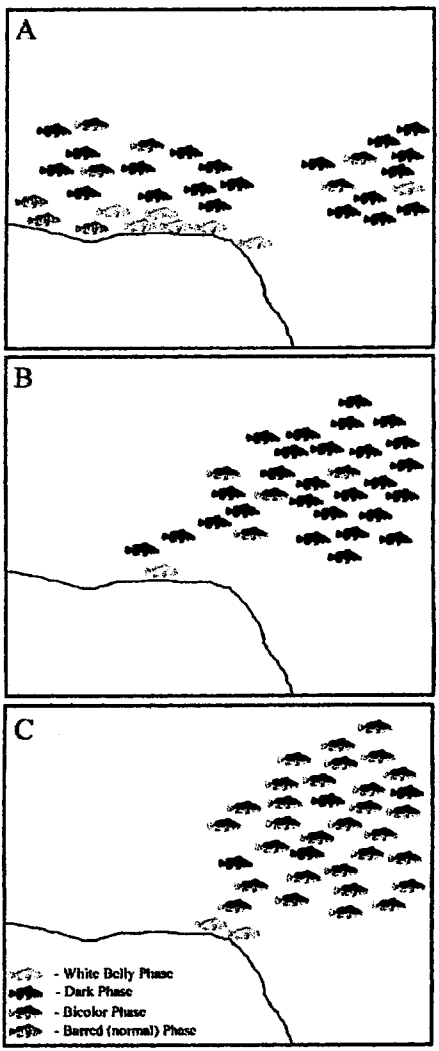

Figure 4. Crepuscular and lunar phase shifts in color phase composition and location of the aggregation. A and B) Crepuscular shifts seen early in the aggregation cycle (full moon – 4 dafm). Prior to sunset (A), all color phases were present. As sunset approached and passed (B), most fish were in the dark phase and the entire aggregation moved from the plateau to over the shelf edge. The proportion of bicolor phase fish remained low (approximately 10 %) during the entire early period of the aggregation cycle. C) Later in the aggregation cycle (5 dafm – 8 dafm), there was no nightly shift in color phase or location. The aggregation formed a cone out over the shelf edge with most fish in bicolor phase.

Courting and Spawning Behavior

Nassau grouper spawning was documented on four nights, beginning 5 dafm (February 2 - 5). On each of those evenings, divers were in the water from 28 to 30 mbs to between 7 and 15 minutes after sunset (mas). The highest level of spawning activity was documented 6 dafm, when at least 30 gamete releases occurred. A significant level of spawning activity was also documented 7 dafm; minimal activity was seen 5 and 8 dafm. On the two evenings of significant activity, the earliest spawning was documented 26 mbs and activity continued for up to 15 mas.

On each of the nights that spawning was observed, the grouper formed a cone, with the thickest layer around 33 m, tapering off up to a depth of approximately 18 m. Several types of pre-spawning movement behavior were seen, including 1) vertical spirals, 2) vertical movement without spiraling, 3) rapidly coming together after a short vertical movement and then radiating outward ('bursts'), and 4) rapid horizontal runs near the substratum (Colin 1992). Gamete release was only documented during the radiating outward bursts (ROBs). Each ROB started with 1 - 7 bicolor fish chasing one dark phase fish. The group, led by the dark phase individual, would run vertically for 3 - 6 m, resulting in gamete release before radiating outward. Additional bicolor fish would often join in during the ascent. Most ROBs ranged in size from 6 - 25 individuals, but up to 50 individuals were seen in a few ROBs. ROBs often initiated additional ROBs and up to 4 ROBs were seen within a minute.

Multiple Species Observations

Surveyors documented several other primarily large predatory species of fishes at the west end aggregation site. Small, site-attached reef fish were scarce. Spawning coloration, courting behavior, and/or spawning were witnessed in ten species – tiger grouper, yellowfin grouper, black grouper, horse-eye jack (*Caranx latus*), bar jack (*Caranx rubber*), black jack (*Caranx lugubris*), yellow jack (*Caranx bartholomaei*), mackerel scad (*Decapterus macarellus*), dog snapper (*Lutjanus jocu*), and ocean triggerfish (*Canthidermis sufflamen*). Of those, actual gamete release was documented in five species (Table 1).

Tiger grouper were seen in the characteristic tricolor phase known to occur during courting and spawning (Sadovy et al. 1994a) 4 - 8 dafm, and spawning was documented 5 and 8 dafm. The tricolor phase featured a pale head, white rectangular ventral blotch, and a dark dorsal area. The tiger grouper ROBs consisted of 5 - 12 individuals; eight dafm, the first ROB was documented at 5 mbs and a total of six ROBs were observed before divers exited the water at 15 mas. There were approximately 150 tiger grouper present in the area and all were in the tricolor phase at 15 mas. Two small groups of yellowfin grouper (2 and 4 individuals) were seen 8 dafm with distended abdomens, but no courting behavior or color patterns were seen. On two different evenings, a small group (3 - 4 individuals) of black grouper circled above the Nassau grouper cone. Seven dafm, the black grouper were seen with distended abdomens and were heard booming. Large schools of horse-eye, black, and bar jacks were seen spawning most nights

and all displayed courtship color patterns. Horse-eye jacks took on a bicolor coloration with a dark dorsal and white ventral pattern and a dark tail, black jacks displayed brilliant white tips on their tails, and bar jacks displayed a yellow tail and would flash dark bars on their body during the release of gametes. Yellow jack, which are typically solitary or in small groups, were present in schools of several hundred on two evenings and were most likely aggregating to spawn (Domeier and Colin 1997). Mackerel scad were seen spawning 5, 6, and 8 dafm, between 1 and 8 mas. A small group of dog snapper (4 individuals) was seen exhibiting spawning behavior (circling each other and performing upward spirals) 4 dafm and again 8 dafm. Eight dafm, the snapper also flashed white bars on their sides as they courted. Two and 4 dafm, ocean triggerfish were seen displaying courting coloration that featured a dark bar on each cheek that extended from below the eye to the jaw.

Seven dafm, a daytime dive was made on the east end of the island to an area historically known as a Nassau grouper aggregation site (Figure 1; Site A2). This site has not been fished during grouper spawning since at least 1995. Small groups (2 - 5 individuals) of Nassau, black, and yellowfin grouper were seen, along with a large aggregation (250 individuals) of tiger grouper.

In addition to those species seen courting or spawning, requiem sharks (Carcharhinidae), great barracuda (*Sphyraena barracuda*), spotted eagle ray (*Aetobatus narinari*), greater amberjack (*Seriola dumerili*), bigeye scad (*Selar crumenophthalmusi*), and rainbow runner (*Elagatis bipinnulata*) were all seen actively swimming around the Nassau grouper aggregation. The only fish seen eating gametes of any species were bigeye scad, which came in a large school to consume horse-eye jack spawn on one evening. During that same event, several great barracuda fed on the bigeye scad.

Table 1. Summary of spawning seen in other species by lunar date. Colorations and other courting behavior are noted in the text.

Lunar Date	Tiger Grouper	Horse-Eye Jack	Bar Jack	Black Jack	Mackerel Scad
2 dafm		spawning		spawning	
3 dafm		spawning			
4 dafm		spawning			
5 dafm	spawning	spawning	spawning	spawning	spawning
6 dafm		spawning	spawning	spawning	
7 dafm			spawning		
8 dafm	spawning	schooling	spawning		spawning

DISCUSSION

Reproductive aggregations in mobile marine species are common, yet poorly understood. Documenting the location and spatial and temporal dynamics of aggregations, as well as the behavior of aggregating individuals is of paramount importance in order to understand the reproductive biology of animals that

aggregate. This is particularly true for species deemed 'at risk' from a conservation stand point, as aggregations tend to increase the vulnerability of individuals to harvest. Additionally, because animals that exhibit this type of life history rely on behavioral interactions that may be mediated by density, declines in the number of individuals may result in disproportionate declines in the reproductive potential of the population (Alee 1931).

The high number and large size of Nassau grouper present at the SPAG site on the southwest corner of Little Cayman, along with the degree to which the aggregation site is used by other species, sets this site apart from other currently active Nassau grouper SPAGs in the Caribbean. It is difficult to say how many Nassau grouper used the SPAG site given that fish were undoubtedly both leaving and joining the aggregation over the course of the aggregation cycle and because the site was being intensively fished. However, at least 5,000 fish were present at the aggregation on January 30 based on the visual estimates. Based on these counts, the Nassau grouper spawning aggregation documented here is undoubtedly the largest known aggregation currently in the Cayman Islands. Additionally, the mean size of aggregating grouper (62 cm TL) was larger than any other aggregation documented in the Cayman Islands or elsewhere (Sadovy and Eklund 1999). Use of aggregation sites by multiple species has been documented previously (Carter 1989, Aguilar-Perera 1994, Carter et al. 1994, Luckhurst 2001, Paz and Grimshaw 2001), although the diversity of species documented spawning in this study is unique. This could be in part due to the large number of observers participating in the expedition. Nonetheless, it is clear that this area has properties that are of great reproductive benefit for many species of marine fish.

The role of coloration in Nassau grouper aggregations has received considerable attention in the literature. There is general agreement that both sexes exhibit bicolor and white belly phases (Colin 1992, Carter et al. 1994, Aguilar-Perera and Aguilar-Davila 1996). Colin (1992) postulated that the bicolor phase signals submissive behavior, and is thus important for large schools of aggregating individuals who are typically territorial. Paz and Grimshaw (2001) suggested that the bicolor and white belly phases were forms of cryptic coloration specific to the unique habitats of the aggregation site. There has been conflicting speculation as to whether dark color phase fish are either male (Paz and Grimshaw 2001) or female (Colin 1992). Based on the results of this study, it seems likely that both sexes exhibit dark phase coloration at least some of the time. We have drawn this conclusion from the lack of consistency between the sex ratios of daily fish catches and nightly proportions of fishes exhibiting dark phase coloration (Figure 3). For instance, the first night after the full moon fishermen caught 56 % males, while 90 % of the fishes observed on that evening were dark phase. All ROBs observed were led by dark phase fish followed by bicolor phase fish, suggesting that at the point of gamete release, females exhibit dark phase and males exhibit bicolor phase. The shift in color phase of fish each night early in the aggregation cycle to mostly dark individuals has been previously reported by (Colin 1992). It may be that early in the aggregation cycle, when spawning is not occurring, all sexes assume dark phase as light levels drop and

it becomes a more effective cryptic coloration than bicolor or white belly phases.

Later in the aggregation cycle when spawning is occurring, bicolor phase is maintained throughout the evening to distinguish and advertise sex among spawners. The overall sex ratio of 1:1.6 female to male during the aggregation period contrasts strongly with other aggregation sites in the proportion of males present. For instance, Little Cayman's historical east end SPAG had a smaller proportion of males early in the cycle when the proportion of males is expected to be near its highest point (1:0.5 female to male, 4dbfm, Jan 20, 1978). If protogynous hermaphroditism plays a bigger role in Nassau grouper's sexuality than gonochorism, the difference in sex ratios between the historical east end SPAG versus the west end SPAG could be explained by the differences in fishing pressures. In this scenario, the demography of a fished population would be skewed towards smaller/younger individuals, a high proportion of which would be females who have not matured enough to undergo sex change. Little Cayman's historical east end SPAG was fished intensively until exhausted in 1995. Carter (1994) also found that heavily fished Nassau grouper aggregations in Belize showed higher female to male sex ratios than did unexploited aggregations. In heavily fished aggregations in the Bahamas, female to male sex ratios varied from 1:0.2 to 1:0.3 (Colin 1992). In each of these examples there appears to be a link, perhaps causal, between heavy fishing pressure and a high proportion of females. This conclusion is consistent with the facts that the east end aggregation was intensively fished for almost 100 years and had a high proportion of females while the west end aggregation has only been fished for the past two years and has a high proportion of males. It is important to note that the change in sex ratio typically seen through the spawning cycle can complicate comparisons of sex ratios across aggregations, as catch statistics are often not reported throughout the entire duration of the aggregation.

Over the past two seasons, the Little Cayman west end aggregation has been fished heavily. In 2001, fishermen harvested an estimated 2,000 Nassau grouper during the aggregation, including 1,200 fish by a single Cayman Brac fisherman. In 2002, fishermen were present on the aggregation site each day of the project and cumulatively harvested nearly 2,000 fish. The majority of vessels were from Cayman Brac, two were from Grand Cayman, and three were from Little Cayman. In 1985, the Cayman Islands Governor in Council issued a general license for all residents to enter the grouper spawning areas, but prohibited the use of fish traps, spear guns, explosives, seine nets or any other form of nets. In late February 2002, the Cayman Island Marine Conservation Board defined a spawning season of November 1 – March 31 and implemented 'no trapping' 1 nautical mile buffer zones around each designated spawning area, along with an alternate year fishing strategy. During fishing years (i.e. 2004 and 2006), only 12 Nassau grouper may be taken per boat per day. No Nassau grouper may be taken from aggregation sites during non-fishing years. While the west end aggregation site has not been designated as a spawning area yet, it will be before the 2003 Nassau grouper aggregation. If new legislation is properly enforced, the strategy should reduce fishing mortality by half or more. Given that most of the fishermen exploiting the aggregation are from Cayman Brac,

it seems likely that at least some will choose not to make the 40 km journey to Little Cayman each day for only 12 fish.

The west end aggregation appears relatively healthy despite fishing pressure in recent years, given both that males numerically dominated the aggregation, and that the size of harvested fish were large in comparison to other aggregation studies. Anecdotal evidence suggests that a few patriarchal fishermen were aware of this spawning aggregation as recently as the 1960s. However, it has not been exploited since 1987, when the Cayman Island government began monitoring the fishery, and probably has gone largely unexploited since the 1960s. It is likely that most if not all Nassau grouper participating in the west end aggregation are residents on Little Cayman given the deep waters surrounding all three islands and the relatively high abundance of Nassau grouper on Little Cayman (Pattengill-Semmens and Semmens in press). Tagging studies would be useful in determining where aggregating individuals go after leaving the aggregation site. In the Cayman Islands as a whole, Nassau grouper stocks have demonstrated some degree of resilience under fishing pressure perhaps due to the cumulative effects of inclement weather during aggregations, recruitment from proximal offshore banks, possible shifting of aggregation sites, and the existence of minor satellite aggregation sites that remain unfished. However, over the last two decades, catch statistics indicate a steady decline in the Nassau grouper fishery. While small, the Cayman fishing fleet is potent in its effects on seasonal reproductive aggregations. At present, the west end on Little Cayman is the only known Nassau grouper aggregation in the Cayman Islands that could reasonably be considered healthy. As such, it is likely that this aggregation is providing a high proportion of the total local recruitment of Nassau grouper to the Caymans. Clearly, maintaining the health of this aggregation is of paramount importance in order to protect Nassau grouper stocks and the viability of the fishery now and in the future.

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Fishing on Spawning Aggregation Sites of Groupers in Martinique (Mutton hamlet – *Alphestes afer*)

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ABSTRACT

Following the last GCFI meeting proposition on groupers spawning aggregations fisheries, a survey has been undertaken in Martinique. This survey reveals that fishing occurs on one species *Alphester afer* and marginally on *Epinephelus fulvus*. This poster presents a first description of the fishing techniques and their evolution. A rough localisation of these fishing areas is presented.

KEY WORDS: *Alphestes afer,* groupers, spawning sites

La Pêche sur Frayère de Mérous en Martinique Vierge Varech (*Alphestes afer*)

Une enquête a été réalisée en Martinique pour faire suite aux propositions faites lors de la dernière réunion du GCFI sur les pêches sur frayères de mérous. Cette enquête révèle l'existence de ce type de pêche sur une espèce : *Alphester afer* et marginalement sur *Epinephelus fulvus*. Une première description des techniques de pêche et de leur évolution est faite. Une localisation grossière des zones où se pratique cette activité est également présentée.

MOTS CLÉS : *Alphestes afer*, mérous, sites de ponte

INTRODUCTION

Groupers are species of high economical value in tropical and subtropical fishing activities. Most of these species are solitary and sedentary. Individuals stay for long periods in coral reef habitats. This site specificity and their relatively slow growth rate make them particularly vulnerable to overfishing. Moreover, some groupers migrate for several kilometers towards localized spawning sites. These sites are often exploited intensively by local fishermen during the brief spawning period of one or two weeks. This intensive exploitation is depleting some of the spawning aggregation sites and leading to overfishing of the concerned species.

There is no publication on spawning sites of groupers available in Martinique. To contribute to the GCFI reflection on management of groupers spawning

aggregations in the Caribbean, a preliminary survey has been launched in Martinique. The main objective was to compile an inventory of the concerned species and to localize the spawning aggregation sites known by fishermen. In addition, it aimed at describing the fisher's activities on groupers spawning aggregations in Martinique.

METHODOLOGY

Investigations were conducted with fishermen from around the island. The informants were not chosen by random sampling. Persons were questioned after spontaneous meeting on landing sites or on fishermen or fisher folk's indications.

The surveys were carried out on an informal mode of conversation, although managed around a specific theme. The main inquiry utilized underwater colour photos extracted from Reef Fish Identification book (Humann 1997). A map with landmarks and shoals of Martinique was used to localize spawning aggregation sites and fishing areas.

After identification of the concerned species, fishing trips on the spawning aggregation were made with professional fishermen. Monitoring of this fishery was undertaken on landing points. Fishing techniques, fishing areas, as well as the qualitative evolution of this fishery were described by investigation on landing sites, or at fishermen's home and by telephone interviews. Thirty-five fishermen were questioned. Only two fishing trips were carried out due to bad weather during the spawning season.

RESULTS

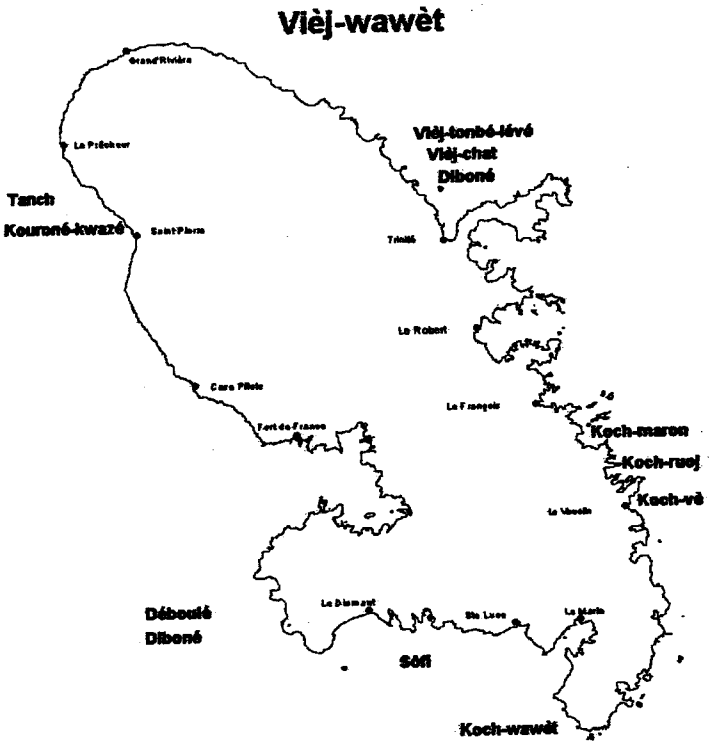
Fishing of Groupers on Spawning Aggregation Sites

Martinican fishermen have identified two grouper species that have spawning aggregation sites: *Alphestes afer* (Mutton hamlet) and *Cephalopholis fulva* (coney seabass). Fishing targeting Mutton hamlet operates every year at spawning season. Coney is also caught in breeding phase with Mutton hamlet but in lower quantities (less than 20 % weight). Martinican fishermen are unaware of spawning sites of other groupers.

Fishing of Mutton Hamlet on Spawning Aggregation Sites

Mutton hamlet has various vernacular names according to landing sites around Martinique (Map 1). The Mutton hamlet and Coney represent the principal varieties fished in Martinique. Annual catches were respectively 37.3 and 38.7 metric tons, in 1987. *Alphestes afer* represent 27.6 % of the landings of groupers and 22.6 % of the trap captures. Mutton hamlet is mainly fished by wire netting traps (57.4 %) and by small baited traps built from wood ("Tombé lévé": 25.2 %). In both cases, recruitment starts at 12 cm up to 17 - 20 cm. The more important Catch Per Unit Effort (C.P.U.E.) is obtained between 10 and 30 m depth for this inshore species (Gobert 1991). They settle among seagrass and seaweed or in crevices where they

hide.

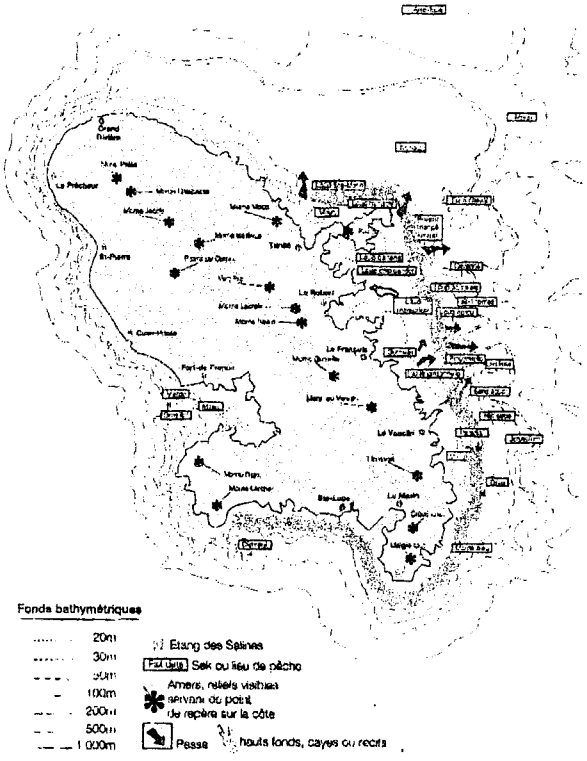


Map 1. Vernacular names of *Alphestes afer* in Martinique

The spawning aggregation sites of Mutton hamlet exploited by fishermen are located between 10 - 15 m and 25 - 30 m depth between Le Diamant and Trinité (Map 2). Mutton hamlets spawn on the outer part of shelf edge reef in February and March.

The spawning aggregation sites of Mutton hamlet are exploited mainly by fishermen living between Anses d'Arlet and Trinité. Various fishing techniques are used to catch Mutton hamlet during the spawning season. Bottom nets are used instead of "Tombé lévé" which are only used by a few fishermen. A dozen fishermen of Vauclin and some divers along the coast (Tartane, ...) use harpoon fishing to target this specie. Wire netting traps may be used to catch large quantities during

spawning season but this cannot be considered as a target fishing technique. Anglers also catch *Alphestes afer* outside spawning sites.



Map 2. *Alphestes afer* spawning sites in Martinique

The nets used are mono or multi-mono filament nets of mesh size between 25-40 mm. Heights range from 2,5 - 4 m and lengths from 100 - 1500 m. Most frequently 3 to 4 nets of 300 - 400 m are set for three to seven hours in the afternoon. This technique is carried on during one month between February and March. The efficiency lasts a quarter moon. A few fishermen figures that falling moon gives better results and with rising moon fishing stops. For others, the most important catches are made three days before and three days after full moon. Net fishing landings recorded range from 25-50 kg per trip. Fish measurements of one landing at the beginning of the season (probably the first one) showed total length of Mutton hamlet to be ranging between 18-25 cm (Figure 1). All the fishes (120) examined were fluent except two of size respectively 19 and 20 cm. It was therefore possible to establish sex ratio without opening them. Twenty four percent of the individuals caught were females. This sex ratio is not reliable for landings of this fishery. According to fishermen, females caught are much more numerous than males, whichever fishing gears are used.

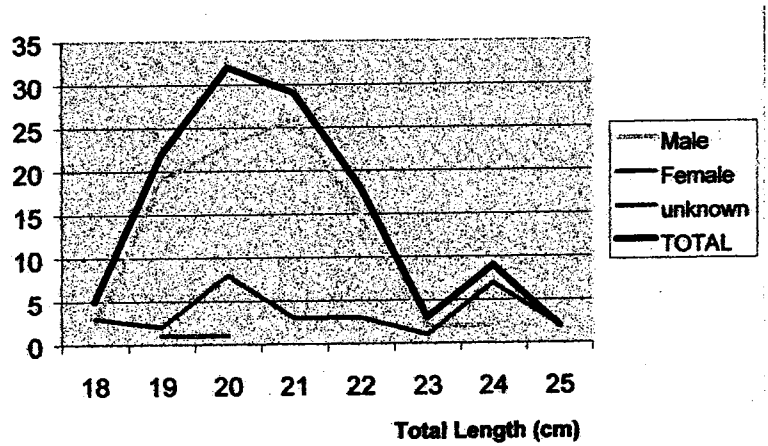


Figure 1. *Alphestes afer* length frequency (Vauclin 05/02/02)

Along with Mutton hamlet, fishermen caught large quantities of parrotfish in their reproductive season. These catches being more abundant and more regular for a longer period (several months), the fishermen prefer this fishery. For the same net length, we have recorded landings around 80 kg of parrotfish per trip.

"Tombé-lévé" are small wooden traps of the following size: length 65 cm, width 50 cm and height 20 – 25 cm. Mesh size is approximately 25 mm. Baits used for those traps are small pelagic fish frozen or caught by beach seines, or roasted octopus is used. With this technique fishermen usually use seven to eight traps. They are all set individually. The first one is raised as soon as the last one is set, meaning 20 or 25 minutes later. This "Tombé lévé" fishing starts in the morning between 6 a.m. to 12. Catches used to be around 20 – 25 kg up to 50 kg per trip. According to one fisherman it is actually round 15 kg per trip since the development of net fishing. Some fishermen think that this is due to the fact that frozen baits are actually used instead of traditional fresh baits coming from seine fishing.

Underwater fishing is practiced in the morning, from Vauclin and lasts for about three to four hours per trip. The teams are made up of three to four scuba divers per boat. Two to three individuals can be caught during one diving session and landing amounts to 25 kg per diver per trip. The divers describe the fish as passive and with no reaction towards the divers. They noted abundance of parrotfish on Mutton hamlet spawning sites. The parrotfish in breeding phase being very alert, they are more difficult to harpoon than Mutton hamlet. According to one scuba diver, typical aggregation site of Mutton hamlet lies in 10 - 25 m depth on the outer side on the coral reef covered with seaweed thus allowing hiding places.

FISHING TRENDS AND THREAT FOR MUTTON HAMLET STOCK

Assessment of Mutton hamlet fishing trends on or outside spawning sites cannot be undertaken from this preliminary survey. Gobert (1991) could not establish a diagnosis of the Mutton hamlet stock. Annual catch of Mutton hamlet recorded in 1987 with fishing gear used on spawning sites ("Tombé lévé", scuba diving, bottom nets) totalled up to 13,6 % of landings of this specie with all type of gears (Gobert 1991). This means that fishing on the spawning aggregation sites represent only a small percentage of total catches for this species. Mutton hamlet is most probably protected due to its small size allowing it to slip through the nets. Fishermen are unanimous in thinking that Mutton hamlet remains abundant. In addition, the rough sea protects the spawning areas during the breeding season. Sale price of Mutton hamlet is approximately the same as that of other benthic and demersal fish, which is less than US$10 and slightly less (US$8) when landings are important. This does not incite the fisherman to increase fishing activity on this species.

Only one "Tombé lévé" fisherman at Vauclin mentioned a decline in yields resulting from net development. Formerly about twenty fishermen used "tombé lévé" traps in Vauclin. Actually, only one fisherman practices this activity with traps approximately thirty fishermen use bottom nets and 10 scuba divers target Mutton hamlet in February – March. The increasing trend towards use of fishing nets instead of traps which are less efficient must be practiced with prudence, namely because other species like the parrotfish will contribute to increase fishing effort on the Mutton hamlet spawning aggregation sites.

Description of the spawning area (geographical limits, period of activity) and inventory of the species reproducing there should be undertaken. It is important to monitor fishing in this sensitive area that is favourable to spawning aggregation of various species of high economical value.

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Survey of Fish Assemblages and Habitat within Two Marine Protected Areas on the West Florida Shelf

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ABSTRACT

The Madison-Swanson and Steamboat Lumps MPAs were established by the Gulf of Mexico Fishery Management Council in 1999 to protect spawning aggregations of groupers. The primary goals of this project were to:

i) Establish baseline estimates of fish abundance, especially for species of groupers and snappers;
ii) Describe significant habitat features in the Madison-Swanson and Steamboat Lumps MPAs; and,
iii) Analyze the relationship between habitat and species assemblages.

The secondary objective was to locate spawning aggregations of gag (*Mycteroperca microlepis*), and scamp (*Mycteroperca phenax*). Side scan mosaics and multibeam bathymetry were used to stratify each MPA based upon benthic topography and geology. The Madison-Swanson, and Steamboat Lumps MPAs were surveyed during 5 cruises between February, 2001 and May, 2002. Gear employed during the surveys included stationary video camera arrays, (Hi-8 cameras or digital cameras), chevron fish traps, and an ROV. Spawning aggregations of gag and/or scamp were confirmed within the Madison-Swanson MPA in 2001 and 2002. Species assemblages varied with habitat. At sites along ridges and rocky outcrops, species observed included gag, scamp, red grouper (*Epinephelus morio*), snowy grouper (*Epinephelus niveatus*), speckled hind (*Epinephelus drummondhayi*), red snapper (*Lutjanus campechanus*), silk snapper (*Lutjanus vivanus*), vermilion snapper (*Rhomboplites aurorubens*), red porgy (*Pagrus pagrus*), knobbed porgy (*Calamus nodosus*), gray triggerfish (*Balistes capriscus*), and greater amberjack (*Seriola dumerili*). At sites on sandy substrates, species observed included honeycomb moray (*Gymnothorax saxicola*), bank sea bass (*Centropristis ocyurus*), and bandtail puffer (*Sphoeroides spengleri*).

KEY WORDS: Gulf of Mexico, Marine Protected Area, reef fish

Estudio de Congregados y Habitat de Peces dentro de Dos Areas Marinas Protegidas en la Plataforma de Florida Oriental

Las áreas protegidas (MPA) de Madison-Swanson y Steamboat Lump fueron establecidas por el concejo de manejo pesquero del Golfo de México en 1999 para proteger las agregaciones desovantes de meros. Las primeras metas de este proyecto fueron:

i) Establecer estimaciones básicas de abundancia de peces, especialmente para las especies de meros y huachimnangos;
ii) Describir las características significativas del hábitat en el Madison-Swanson y Steamboat Lump MPAs; y
iii) Analiar la relación entre el hábitat y los congregados de la especie.

El objetivo secundario fue localizar las agregaciones desovantes de mordaza (*Mycteroperca microlepis*), y pícaro (*Mycteroperca phenax*). Se utlizaron análisiss de mosaico por lado y mutiemisión batimétrica para estratificar cada MPA basado en la topografía del bentos y geología. Madison-Swanson, Steamboat Lump y una área de control adyacente (bordes gemelos) fueron muestreados durante 5 cruceros entre febrero, 2001 y mayo, 2002. El equipo empleado durante los estudios incluyeron cámaras de video en form estacionaria (Hi-8 cámaras o cámaras digitales), señales de trampas de pesces, y un ROV. Las agregaciones desovantes de mordaza y/o pícaro fueron confirmadas dentro del Madison-Swanson MPA en 2001 y 2002. Los congregados de la especie variaron con el hábitat. En los sitios a lo largo de los bordes y los afloramientos rocosos, se observaron especies que incluyen al mordaza, pícaro, mero rojo (*Epinephelus morio*), mero nevado (*Epinephelus niveatus*), speckled hind (*Epinephelus drummondhayi*), huachinango rojo (*Lutjanus campechanus*), huachinango de seda (*Lutjanus vivanus*), huachinango café (*Rhomboplites aurorubens*), el red porgy (*Pagrus pagrus*), porgy del knobbed (*Calamus nodosus*), el triggerfish gris (*Balistes capriscus*), y el gran amberjack (*Seriola dumerili*). En los sitios muestreados sobre substratos arenoso, las especies observadas incluyen la morena apanalado (*Gymnothorax saxicola*), bank sea bass (*Centropristis ocyurus*), y bandtail puffer (*Sphoeroides spengleri*).

PALABRAS CLAVES: Golfo de México, areas marinas protegidas, peces

INTRODUCTION

The Madison-Swanson and Steamboat Lumps Marine Protected Areas (MPAs) on the West Florida Shelf were established by the Gulf of Mexico Fishery Management Council (GMFMC) in 1999 (Figure 1). They were established primarily to protect spawning aggregations of gag grouper (*Mycteroperca microlepis*), which is considered to be at risk since this protogynous species is attracted to high-relief sites where they aggregate to spawn (Gilmore and Jones

1992, Coleman el al. 1996). These reserves contain areas of reef structure that support populations of economically valuable reef fish and other reef-associated fishes and invertebrates (Koenig et al. 2000). The MPA designations, which included no-take regulations, went into effect on June 19, 2000. The MPA designations will expire on June 16, 2004 unless extended by the Gulf Council at their May, 2003 meeting. It is therefore important to document the extent and nature of the reef habitat within each MPA, document the species composition and relative abundance of the dominant economically-important reef fishes, and monitor these parameters for changes which have occurred after the reserves were established. Our objectives were to establish baseline estimates of the fish assemblages associated with bottom features within each MPA, especially for species of groupers and snappers, describe significant habitat features in the Madison-Swanson and Steamboat Lumps MPAs, and document the relationship between habitat and species assemblages. The secondary objective was to locate spawning aggregations of gag (*Mycteroperca microlepis*), and scamp (*Mycteroperca phenax*).

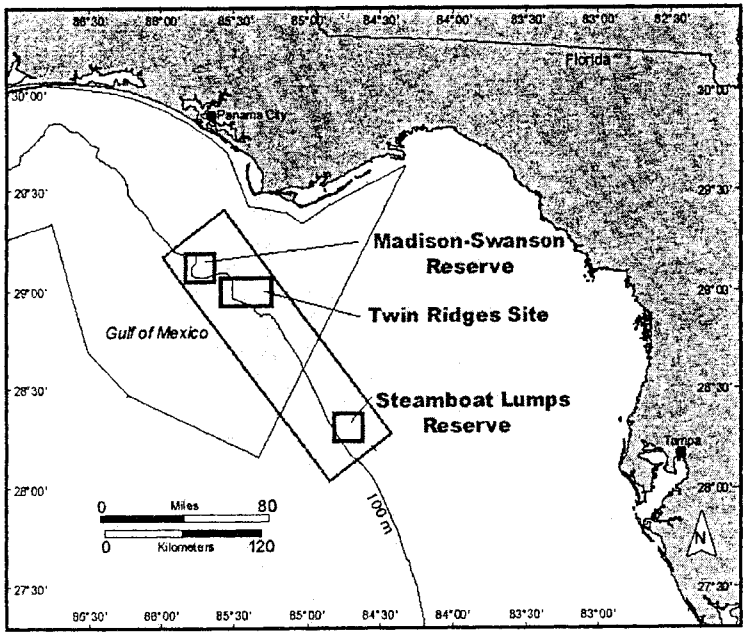

Figure 1. Location of Madison Swanson and Steamboat Lumps MPAs.

METHODS

The Madison-Swanson and Steamboat Lumps MPAs were mapped using side-scan sonar (Scanlon et. al. USGS, Woods Hole, unpublished data.), and multibeam sonar (Gardner et al. 2001). The MPAs were stratified using bathymetry, acoustic backscatter, and features apparent on multibeam and side-scan mosaics. Madison-Swanson was divided into seven strata:

i) Northeast (51 km²),
ii) Ridge (4 km²),
iii) Central (140 km²),
iv) Pinnacles (18 km²),
v) Mounds (1 km²),
vi) Snake feature (1 km²), and
vii) Northwest (2 km²).

Steamboat Lumps was divided into five strata:

i) Northeast (105 km²),
ii) Pits (1 km²),
iii) Central (200 km²),
iv) South Paleo-shore (12 km²), and 5
v) Ridge (3 km²).

The areas (km²) were estimated for each stratum, and used for stratum weights in estimators of fish abundance. We used a stationary video camera array to determine the relative abundance of fish within each MPA. Two different camera arrays were used. In March, 2001, Madison-Swanson was sampled with an array comprised of four Sony Hi-8mm video cameras mounted orthogonally at a height of 30 cm above the bottom of the array. The remaining surveys employed either Sony VX1000 or Sony VX2000 digital camcorders. The camera arrays were allowed to soak on the bottom for at least thirty minutes. This ensured twenty minutes of video tape, which was viewed with all fish identified to the lowest discernable taxonomic level. The estimator of abundance was the maximum number of fish of each species in the field of view at any time during the twenty-minute video tape. Stratified means and variances were calculated (Cochran 1977). We also employed an ROV, chevron fish trap, and hook and line gear to collect fish for age and growth studies. However, only used video data is reported in this paper.

RESULTS

Forty-three sites were examined within Madison-Swanson in 2001, and fifty-one sites in 2002. Spawning, aggregations of gag and scamp were confirmed at sites located along the pinnacles in both 2001 and 2002. Substrate at all sites was dominated by sand-clay, with rock and soft-coral found primarily along a ridge located at the 74 m isobath (Stratum2), the pinnacles (Stratum 4) and at a topographic feature we named the snake (Stratum 6) (Table 1). A total of 55 taxa were observed in 2001, and 64 taxa were observed in 2002 (Figure 2).

Table 1. Substrate percent composition discerned from video at stations sampled within Madison-Swanson (n = 93) and Steamboat Lumps (n = 63) MPAs during 2001 and 2002.

		Substrates								
MPA	**Stratum**	**Sand-Clay**	**Shell-gravel**	**Rock**	**Coral**	**Soft-coral**	**Sponge**	**Seawhips**	**Algae**	**Sessiles**
Madison-Swanson	1-NE	73.78	17.67	-	-	2.33	0.22	0.11	1.22	4.67
	2-Ridge	40.04	5.84	29.68	-	14.20	0.36	0.80	2.64	6.52
	3-Central	82.50	5.83	1.67	-	4.17	-	2.33	0.00	3.50
	4-Pinnacle	43.27	9.59	20.00	0.62	16.54	-	1.54	2.03	5.51
	5-Mounds	90.50	3.75	-	-	3.75	-	-	-	1.25
	6-Snake	70.17	5.00	7.50	-	10.50	-	0.33	2.67	3.33
	7-NW	95.33	2.33	-	-	-	-	-	-	2.33
Steamboat Lumps	1-NE	88.28	88.28	6.72	0.72	0.72	-	-	0.11	1.78
	2-Pits	79.00	79.00	6.60	1.30	0.20	-	-	8.20	4.70
	3-Cental	91.32	91.32	5.21	0.68	0.32	-	0.11	0.63	1.79
	4-S Shore	94.86	94.86	1.86	0.00	0.43	-	0.00	0.86	2.00
	5-Ridge	60.25	60.25	12.50	3.50	6.75	1.00	0.30	9.75	6.00

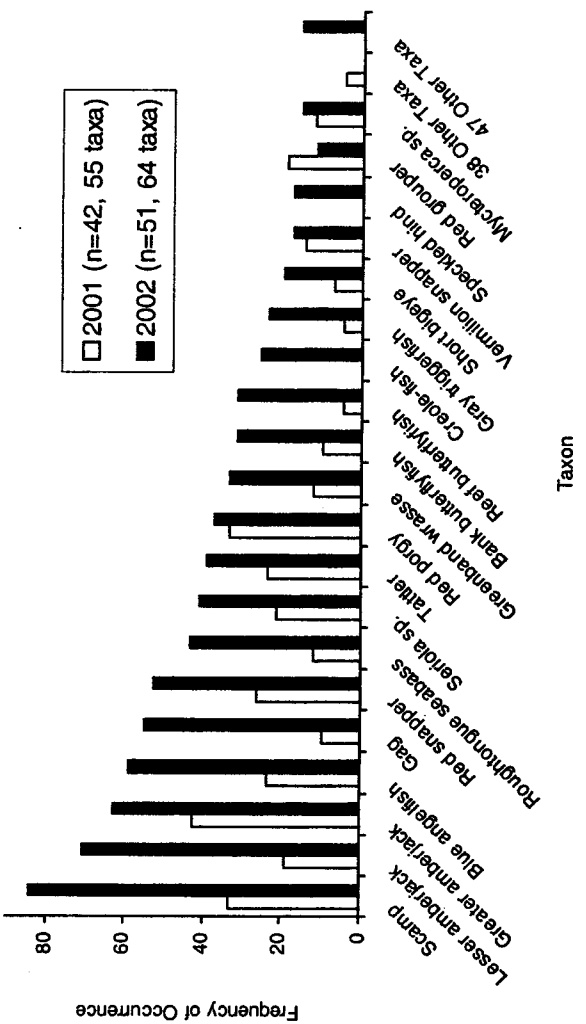

Figure 2. Most frequently observed taxa at Madison-Swanson MPA during 2001 and 2002 surveys

Scamp (*Mycteroperca phenax*), lesser amberjack (*Seriola fasciata*), greater amberjack (*S. dumerili*), blue angelfish (*Holacanthus bermudensis*), gag, and red snapper (*Lutjanus campechanus*) were the most frequently observed taxa (Figure 2). Other species included red porgy (*Pagrus pagrus*), vermilion snapper (*Rhomboplites aurorubens*) and red grouper (*Epinephelus morio*). Frequency of occurrence of these species, and most of the top twenty taxa were generally higher in 2002 than in 2001. The abundances of snappers and groupers were highest at the ridge, pinnacles and snake features (Table 2). The mounds and northwest strata were not sampled in 2002, so those strata were not used in estimates of stratified mean abundance. Mean abundance of snappers and groupers ranged from 0.1 fish to 3 fish per site (Table 3). The estimates of scamp, gag, and red grouper abundance all increased from 2001 to 2002.

Forty-three sites within Steamboat Lumps MPA were sampled in 2001, and 20 sites in 2002. Since all sampling was conducted during the summer and after gag and scamp spawn, no aggregations were observed. Substrate within all strata was dominated by sand-clay (Table 1). The most diverse substrate composition was found at the ridge (Stratum 5). A total of 53 taxa were observed in 2001, with 50 taxa observed in 2002 (Figure 3). Red porgy, tattler (*Serranus phoebe*), flatfish (Bothidae), vermilion snapper, and bank seabass (*Centropristes ocyurus*) were observed with the highest frequency (Figure 3). Species of grouper and snapper were observed in the greatest abundance at the ridge located at the 74-m isobath (Stratum 5), and a nearby area with pits (stratum 2) (Table 2). These areas were small, with an estimated area of 3 km^2 for the ridge and 1 km^2 for the pits (Stratum 2). Stratified mean abundance for groupers and snappers were lower in Steamboat Lumps than within Madison-Swanson (Tables 3 and 4). Mean abundances within Steamboat Lumps were near-zero for most of the grouper-snapper species. Among groupers and snappers, scamp had the largest abundance (1.5 fish per site in 2002), but overall, red porgy abundance was highest at 4.7 fish per site in 2002. Abundances were generally greater in 2002 than 2001 (Table 4).

Table 2. Mean counts of groupers and snappers by stratum observed at Madison-Swanson and Steamboat Lumps MPAs during 2001 and 2001 surveys.

MPA	STRATA													
Madison-Swanson	**1-NE (n = 9)**		**2-Ridge (n = 25)**		**3-Central (n = 6)**		**4-Pinnacles (n = 40)**		**5-Mounds (n = 4)**		**6-Snake (n = 6)**		**7-NW (n = 3)**	
	Mean	**SE**	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**
Epinephelus sp.	-	-	-	-	-	-	0.03	0.03	-	-	-	-	-	-
Snowy grouper	-	-	-	-	-	-	0.05	0.05	-	-	-	-	-	-
Warsaw grouper	-	-	-	-	-	-	-	-	-	-	-	-	0.33	0.33
Speckled hind	-	-	0.24	0.09	-	-	0.13	0.08	-	-	-	-	-	-
Red grouper	0.44	0.18	0.20	0.10	0.50	0.22	0.08	0.04	-	-	-	-	-	-
Mycteroperca sp.	-	-	0.04	0.04	0.50	0.34	0.30	0.13	-	-	0.33	0.21	-	-
Gag	-	-	0.32	0.11	0.33	0.21	1.00	0.21	-	-	1.50	0.81	-	-
Scamp	0.78	0.36	2.16	0.52	1.50	0.81	2.83	0.41	1.00	1.00	5.00	1.61	-	-
Lutjanus sp.	-	-	-	-	-	-	-	-	-	-	0.17	0.17	-	-
Red snapper	3.33	3.09	2.16	0.74	0.17	0.17	1.15	0.35	-	-	0.17	0.17	0.33	0.33
Vermilion snapper	-	-	8.04	2.62	-	-	0.08	0.06			5.00	2.97	1.33	1.33
Red porgy	-	-	1.96	0.70	-	-	0.70	0.27	1.00	1.00	7.50	2.47	2.00	2.00
Steamboat Lumps	**1-NE (n=19)**		**2-Pits (n=9)**		**3-Central (n=19)**		**4-S Shore (n=7)**		**5-Ridge (n=8)**					
	Mean	**SE**	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**				
Red grouper	-	-	0.33	0.33	0.05	0.05	-	-	0.13	0.13				
Mycteroperca sp.	-	-	0.33	0.33	-	-	-	-	0.38	0.18				
Gag	-	-	-	-	-	-	-	-	0.25	0.16				
Scamp	-	-	0.78	0.66	0.37	0.37	-	-	2.88	0.72				
Red snapper	-	-	0.11	0.11	-	-	-	-	-	-				
Vermilion snapper	-	-	16.22	6.11	-	-	-	-	1.88	1.26				
Red porgy	0.05	0.05	8.67	1.70	0.95	0.95	1.29	0.89	7.75	2.66				

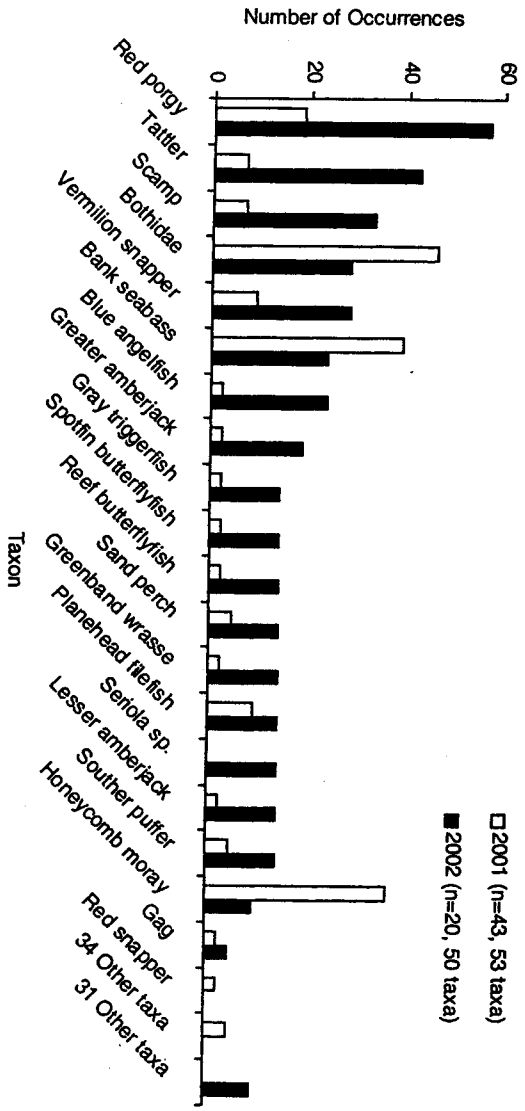

Figure 3. Most frequently observed taxa at Steamboat Lumps MPA during 2001 and 2002 surveys

Table 3. Stratified mean counts of groupers and snappers observed at Madison-Swanson MPA during 2001 and 2002 (Strata 1,2,3,4, and 6 only).

	2001			2002		
	n	Mean	V_{str}	n	Mean	V_{str}
Epinephelus sp.	35	-	-	51	0.003	0.00001
Snowy grouper	35	-	-	51	0.006	0.00002
Speckled hind	35	-	-	51	0.148	0.0001
Red grouper	35	0.397	0.029	51	0.747	0.0063
Mycteroperca sp.	35	0.281	0.069	51	0.684	0.0002
Gag	35	0.150	0.017	51	0.787	0.0005
Scamp	35	0.982	0.273	51	3.088	0.008
Lutjanus sp.	35	0.001	0.0001	51	-	-
Red snapper	35	1.302	1.254	51	0.332	0.027
Vermilion snapper	35	0.089	0.002	51	0.228	0.005
Red porgy	35	1.409	0.128	51	2.042	3.636

Table 4. Stratified mean counts of groupers and snappers observed at Steamboat Lumps MPA during 2001 and 2002.

	2001			2002		
	n	Mean	V_{str}	n	Mean	V_{str}
Red grouper	43	0.002	0.00001	20	0.210	0.043
Mycteroperca sp.	43	0.005	0.00002	20	0.004	0.00001
Gag	43	0.003	0.00001	20	0.002	0.00001
Scamp	43	0.019	0.0002	20	1.489	2.114
Red snapper	43	0.0008	0.00001	20	-	-
Vermilion snapper	43	0.104	0.0014	20	0.040	0.0005
Red porgy	43	0.479	0.080	20	4.65	1.12

DISCUSSION

Early work along the west Florida shelf focused on identifying locations of spawning habitat for gag (Koenig et al. 2000). Several areas along the west Florida shelf were considered as possible locations for establishing MPAs for protecting of gag spawning aggregations (see Figure 1 in Koenig et al. 2000), with the majority of the sites known to be established fishing grounds for the reef-fish fishery (Moe, 1963). The Gulf of Mexico Fishery Management Council selected the Madison-Swanson and Steamboat Lumps areas. The mapping and biological assessments of these MPAs along the west Florida shelf was a team effort between the National Marine Fisheries Service, the U.S. Geological Survey (USGS), Florida State University, and the University of South Florida (USF). Prior to sampling fish, each MPA was first mapped. Kathy Scanlon (USGS - Woods Hole, MA) produced side scan maps of the MPAs, James Gardner (USGS - Menlo Park, CA) produced multibeam maps of major portions of the same areas, and David Naar (USF - St. Petersburg, FL) completed the multibeam mapping of Madison-Swanson. Both the mapping work, and the biological sampling efforts we report indicate the distribution of reef fish is concentrated on hard-bottom features within each MPA. A larger

proportion of the bottom within Madison-Swanson was comprised of high-relief, hard-bottom features than was found at Steamboat Lumps. In Madison-Swanson, groupers and snappers were among the most frequently occurring and abundant taxa. This was not the case for Steamboat Lumps, where red porgy and tattler dominated the fish assemblage. Scamp were found at Steamboat Lumps, but their abundance was much lower than at Madison-Swanson. This difference in fish assemblage structure is most likely explained by the greater amount of high-relief habitat at Madison-Swanson. The MPAs have been in effect for two years. We have noticed an increase in some species of groupers during this time, however, two years do not necessarily indicate a trend. Previous work has shown that recovery of reef fish populations within established MPAs make take ten years or more (Russ and Alcala 1996).

One problem has been limited enforcement within the two MPAs. We have noticed during all of our sampling trips commercial vessels fishing within each reserve. The amount of fishing activity within each MPA is not known. This is of great concern since the ultimate success of any no-take MPA depends on strict enforcement of no-take regulations. Recently the US Coast Guard has increased enforcement patrols in the MPAs which has resulted in reduced levels of illegal fishing.

ACKNOWLEDGMENTS

The work to monitor fish within the Madison-Swanson and Steamboat Lumps reserves has been supported through the Marine Fishery Initiative (MARFIN) and Coral Reef Initiative programs. We thank Jennifer Arcuri, John Brusher, Paul Felts, Kin Foster, Lanora Land and Kevin Rademacher for their many hours viewing video tapes. We also thank the crews of the R/V Caretta and NOAA Ship Oregon II.

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Predation in Marine Protected Areas: Preliminary Results of the Effects on Growth and Survivorship of Newly-settled Coral Reef Fishes

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ABSTRACT

Substantial attention has been paid to the implementation and efficacy of marine protected areas. As a result, data are available on the increased abundance of large piscivorous and commercially-important fishes within marine protected areas. Fewer studies have evaluated the indirect effects of this build-up, such as the influence on recruitment and survivorship of young fishes. Higher predation pressures in marine protected areas should lead to lower post-settlement survival rates of newly-recruited fishes as well as higher selective mortalities. For example, surviving recruits in these areas may exhibit traits such as faster growth rates and larger sizes-at-age than elsewhere. Due to the constraints of testing these hypotheses in marine protected areas (e.g. permit restrictions, confounding environmental variables), mesocosm tanks were constructed in order to run experimental trials in a controlled setting. Recruits of the bluehead wrasse, *Thalassoma bifasciatum,* were collected from the field, transplanted in natural densities to replicate experimental tanks and then subjected to three treatments—high predation or SPA (reflecting predator densities in marine protected areas), lower predation or NSP (reflecting predator densities in non-protected areas) and control treatments (CON) with no predators. Survivorship of recruits was recorded and compared among treatments to evaluate differential predatioan rates. To evaluate selective mortality, growth rates of individual recruits (as recorded in otoliths) were compared between the initial population of recruits and the survivors of each treatment. Differences in post-settlement survival and selective mortality among treatments will enhance our understanding of ecological processes occurring within marine protected areas by shedding light on factors affecting successful recruitment of fishes to these areas.

KEY WORDS: MPAs, predation, larval fish

Depredacion en las Areas Marinas Protegidas: Efecto sobre el Crecimiento y la Superviviencia de Larvas de Peces de Arrecifes Coralinos Recientemente Asentados

La implementación y la eficacia de las áreas marinas protegidas han sido objeto de mucha atención. Consecuentemente, ahora hay datos sobre el incremento en abundancia de grandes piscívoros y de peces de importancia comercial dentro de dichas áreas, pero pocos estudios han evaluado el efecto indirecto de esta

acumulación, así como su influencia sobre la supervivencia y el reclutamiento de los peces juveniles. Una mayor presión de depredación en áreas marinas protegidas debería reducir las tasas de supervivencia post-asentamiento de peces recién reclutados y aumentar la mortalidad selectiva. Por ejemplo, los reclutas que sobreviven en estas áreas podrían mostrar tasas de crecimiento más rápidas y talla-por-edad más grande que en otros sitios. Debido a limitaciones para poder probar esas hipótesis en áreas marinas protegidas (e.g. restricción de licencias, variables ambientales que confunden los resultados), se construyeron acuarios mesocosmos para realizar experimentos en un medio controlado. Reclutas del limpiador cabeza azul, *Thalassoma bifasciatum*, se recolectaron en el campo, se pusieron en densidades naturales en los aquarios experimentales replicados, y luego se sometieron a tres tratamientos diferentes – depredación alta (reflejando la densidad de depredadores en áreas marinas protegidas), depredación baja (reflejando la densidad de depredadores en zonas no protegidas), y tratamiento de control sin depredadores. La supervivencia de los reclutas se midió y se comparó entre los tratamientos para evaluar tasas de depredación diferenciales. Para la evaluación de mortalidad selectiva, el crecimiento de reclutas individuales (interpretado de los otolitos) se comparó entre la población inicial de los reclutas y los que sobrevivieron cada experimento. Las diferencias entre la supervivencia post-asentamiento y la mortalidad selectiva entre tratamientos, mejorará nuestro entendimiento de los procesos ecológicos que ocurren en las áreas protegidas, al identificar los factores que afectan el reclutamiento exitoso de los peces en esas zonas.

PALABRAS CLAVES: Areas Marinas Protegidas, depredacion, larvas de peces

INTRODUCTION

Though substantial attention has been paid to the increase in densities of larger, commercially-important species in marine protected areas, relatively fewer studies have focused on the possible indirect impacts of this increase. Since larger fishes tend to be piscivorous, we would expect that an increase in their density would lead to an increase in predation pressure for their prey. Higher predation pressures would lead not only to decreased survivorship of prey species, but also to a possible higher level of selective mortality. For newly-settled coral reef fishes, which are particularly vulnerable to predation, an increase in predation pressure could have an impact on the post-settlement processes influencing their survival and growth. As densities of recruits decrease and selective mortality increases, survivors should exhibit relatively larger sizes-at-age and higher levels of condition (e.g. higher lipid content, faster swimming speeds, behavioral advantages). We hypothesize that recruits settling to marine protected areas will indeed be subjected to higher predation pressures, leading to decreased survivorship, larger mean size-at-age and faster larval or juvenile growth rates.

METHODS

All field research was conducted in the upper Florida Keys, USA within the Florida Keys National Marine Sanctuary (FKNMS). Within the reserve, sites are defined by varying degrees of protection. Sanctuary Preservation Areas (SPAs) are considered "no-take" zones, in which all collection is prohibited. Other areas are restricted to general size limits, bag limits, and gear restrictions, with all forms of collection permitted except spearfishing.

Due to the prohibition of scientific collection in the SPAs of the FKNMS, an in-situ study was not possible. To isolate the effect of predation pressure on new recruits while controlling for as many variables as possible, mesocosm manipulations were necessary. The bluehead wrasse *Thalassoma bifasciatum* was chosen as the study species for this experiment due to the high abundance of recruits on the reef, ease of recruit collection and large amount of information available on its life history.

To determine the effect of various piscivores on the recruitment and post-settlement survival of *T. bifasciatum*, recruits were subjected to different densities of predators in large aquaria to estimate survival and selective mortality under varying levels of predation pressure. Using survey data of piscivore density from both protected and unprotected areas of the FKNMS, three treatments were established: SPA, with a higher density of predators reflecting protected area densities; NSP, with a lower piscivore density reflecting natural densities outside protected areas; and Control (CON), with no predators. An equal number of recruits, also reflecting natural densities in the field, were transplanted to each treatment. Each treatment was replicated, resulting in a total of six experimental tanks, two of each treatment.

The most abundant predators in the FKNMS, the yellowtail snapper, *Ocyurus chrysurus*, and the gray snapper, *Lutjanus griseus*, were caught using hook and line and transported to the mesocosm facility. Predators were immediately fed and then starved for a period of two days in order to standardize their level of hunger. Recruits also were collected from the field by SCUBA divers and transported to the mesocosms. They were transplanted in equal densities (n = 30) to each of the six tanks and then left to acclimate in the tanks for 24 hours. At the end of this period, predators were introduced to the SPA and NSP treatments (n = 5 and n = 2, respectively) and control tanks received no predators. Predation trials ran for 48 hours post-predator introduction. At the end of the experiment, predators were captured and released while recruits were caught and preserved for further analysis.

Recruits were measured for standard length and then dissected to obtain their otoliths. These structures, the "ear bones" of the fish, serve as a record of both the age and growth of the recruit throughout its life history. By counting the increments deposited along the otolith as well as measuring the width of each increment, we are able to obtain measures of larval and juvenile age and otolith growth during these periods. Since standard length of these fishes and otolith length are significantly correlated (Figure 1), we can use the otolith measurements as a proxy for understanding the somatic growth of the fish. Half of the fish from each treatment tank were randomly selected for otolith analysis.

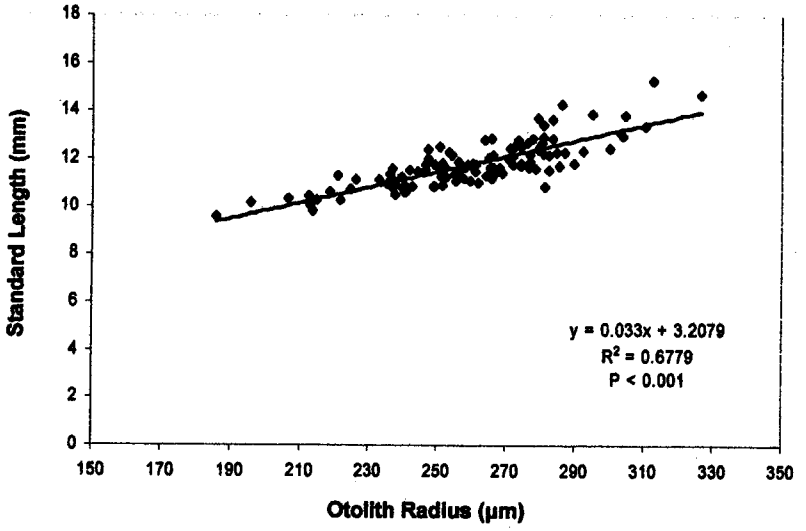

Figure 1. The relationship between otolith radius and standard length

RESULTS AND DISCUSSION

Mean numbers of survivors recovered from each experimental treatment show that fishes subjected to higher levels of predation (SPA treatment) do have lower levels of survivorship than those not subjected to predation pressure (CON treatment) (Figure 2). Levels of survivorship were similar between the CON and NSP treatments, but error bars indicate higher survivorship may be more frequent for those fish free from predation in the control treatments.

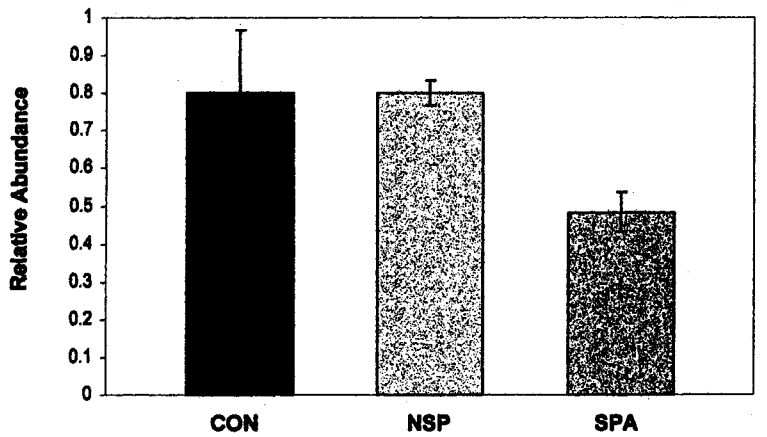

Figure 2. Survivorship of fish subjected to high levels of predation pressure (SPA), lower levels (NSP), and fish free from predation (CON)

Analysis of larval growth rates of survivors from each of the treatments indicated that recruits subjected to predation pressure in both the SPA and NSP treatment have a higher rate of larval growth than do recruits in the CON treatment (Figure 3). This corroborates the predictions of our working hypothesis—recruits subjected to predation may show higher selective mortality, indicating those with some selective advantage will survive. In this case, this advantage may be conferred through faster growth rates during larval life. The data also show that these differences in growth rates translate into larger mean otolith length-at-age.

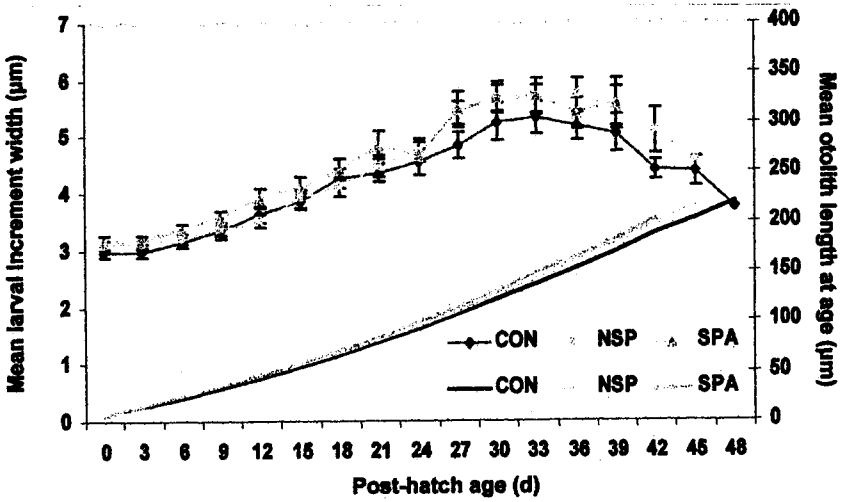

Figure 3. Larval otolith growth of fish subjected to high levels of predation pressure (SPA), lower levels (NSP), and fish free from predation (CON)

Due to these faster larval growth rates, recruits in the SPA and NSP treatments were able as larvae to achieve a minimum level of condition or size required for settlement more quickly. They settled to the reef earlier, resulting in a shorter mean pelagic larval duration relative to those recruits not subjected to selective mortality in the CON treatment (Figure 4).

While this trend continued during the first three days of juvenile life, this difference was likely insignificant (Figure 5).

In order to ascertain that the trends exhibited were a natural phenomenon and not merely an artifact of the mesocosm manipulations, recruits from the field were collected and compared to the experimental survivors. Recruits from the initial population were collected just after emergence onto the reef, and recruits from the same population were collected a week later. We would assume that during this week, recruits were exposed to natural levels of predation on the reef. By comparing the larval growth rates of the two collections, we see that larval growth rates were faster for those recruits surviving to the final collection than those initially collected (Figure 6). This is consistent with our mesocosm findings: the final

population, exposed to more predation, shows evidence of selective mortality based on larval traits. Only those faster growing fishes survived. Similarly, the survivors had a lower mean pelagic larval duration (Figure 7).

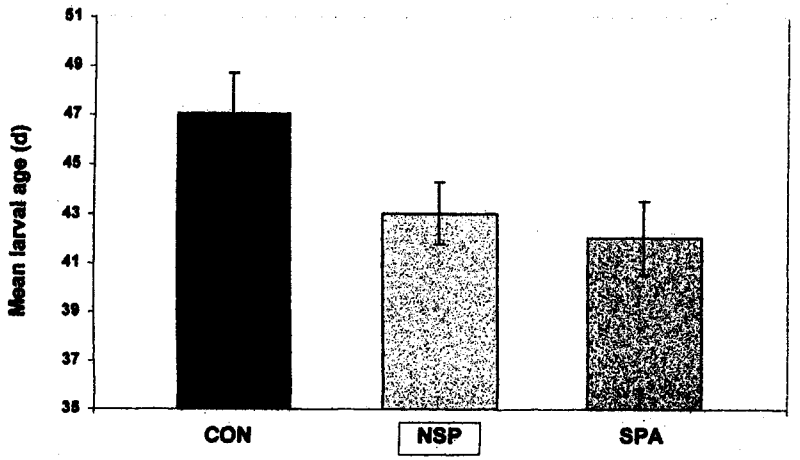

Figure 4. Pelagic larval duration of fish subjected to high levels of predation pressure (SPA), lower levels (NSP), and fish free from predation (CON)

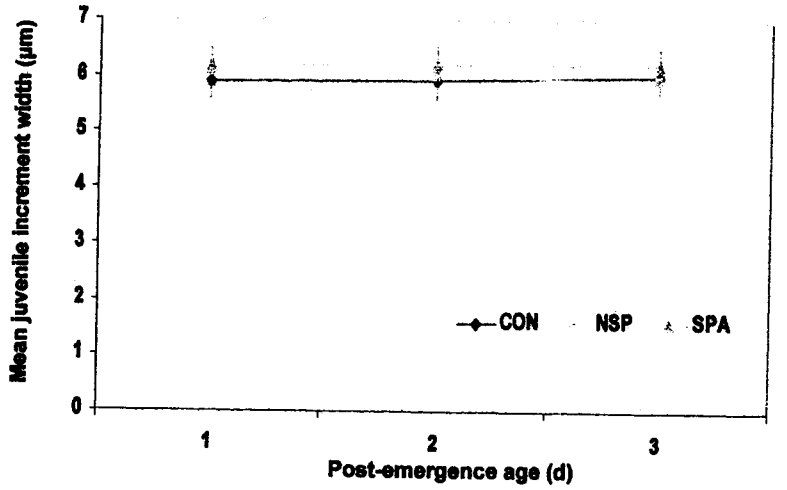

Figure 5. Juvenile otolith growth of fish subjected to high levels of predation pressure (SPA), lower levels (NSP), and fish free from predation (CON)

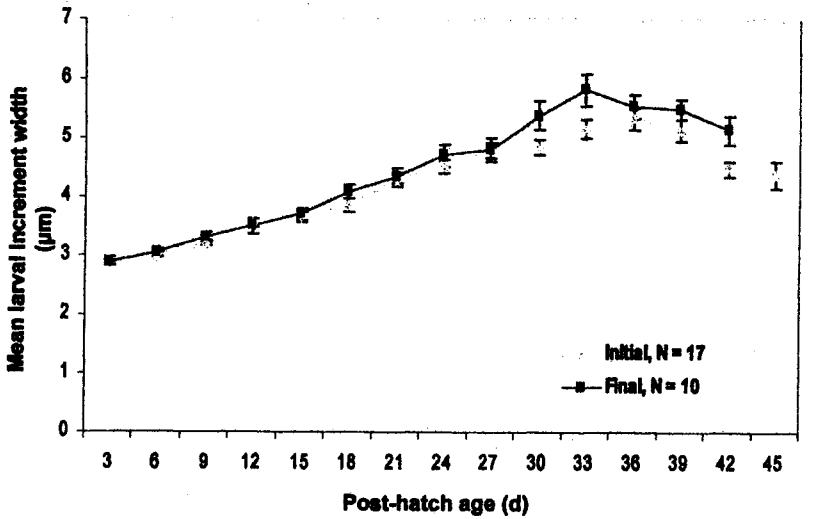

Figure 6. Larval growth rates of recruits surviving to the final collection versus those initially collected

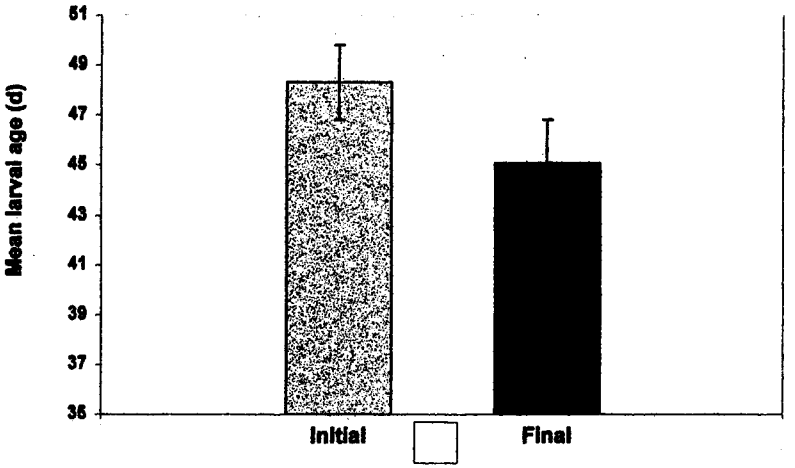

Figure 7. Pelagic larval duration of recruits surviving to the final collection versus those initially collected

IMPLICATIONS

Preliminary analyses show trends in the data that will require further analysis to indicate the importance of indirect effects acting in marine protected areas. If fishes recruiting to these areas are indeed subject to higher predation pressures that limit their survivorship and exert selection on survivors, repercussions for the protected population as a whole may occur. By decreasing the number of newly-settled coral reef fishes, there would be a subsequent decrease in recruitment success and overall diversity. Selective mortality also may potentially change the traits of the surviving population as a whole. Indirect effects of protection such as these potential mechanisms should be considered when attempting to manage fish populations using marine protected areas.

Predicting Community Changes in Marine Reserves

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ABSTRACT

Although marine reserves are proving, throughout the world, to be valuable tools for fishery management, uncertainty in the timing and magnitude of expected changes has left some resource managers and many fishers hesitant to accept establishment of reserves. Trophic models, using *Ecopath* with *Ecosim*, can be used to predict changes in target species, to assess differences in reserve performance based on inclusion/exclusion of different habitat types, and to predict time frames within which changes in species abundance and size distributions can be expected. A trophic model of a Caribbean coral reef ecosystem, representing the Turromote reef platform off La Parguera, is being generated using both extensive historical data sets and recent field data. By using the combination, we can track historical trends in community changes, evaluate fishing pressure over time, and predict future changes in fish assemblages. The first stage of model construction, updating and completing a generalized Caribbean model, is presented along with model simulations run over space and time. Results of the model simulations can estimate the effects of a no-take reserve on different target species and can predict time frames within which benefits should accrue. Future work will continue the customization of the model and will use changes in field conditions to validate the model. Reliable predictions should help fishery managers to understand the use and applicability of no-take marine reserves for improved management and realistic time frames for assessing reserve effectiveness.

KEY WORDS: Marine reserves, Ecopath, coral reef ecosystem

Prediciones de Cambios de la Comunidad en las Reservas Marinas

Aunque las reservas marinas estan demostrando, a traves del mundo, ser herramientas valiosas para la gerencia de la industria pesquera, la incertidumbre en la sincronizacion y la magnitud de cambios previstos ha dejado algunos encargados de recurso y muchos pescadores vacilantes aceptar el establecimiento de reservas. Los modelos troficos, usando *Ecopath* con *Ecosim*, se pueden utilizar para predecir cambios en especies apuntados, para determinar diferencias en el funcionamiento de la reserva basado en la inclusion/exclusion de diversos tipos del habitat, y para predecir los marcos de tiempo dentro de los cuales los cambios en la abundancia y distribucion de tamano de las especies pueden esperar. Un modelo trofico de un ecosistema del arrecife coralino del Caribe, representando la plataforma del arrecife

de Turromote afuera del la Parguera, se esta generando usando ambos conjuntos historicos extensos de datos y datos recientes del campo. Usando la combinacion, podemos seguir tendencias historicas en cambios de la comunidad, evaluar la pression de la pesca en un cierto plazo, y predecir cambios futuros en ensambladuras de los pescados. La primera etapa de la construccion modelo, poniendo al dia y terminando un modelo del Caribe generalizado, se presenta junto con el funcionamiento de simulaciones modelo sobre espacio y tiempo. Los resultados de las simulaciones ejemplares pueden estimar los efectos de un no toma la reserva en la especie apuntada diferente y pueden predecir los marcos de tiemp dentro de los cuales las ventajas deben acrecentarse. El trabajo futuro continuar el arreglo para requisitos particulares del modelo y utilizara cambios en las condiciones del campo para validar el modelo. Las predicciones confiables deben ayudar a encargados de la industria pesquera a entender el uso y la aplicabilidad de no toma las reservas marinas para la gerencia mejorada y los marcos de tiempo realistas para determinar eficacia de la reserva.

PALABRAS CLAVES: Reservas marinas, modelos trophic

INTRODUCTION

Marine reserves ("no-take") are being used throughout the world as tools to reduce habitat loss and degradation, to conserve biodiversity, and to enhance fishery management. They have found particular utility in tropical settings where fisheries have been difficult to manage using conventional management regimes. In parts of the United States, fishers and fishery managers voice doubts about the ability to accomplish fishery goals through area-based management such as marine reserves. Although scientist have been able to point to examples of marine reserves successfully improving fishery conditions throughout the world, resistence has continued. In instances where marine reserves have been established in the United States, managers have set time limits, often five to ten years, within which time the reserve should demonstrate its efficacy.

Trophic models, using *Ecopath* with *Ecosim*, can be used investigate some of these questions and to offer a predictive method that can be readily tested in systems where reserves have been instituted. *Ecopath* is used to portray the trophic structure of an ecosystem with the option of including fishing as a type of predation mortality within the system. The *Ecosim* module is designed to test the effects of different fishing management options on the modeled community structure and can be used to predict changes in target species. The recent inclusion of *Ecospace* has presented the opportunity to examine the effects of the *Ecosim* simulations over heterogeneous habitat types (Christensen and Pauly). This can allow the testing of various hypotheses regarding the dynamics and performance of marine reserves.

This paper is an initial presentation of a multi-year project designed to build a trophic model of a Caribbean coral reef ecosystem, representing the Turromote reef platform off La Parguera, Puerto Rico. It is being generated with current and

historical data in order to mimic historical trends in community changes, evaluate fishing pressure over time, and predict future changes in fish assemblages. The first stage of model construction, updating and completing a generalized Caribbean model, is presented along with sample model simulations. Future work that will allow prediction of reserve dynamics and allow for future validation of simulation work will be discussed.

MATERIALS AND METHODS

The *Ecopath* modeling system is a modification and refinement of an approach presented by Polovina (1984) for the estimation of the biomass of the various elements (species or groups of species) of an aquatic ecosystem. It was modified with various approaches from theoretical ecology, notably those proposed by R.E. Ulanowicz (1986), for the analysis of flows between the elements of ecosystems. It is readily available (www.ecopath.org), has simple data requirements, is constantly being updated and improved, and offers a wide variety of helpful routines to help with model building.

One improvement in the basic routine of *Ecopath* is a shift from its original assumption of steady state. *Ecopath*, instead, bases the parameterization of the model on an assumption of mass balance over the chosen time period, typically a year. In its present form *Ecopath* parameterizes models based on two master equations, one to describe the production term and one for the energy balance of each group.

The series of equation are developed on the premise that "Mortality for a prey is consumption for a predator." The first *Ecopath* equation describes how the production term for each group (i) can be split in components. A box (group) in an *Ecopath* model may be a group of (ecologically) related species, a single species, or a single size/age group of a given species. This is implemented with the equation,

Production = Catches + Predation Mortality + Biomass Accumulation + Net Migration + Other Mortality

Secondly, the energy input and output of all living groups must be balanced. The first *Ecopath* master equation (above) includes only the production of a box. When describing the energy balance of a box, other flows should be considered. So as to ensure mass balance between groups, energy balance is ensured within each group using the equation:

Consumption = Production + Respiration + Unassimilated Food

This equation is in line with Winberg (1956) who defined consumption as the sum of somatic and gonadal growth, metabolic costs and waste products. The main differences are that Winberg (along with many other bioenergeticists, see Ney 1990) focused on measuring growth, where Ecopath focuses on estimating losses. The

Ecopath formulation does not explicitly include gonadal growth. The *Ecopath* equation treats this as included in the predation term (where nearly all gonadal products end up in any case).

Once a trophic model has been built in *Ecopath* it can be used directly for simulation modeling using Ecosim. This approach is fully integrated with *Ecopath*, and is a complex simulation model for evaluating the impact of different fishing regimes on the biological components of ecosystems. One identified short coming was the lack of a means to investigate habitat mediated differences in trophic relationships. This has been remedied through the development of *Ecospace* (Walters et al. 1998), a dynamic, spatial version of *Ecopath*, incorporating all key elements of *Ecosim*.

Data sources and reliability are a concern for developing a model that correctly reflect the relationships and functioning of a complex system. In the case of the coral reef ecosystem of La Parguera, including coral reefs, mangroves, seagrass beds, algal plains and other interacting habitats, a large body of research and monitoring has gone on for the last four to five decades. This has been a focus of residents and visitors to the Marine Science Department of the University of Puerto Rico-Mayagüez All aspects of the area have been examined in varying detail. Fish assemblages, benthic communities, and planktonic organism have been examined. Sedimentology, tidal regimes, and current patterns have been documented. Where sampling has been done locally, information from the wider Caribbean is generally available that will complete the data needs of the project. Continuing sampling and research will allow updating a modification of the model into the future.

RESULTS

The initial work with the Optiz models has begun with evaluation of the dynamics of the 20-box model produced as a representation of a generalized Caribbean reef from the Puerto Rican-Virgin Islands area. The Opitz model, modified with representative fishing information, has been run under a variety of scenarios that examine trophic and fishing interactions. Figures 1, 2 and 3 display results of different intensities and durations of fishing mortality. Under a constant, low level of fishing pressure the biomass levels for each species group are stable over the 20 year run cycle (Figure1). If fishing mortality is doubled for a longer period of time, various biomasses are changed but when fishing pressure returns to its previous low level, the biomasses return to their original levels, too (Figure 2). If, however, the fishing mortality is increased for a slightly longer period of time, the biomasses shift and do not regain their original relationships even when the model is run for 50 years instead of 20 years. These are particularly significant in the interacting groups of competitors, predators and prey.

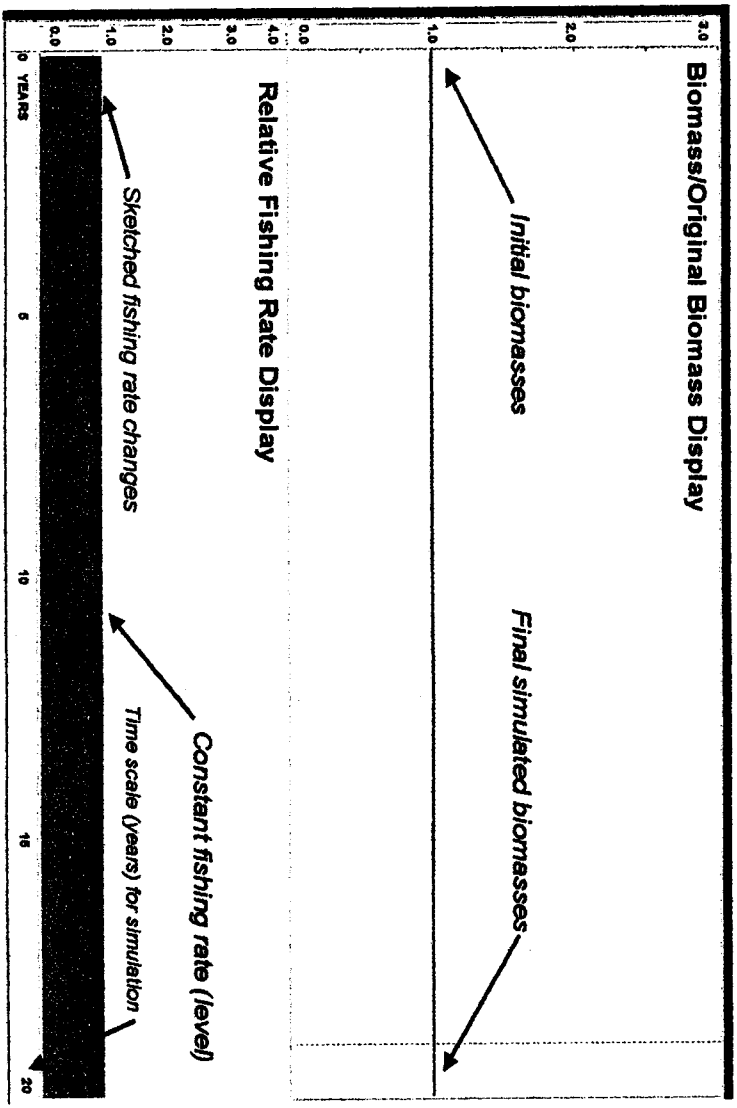

Figure 1. Computer "screen capture" of mass balanced model from EwE simulation. Model run with base constant fishing rate. Biomass ratios (compared to starting biomass) are displayed, all with a ratio of 1.0; all biomass levels remain constant throughout the simulation.

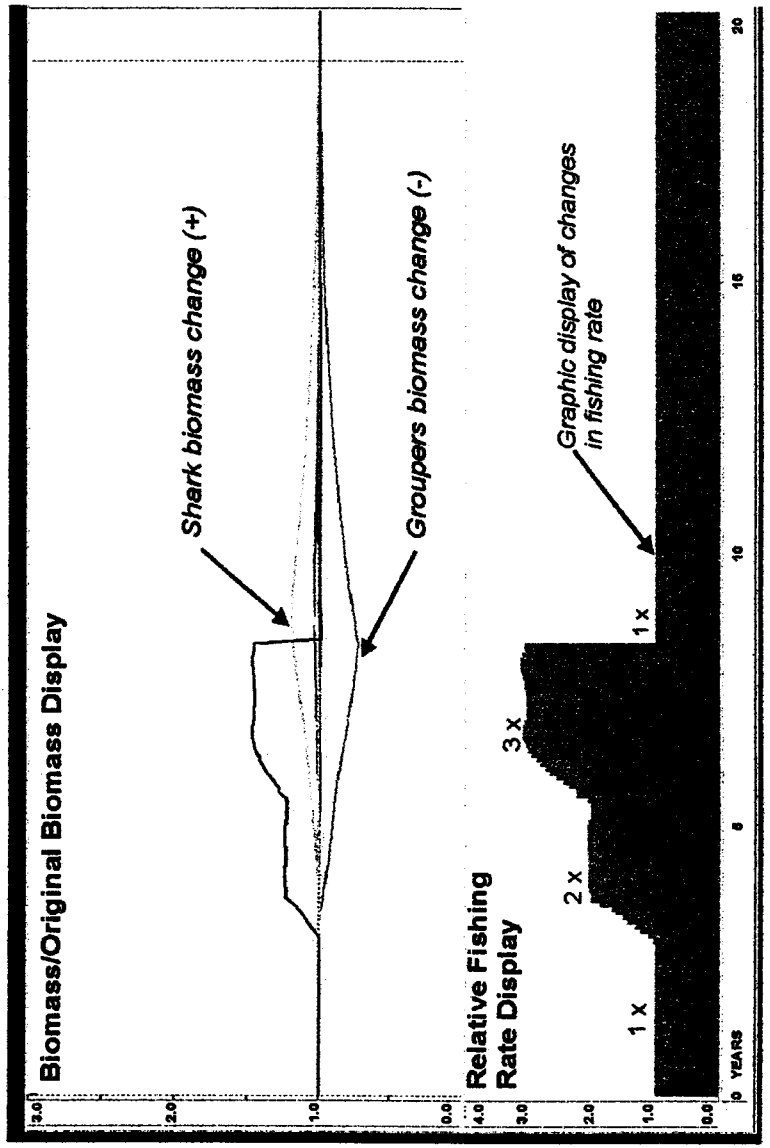

Figure 2. Model run with increased fishing mortality over a relatively short duration. Notice different biomass responses of different species.

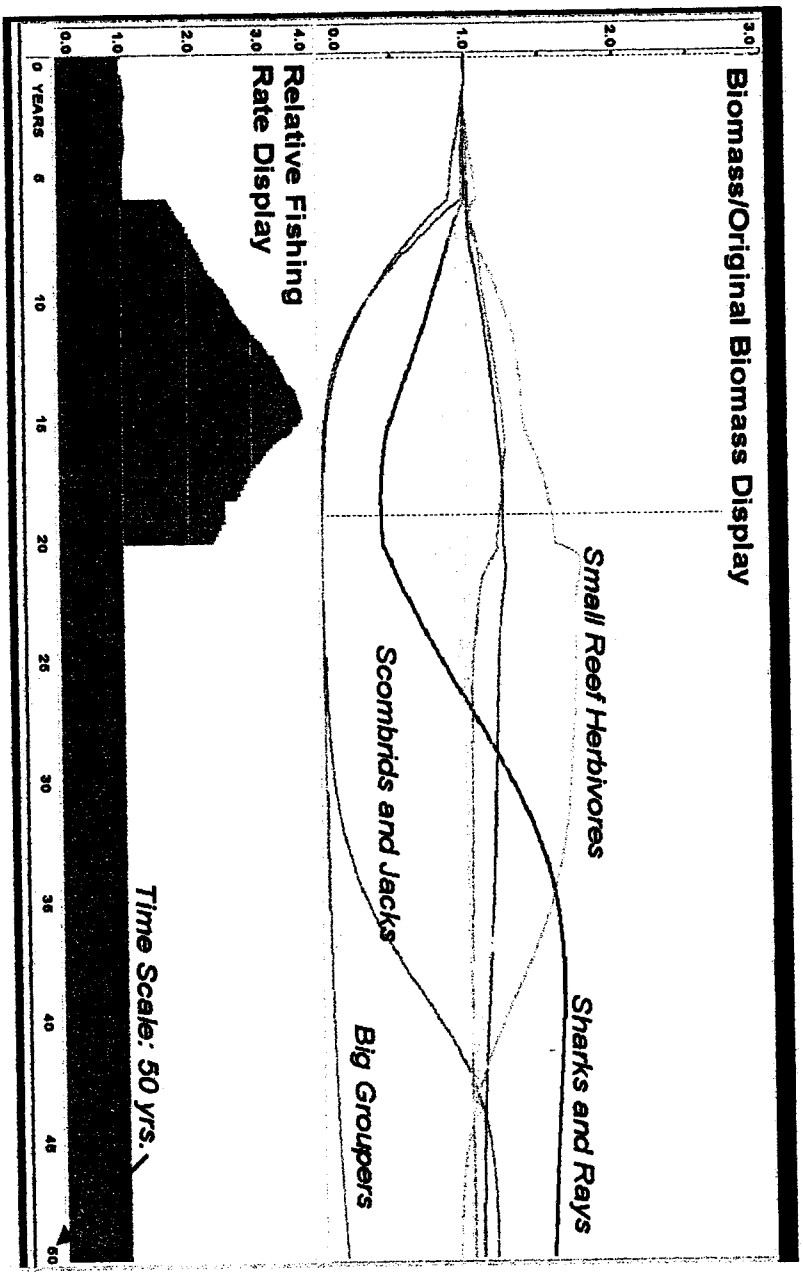

Figure 3. Computer "screen capture" of EwE simulation run with increased fishing mortality over a longer duration. Notice different biological responses of different trophic groups.

DISCUSSION

"Real ecosystems are more complicated than the mass-balance fluxes of biomass in Ecopath, however large the number of functional groups we include in our models. Real ecosystems also have dynamics far more complex than represented in Ecosim. The issue to consider, when evaluating the realism of a simulation software is, however, not how complex the software and the processes are that are represented therein. Rather, the question is which structure allows a representation of the basic features of an ecosystem, given a limited amount of inputs."

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Comunidades Inter-mareales de la Costa Rocosa de la Reserva de la Biosfera de Sian Ka'an

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RESUMEN

Considerando que la predicción de la distribución de especies es importante elemento en la conservación biológica y en el manejo de especies, se realizó una investigación de campo de las comunidades inter-mareales en dos localidades con diferente grado de exposición al oleaje en la RB de Sian Ka'an, Osho Oasis y Boca Paila. Los muestreos fueron realizado en base a tres transectos por cada sitio con una periodicidad semestral, colectando los organismos circunscritos a un cuadrado de 900 cm^2. No se presentó ninguna diferencia temporal significativa ($p = 0.05$). Los resultados muestran que el principal componente de estas comunidades fueron tanto en biomasa como en abundancia, los gasterópodos y las macroalgas en las zonas inter-mareales medias. Las tendencias espaciales muestran una distribución casi exclusiva de moluscos en las zonas intermareales bajas. Se muestran algunas correlaciones negativas significativas entre sitios detectadas entre la densidad de algunos grupos funcionales y entre algunos parámetros ambientales. La variación de densidad de los grupos funcionales más abundantes con cada nivel de marea fueron en la mayoría de los casos abruptos, lo que podría indicar un cambio en las micro-condiciones ambientales o biológicas, a pesar de que no existe ningún patrón de zonación evidente. Los cambios en las condiciones ambientales puede ser la principal causa de heterogeneidad paisajística a media (decenas de metros) y pequeña escala (centímetros a metros). Los patrones de distribución de similitud de ensamblajes en los sitios no fue significativamente diferente entre los sectores de cada uno. El presente trabajo serviría como el inicio hacia investigaciones de la consistencia de patrones espaciales en diferentes escalas jerárgicas.

PALBRAS CLAVES: Comunidades inter-mareales, zonación, Sian Ka'an, Caribe Mexicano

Intertidal Communities of the Rocky Coast of Sian Ka'an Biosphere Reservation

Considering that the prediction of the especies distribution is important element in the biological conservation and in the especies management, we were carried out an investigation of field of the intertidal communities in two sites with different wave exposition in the Sian Ka'an RB, Osho Oasis and Boca Paila. The samplings were carried out based on three transectos by each site with a biannual periodicity collecting the organisms bounded to a square of 900 cm^2. Any significant temporary difference was not presented ($p = 0.05$). The results show that the main component of these communities was as much in biomass as in abundance, the gasterópodos and

the macroalgas in the middle intertidal areas. The space tendencies show an almost exclusive distribution of mollusks in the low intertidal areas. Some significant negative correlations are shown among sites detected among the density of some functional groups and among some environmental parameters. The density variation of the most abundant functional groups with each tide level was in most cases abrupt, what could indicate a change in the environmental or biological micro-conditions, although any pattern of evident zonación doesn't exist. The changes under the environmental conditions can be the main cause of landscape heterogeneity to middle (dozens of meters) and small scale (centimeters to meters). The patterns of similarity distribution of assemblings in the sites were not significantly different among the sectors of each one. The present work would serve as the beginning toward investigations of the consistency of space patterns in different hierargical scales.

KEY WORDS: Intertidal communities, zonation, Sian Ka'an, Mexico

INTRODUCCION

La caracterización de procesos que operan a diferentes escalas espacio temporales y como interactúan estos procesos para formar patrones, ha sido el foco central en las investigaciones contemporaneas (Levin 1992). Entre escalas locales y regionales, hay una enorme colección de efectos ocasionados por procesos diversos en los patrones de composición de las comunidades y en la abundancia de las especies, que solo son aparentemente claros cuando se comparan sitios separados sobre 10 a 100 km (Leonard 2000). Estos procesos han empezado a recibir la atención de ecólogos marinos y todavía tienen que ser analizados bajo la información derivada de estudios locales y regionales (Cannolly and Roughgarden 1998). El análisis de estos procesos a través de estas micro y meso-escala espacial soportan la promesa de proporcionar un marco de trabajo con los cuales los resultados de estudio a escala local pueden ser usados para hacer predicciones acerca de las respuestas de la comunidad a través de un gradiente ambiental a gran escala.

Bajo este contexto, el presente trabajo explora la distribución espacial de la abundancia y biomasa de la flora y fauna intermareal de la costa rocosa en la Reserva de la Biosfera de Sian Ka'an tanto a una escala local como a una escala de sitios separados entre si por 10 km. El objetivo que persigue este trabajo es demostrar si existe o no alguna variabilidad florística y faunística en áreas cercanas con características muy semejantes en cuanto al oleaje, lo protegido de sus costas y las condiciones de temperatura, y por el otro lado, conocer la variabilidad intrínseca de los diferentes grupos de la biota intermareal y su relación con la pendiente de la playa y el gradiente de humedad que podría darse en función de la cercanía al mar y finalmente comparar la semejanza de los patrones obtenidos con la abundancia numérica y la biomasa.

MATERIAL Y MÉTODOS

Área de Estudio. El estado de Quintana Roo, presenta una línea de costa con una marcada alternancia de playas arenosas y costas rocosas. Esta línea de costa caliza está erosionada extensivamente y proporciona numerosas pozas de marea, fracturas y crestas que son ocupados por los organismos intermareales. Los sitios de muestreo se localizan dentro de la Reserva de la Biosfera de Sian Ka'an en el Caribe Mexicano (Figura 1).

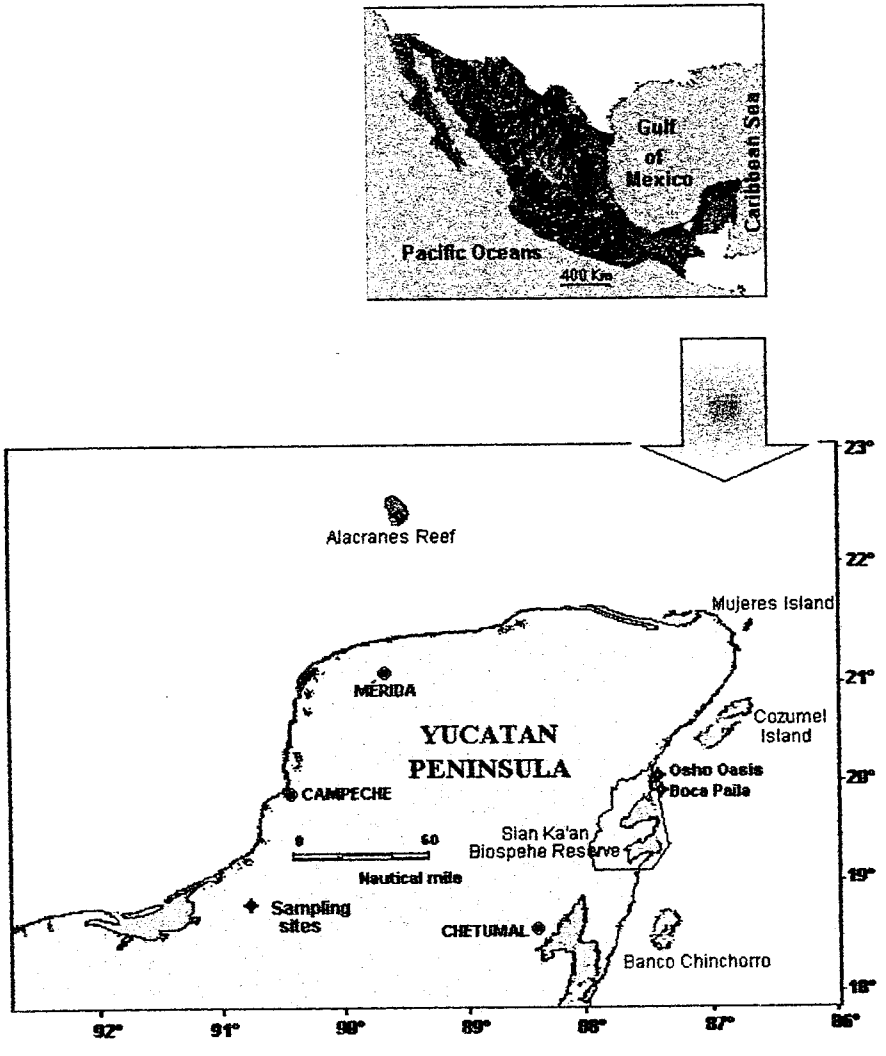

Figura 1. Áreas de muestreo

En ésta parte de la costa no existen ríos; sin embargo, la presencia de dolinas es común y el aporte de agua del subsuelo está directamente relacionada con las lluvias que se presentan usualmente en verano, teniendo un clima cálido- húmedo entre Aw_1 y Aw_2, según la clasificación modificada de Köppen por García (1973). La zona presenta una relación precipitación-temperatura mayor de 55.3. La temperatura en la costa es influenciada por los vientos que son predominantemente Estes o Surestes con presencia de Nortes en la parte final e inicial del año (García 1973, Torruco 1995). La temperatura media mensual del agua varía entre 25.6°C en enero hasta 29.1°C en agosto, dando un promedio anual de 27.5°C. La marea es semi-diurna de poca amplitud y la dirección de la corriente superficial marina es de sur a norte (Torruco op. cit.). No obstante por la topografía misma de la costa, existen pequeñas contracorrientes locales. La separación entre los sitios de muestreo fue de 21 km.

El método de muestreo utilizado se baso en tres transecciones perpendiculares a la playa por sitio, con un número variable de niveles. Cada transecto tenía una distancia de separación de aproximadamente 25 m (González 1995). El nivel inferior se localizó al inicio de la vegetación pionera y el último hasta 2 o 3 m dentro de la línea de agua. Cada nivel estuvo representado por un cuadrado de 25 cm donde se colectaron y fijaron en formalina todos los organismos circunscritos a esa área de los siguientes grupos faunísticos: moluscos, equinodermos, Artrópodos malacostracos. Las algas encontradas también fueron colectadas. Los organismos fueron pesados e identificados siguiendo diferentes autores para los diferentes grupos (Littler y Littler 1989, Torruco et al. 1992).

La secuencia analítica aplicada a los datos tanto de biomasa como de abundancia fue inicialmente una representación espacial de cada transacción y un análisis de agrupamiento de los niveles por cada transecto y un agrupamiento de los diferentes componentes faunísticos y florísticos, con la finalidad de cuantificar la variabilidad espacial de los ensamblajes de los organismos epibénticos intermareales.

RESULTADOS

El número de especies fue de 61 para Boca Paila y de 82 para Osho Oasis destacando en riqueza los gasterópodos (Figura 2); los grupos registrados son 13 (13 en Osho oasis y 8 en Boca Paila). La mayor densidad (tanto en abundancia como en biomasa) fue localizada en Boca Paila (Tabla 1). En esta localidad, las mayores densidades tanto en biomasa como en abundancia, se localizan en los niveles más cercanos al mar en los dos primeros transectos (Figura 3) en el último, altas densidades se presentan a los primeros metros de la línea de humedad. Para Osho Oasis, el patrón cambia, ya que se presentan cambios a todos los niveles en los tres transectos (Figura 4).

La pendiente de la costa es mucho mayor en Boca Paila (1.03 m en promedio), que en Osho Oasis (20 cm en promedio). Una diferencia notable es la costa de Osho Oasis que esta sumergida por un espejo de agua de aproximadamente 10 a 20 cm casi desde los primeros niveles (Figuras 5a y 6a).

La heterogeneidad de la costa en ambos sitios es alta, conformandose con los análisis de agrupamiento en las dos modalidades, numerosos grupos de afinidades semejantes, algunos de ellos muy cercanos en el espacio, lo cual muestra un ensamblaje en mosaico en toda la costa. Los grupos conformados con las abundancias en la mayoría de los casos son corroborados con los de biomasa (Figuras 5 - 6b y 5 - 6c).

La similitud de grupos faunísticos también presentan una gran correspondencia tanto en abundancia como en biomasa en los dos sitios. Los grupos florísticos se diferencían de los ensamblajes faunísticos en ambas localidades (Figuras 5 y 6 d).

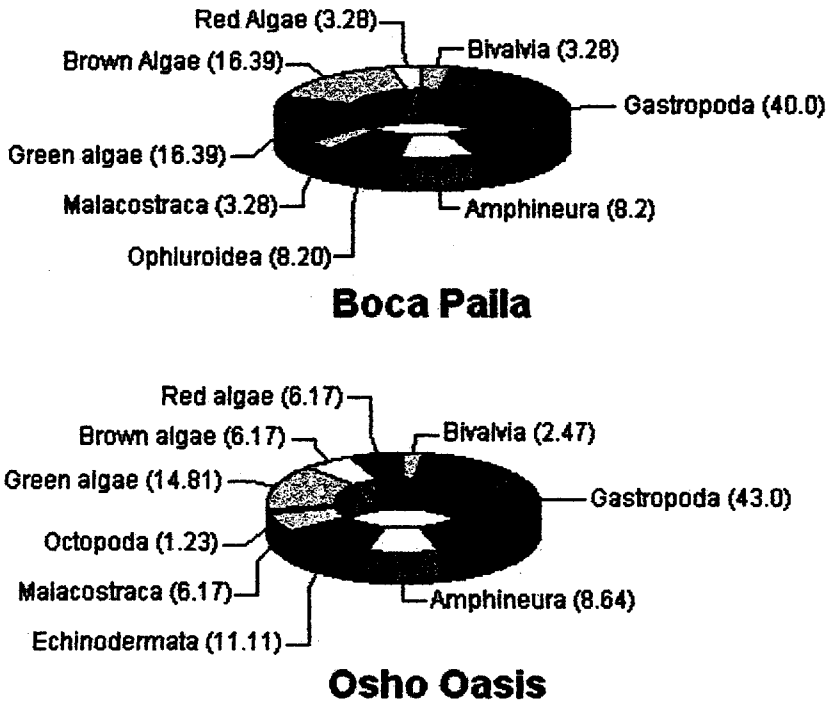

Figura 2. Proporción de las especies en los grupos estudiados en la reserva de la biosfera de Sian Ka'an.

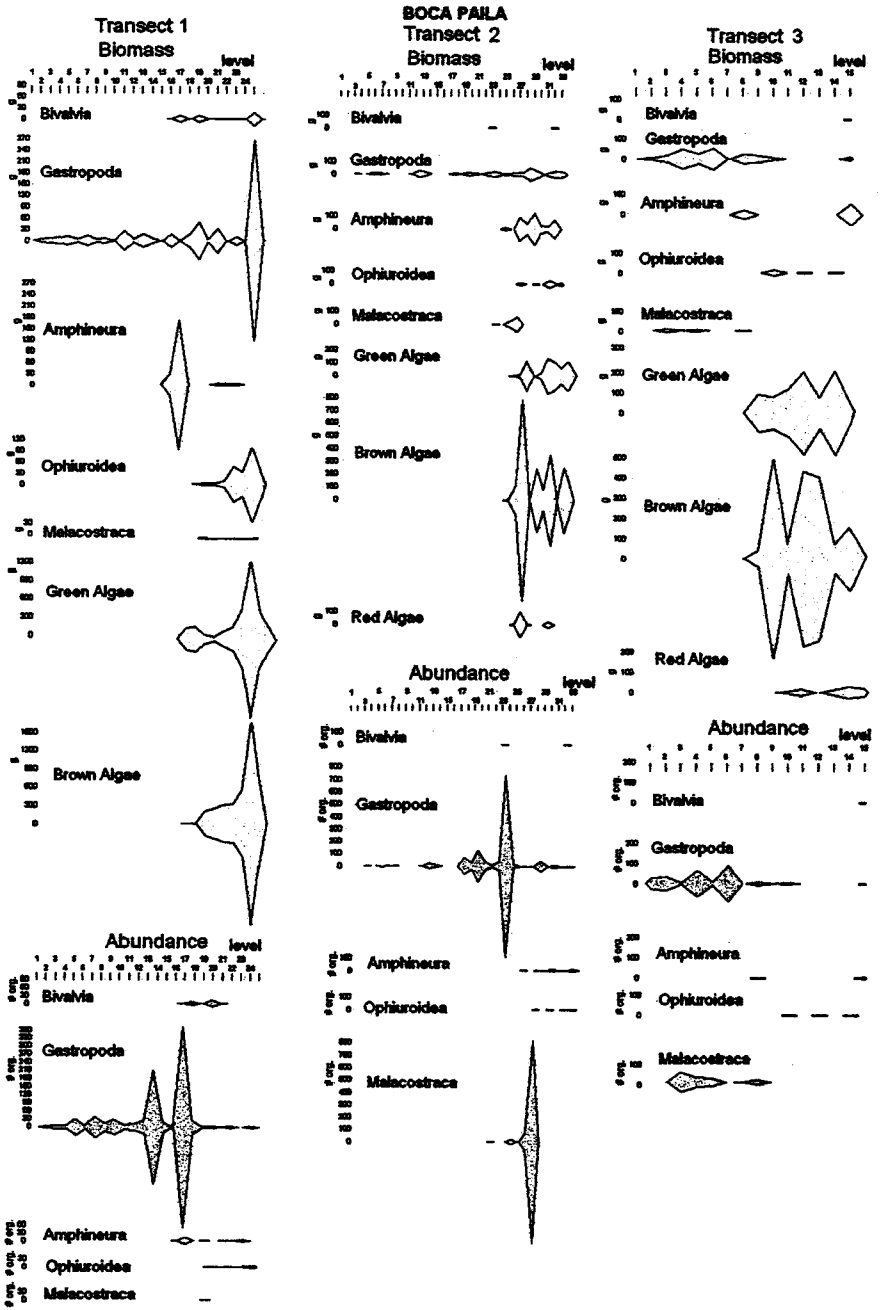

Figura 3. Distribución espacial de los grupos de fauna y flora encontrados en el transecto de Boca Paila. Se demuestra la abundancia y la biomasa.

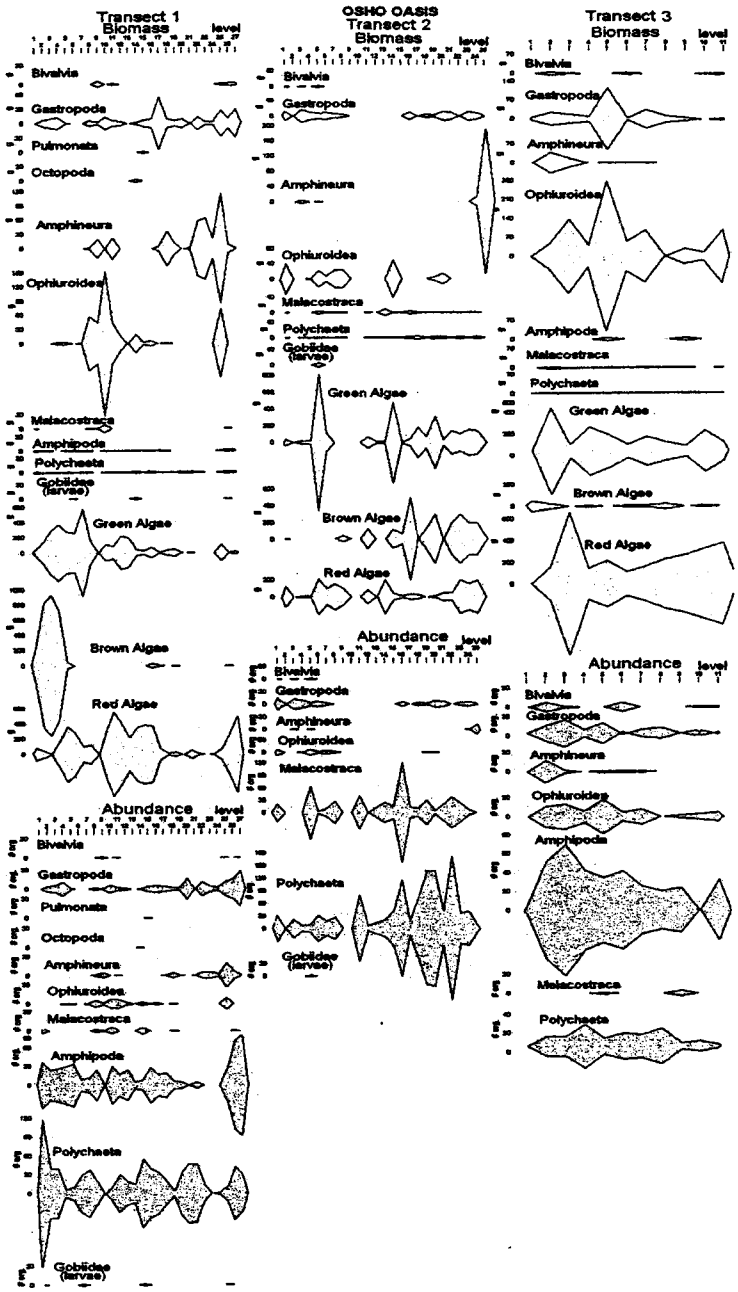

Figura 4. Distribución espacial de los grupos de fauna y flora encontrados en el transecto del oasis de Osho. Se demuestra la abundancia y la biomasa.

Tabla 1. Densidad del grupo en las áreas de muestreo.

	TRANSECTS											
	Boca Paila						Osho Oasis					
GROUPS	Abundance			Biomass			Abundance			Biomass		
	1	2	3	1	2	3	1	2	3	1	2	3
Bivalvia	26	8	1	21	5	0.5	7	5	13	11	4	14
Gastropoda	867	943	257	269.3	371.9	223	147	86	76	248	131	231
Octopoda	-	-	-	-	-	-	1	-	-	3	-	-
Pulmonata	-	-	-	-	-	-	1	-	-	2	-	-
Amphineura	22	32	8	223.6	386.2	78	56	16	17	380	210	62
Ophiuroidea	18	15	3	100	52.5	19	43	25	71	433	189	791
Malacostraca	2	925	111	1	88.5	21.2	534	478	356	30	25.6	21.7
Polychaeta	-	-	-	-	-	-	754	1081	180	29.8	24.7	10.3
Pisces larvae	-	-	-	-	-	-	6	3	-	3.4	6	-
Green algae	-	-	-	1305.5	560	846.5	-	-	-	3048	2777	1907
Brown algae	-	-	-	1666.2	1923	1706	-	-	-	2147	2232	126
Red Algae	-	-	-	0	126	92	-	-	-	4808	1755	2675

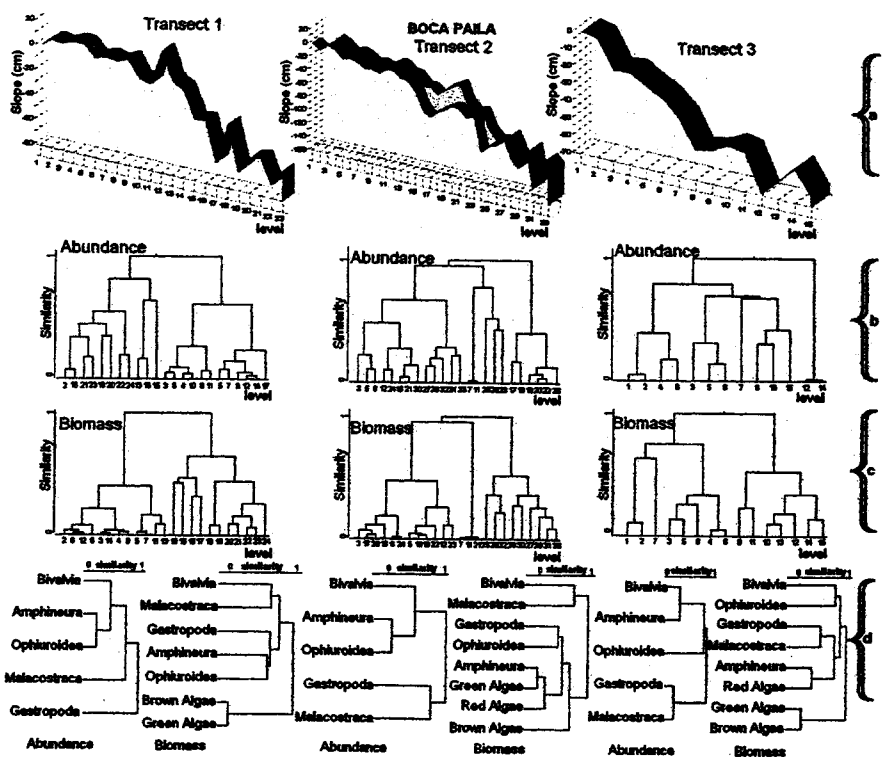

Figura 5. Pendientes y semejanzas entre los niveles y los grupos en Boca Paila. a. pendiente del Transecto, b. semejanza de la abundancia de los niveles, c. semejanza de la biomasa de los niveles, d. semejanza de la abundancia y la biomasa entre grupos.

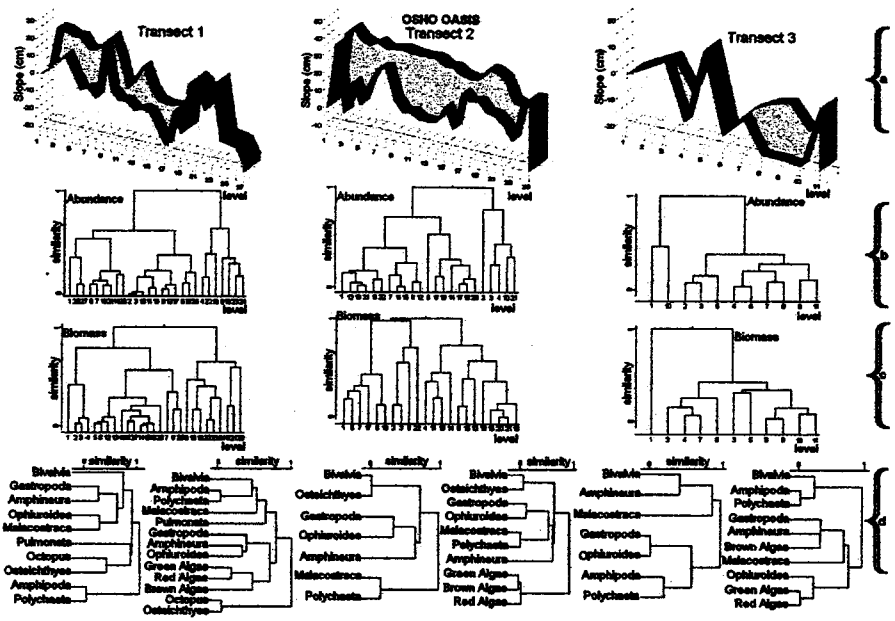

Figura 6. Pendientes y semejanzas entre los niveles y los grupos en Osho Oasis. a. pendiente del Transecto, b. semejanza de la abundancia de los niveles, c. semejanza de la biomasa de los niveles, d. semejanza de la abundancia y la biomasa entre grupos..

DISCUSION

La riqueza de especies y grupos presentes son comparables a otros estudios del Caribe (Randall y Martin 1987, Díaz-Martín y Espinoza-Ávalos 2000, Koltermann 2000), donde también se hace presente la riqueza de moluscos en estas áreas intermareales. La mayoría de los grupos encontrados, están en asociación con la presencia de algas, ya que estas proporcionan un recurso alimenticio para muchos habitantes de la porción intermareal de las costas rocosas del área de estudio. Los moluscos es quizá el grupo que presenta mayor asociación como lo menciona Warmke y Almodóvar en Puerto Rico (1963).

Las diferencias en el número de grupos entre ambas localidades podría ser efecto de la condición de sumergencia en los niveles de Osho Oasis; sin embargo, mayoría de las especies se presentan en ambas localidades y los cambios en la diversidad no son estadísticamente significativos ($p = 0.05$) Ambos sitios soportan una relación entre el número de especies y densidad semejante, a pesar de la heterogeneidad espacial que presentan sus patrones de abundancia y densidad a la escala de transecto. Un aspecto importante que se debe resaltar es que en Boca

Paila, la biodiversidad dentro de los niveles de cada transecto aumentaba conforme se acercaba a la zona de marina, de modo que los niveles con mayor diversidad se encontraban al final de cada transecto, esto es debido a que en estos sitios la presencia de algas y restos coralinos aumenta la disponibilidad de alimento y de refugios, además de que el efecto de la desecación se minimiza. En Osho Oasis por el contrario, al presentar la mayoría de los niveles sumergidos, se presenta una alta diversidad desde los niveles iniciales.

Este trabajo da evidencia de que las depresiones húmedas presentan una gran importancia en el mantenimiento de la abundancia de esta fauna. Para la clase más abundante, los gasterópodos y dada su movilidad, la concentración de especies en los refugios se debe principalmente a tres factores:

i) Una búsqueda activa de zonas protegidas,
ii) Alta disgregación y mortalidad en el desalojo físico por el fuerte oleaje en zonas lisas y expuestas y
iii) La disminución considerable de la energía del mismo en depresiones profundas donde el lavado es más pasivo.

Khon y Leviten (1976) y posteriormente Buschmann (1990) y Williams et al. (2000) consideran que el incremento en la complejidad del hábitat puede proporcionar más caminos para diferenciar estrategias alimenticias a niveles locales, las diferentes calidades de los refugios podrían complementar esta consideración; de manera tal que los ensamblajes detectados entre las diferentes especies estarían influenciados en gran medida por estos procesos y factores (Lindergarth et al. 2001).

En ambas localidades, la longitud de la playa es menor en la parte norte que en la parte sur, donde los niveles se reducen considerablemente, posiblemente sea efecto de la erosión costera por la corriente que viene del sur, de manera tal que las playas intermareales de Quintana Roo, están expuestas a fuerte insolación en bajas mareas y fuerte acción del oleaje en altas mareas y no obstante estas tensiones físicas, altas tasas de productividad organica caracterizan estos hábitats (MacQuaid y Branch 1985, Hutchinson y Williams 2001) que soportan densas poblaciones de moluscos gasterópodos. Curiosamente, esta clase de moluscos son mucho más abundantes en los bancos intermareales que en los más complejos y benignos arrecifes de coral submareales en las mismas localidades, cuya biodiversidad grupal es considerablemente más baja (Vance 1988, González 1995, Torruco y González 2000).

Branch (1984) y Buschmann (1990), argumentan que filtradores sésiles y algas son competidores por espacio y pueden monopolizar rápidamente un hábitat, en contraste herbivoros y carnivoros compiten por alimento, un recurso el cual es más difícil de monopolizar (MacLachlan et al. 1981, Lindegarth et al. 2001), tal situación parece se bastante común en las diferentes áreas estudiadas por estos autores. Para las comunidades intermareales de la costa de Quintana Roo, los depredadores y el disturbio físico parecen jugar un papel importante en la prevención de la monopolización del habitat por un dominante simple; además, otros autores (Branch 1981, Hawkins y Hartnoll 1983, Lubchenco 1983) postulan que en comunidades dominadas por herbivoros los competidores pueden coexistir sin la exclusión de una

especie por otra. En los moluscos estudiados, lo anterior podría originar que algunas especies se colocaran en diferentes planos en el espacio n-dimensional, de acuerdo a su dominancia en alguna de las características de densidad (número de individuos o biomasa), permitiendo su coexistencia.

Un aspecto importante de estas consideraciones es que están referidas a una escala micro-regional, ya que la separación entre las localidades es de pocos kilómetros; sin embargo, las condiciones particulares de cada sitio muestran fuertes diferencias, que probablemente originaran cambios en la consolidación de la arquitectura de estas comunidades, más no de su estructura.

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Small-scale Sicilian Fisheries: Opinions of Artisanal Fishers and Socio-cultural Effects of MPAs

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ABSTRACT

Marine resource management and related stakeholder conflicts have been clearly defined in recent decades as pressing issues worldwide. What most managers neglect to include in management is social science to inform the development of more effective marine protected areas (MPAs). This is a significant problem in the Mediterranean where few socio-cultural and economic studies have been conducted. This paper begins to fill this knowledge gap by accounting for a comparative study of three marine reserves in Sicily, Italy. Using data collected with standard anthropological field methods, analysis was conducted on how artisanal fishers are impacted by reserves, the extent of their knowledge regarding regulations, their opinions on management, and demographics. The results indicate that while fishers are aware of the marine reserves where they fish, most fishers were not well informed of the regulations. Fishers feel alienated from the management process and would feel more comfortable with reserve managers and regulations if they were involved in management. The paper concludes by showing how such data could help to develop more useful and practical management practices.

KEY WORDS: Marine Protected Areas, Italy, socio-economic and cultural impact

Pescadores Artesanales de Sicilia: Opiniones de los Pescadores Artesanales y los Efectos Socio-culturales de las Áreas Protegidas Marinas

La gerencia de recurso marina y los conflictos relacionados del tenedor de apuestas se han definido claramente en décadas recientes como presionar ediciones por todo el mundo. En una escala global, los seres humanos dependen de la existencia y de la abundancia de recursos marinas para satisfacer sus necesidades y desean en dimensiones recreacionales, estéticas y económicas. En años recientes, los encargados de recurso marinas se han centrado cada vez más en las áreas protegidas marinas, reservas de la industria pesquera y ninguno-toman zonas al reparto con esta dependencia. Sin embargo, la mayoría de estas áreas de la gerencia han confiado casi exclusivamente en los mejores datos biológicos disponibles para aconsejar decisiones de gerencia. Qué la mayoría de la negligencia de los encargados incluir es investigación científica social para informar al desarrollo un MPAs más eficaz. Esto

es un problema significativo en el mediterráneo donde pocos, si cualesquiera, socio-culturales y económicos los análisis se han conducido en MPAs. Para comenzar a llenar este boquete del conocimiento en el mediterráneo, conduje un estudio comparativo de tres reservas marinas en Sicilia, Italia. Usando los datos recogidos con métodos antropológicos estándares del campo, analizaba cómo las reservas afectan a los pescadores en reducida escala del artisanal, cómo esta' bien informado están sobre las regulaciones en la reserva, sus opiniones sobre la gerencia, y demographics del pescador. Los resultados indican que mientras que los pescadores están todos enterados de las reservas marinas donde pescan, la mayoría de pescadores entrevistados con no era informada muy bien de las regulaciones asociadas. Los pescadores se sienten muy enajenados del proceso de la gerencia, y se sentirían mucho más cómodos con los encargados y las regulaciones de la reserva si estuvieron implicados en revisar regulaciones actuales. Muy pocos pescadores indicaron que la aplicación es bastante adecuada evitar que los barcos rastreadores ilegales destruyan el habitat béntico en la reserva. Finalmente, los pescadores del artisanal están en conflicto constante con los pescadores recreacionales que se sienten los están exprimiendo fuera de los puertos y están tomando todos los recursos de los fishery's. Estos datos deben ser útiles en convertirse prácticas de gerencia más útiles y más prácticas.

PALABRAS CLAVES: Pescadores artesanales, áreas protegidas marinas, efectos socio-culturales

INTRODUCTION

Marine resource management and related stakeholder conflicts have been clearly defined in recent decades as pressing issues worldwide. On a global scale, humans and economies depend on the existence and abundance of marine resources to satisfy their needs and wants on recreational, aesthetic, and economic dimensions. Commercial users rely on fisheries and aquaculture in many regions of the world, while beaches and rocky cliffs provide for swimming, fishing, beachcombing, and sunbathing as prominent leisure activities (O'Riordan and Voisey 1997). These areas are among the most productive natural systems available to humans. They also include some of the most sensitive ecosystems in the world (Scura et al 1992). The problem of resource depletion already exists from conflict between them. In the case of fishery resources, where as many as 25 - 30 % of species are overfished, and another 44 % are fully exploited (FAO 1999). Previous governance efforts to sustain fisheries have frequently failed and have often exacerbated the problem of biological overexploitation and economic inefficiency (Lauck et al. 1998). Without proper management, the attributes of the coast and marine environment that humans find attractive will be destroyed (Vallega 1999).

With the realization that traditional fishery governance systems that rely on

concepts such as maximum sustainable yield and optimum yield have often failed (as evidenced by over-fishing and habitat loss), a movement has commenced towards the development of more ecosystem-oriented approaches as opposed to traditional single species management efforts. As an alternative to the single species approach, managers and scientists have rapidly been designing and implementing marine protected areas (from here on referred to as MPAs or marine reserves) throughout the world with the hopes of structuring access to marine resources on an ecosystem level. Within the last 20 years, MPAs and marine reserves have become a widely advocated form of marine conservation for protecting these valuable resources and interweaving fisheries management and tourism (Agardy 1997, Bohnsack 1993, Committee on the Evaluation, Design, and Monitoring of Marine Reserves and Protected Areas in the United States et al. 2001,Kelleher 1995, Ray 1999). Such an approach has the potential to effectively address several management objectives and allow multiple stakeholders to use the same resources, a must in reducing conflicts and concerns.

In this paper, I refer to two terms that commonly have different meanings in the primary literature: marine protected areas and marine reserves. The definition that I will follow equates the two terms to the following: any area of the marine environment managed for the primary purpose of preserving biodiversity, aiding in the recovery of overfished stocks and to ensure the persistence of healthy fish stocks, fisheries, and habitats either as a multi-use area or no-take zone. This is a common definition used for Italian MPAs, the subject of this paper.

Over the past decade, marine resource managers have increasingly realized the need to incorporate socio-economic and cultural factors into the decision making process. In many cases, especially in indigenous communities, stakeholder groups such as local residents and fishers can significantly contribute to management, providing historical catch trends, relative comparisons in the state of the environment between the past and present, new management strategies, and methods to gain the respect and trust of the community. Moreover, they can be trained to teach user groups about the reserve and how they can be involved in the management. Finally, enforcement by the community through peer pressure and discouragement are normally more effective and less costly than typically used government enforcement (Wells and White 1995).

While there have been many biological scientific studies conducted within MPAs of the Mediterranean, few if any socio-economic or cultural studies have been done on the impact of MPAs on local populations and visitors. This paper analyzes the effectiveness of MPA management and regulations in Sicily and how the management regimes deal with local stakeholder interests, principally local artisanal fishers. The first section provides background information on two MPAs in Sicily. Section two explains the methodology used in this study. Section three presents the results and analysis of a survey taken of local artisanal fishers in each MPA. Finally, the paper concludes with recommendations on how to improve MPA management

techniques in Sicily, and for MPAs in general, in order to obtain better conservation results from management plans.

BACKGROUND INFORMATION

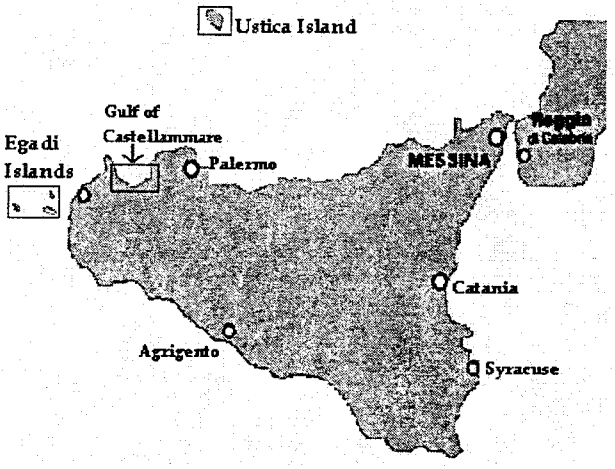
Gulf of Castellammare Fishery Reserve (GCFR)

The Gulf of Castellammare, a broad, crescent-shaped bay, is located on the northwest coast of Sicily west of Palermo (Figure 1). Its coastline is over 70 km long and its surface area is approximately 30,000 ha, making it one of the widest bays in Sicily (Badalamenti 2000). The Gulf is bordered by five villages, from San Vito Lo Capo on the Capo San Vito peninsula marking the westernmost point to Terrasini at Capo Rama marking the easternmost point. Each of these fishing villages has a publicly operated port to accommodate its commercial and recreational fishers. The majority of the fishers that are active in the Gulf are small-scale artisanal and recreational fishers from the local villages.

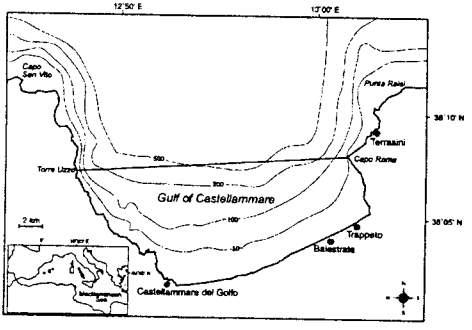
Evolution of the Reserve — The Gulf of Castellammare was established as a fishery reserve in 1990, along with two other Sicilian gulfs with important artisanal fisheries, the Gulf of Catania on the central eastern coast of Sicily and the Gulf of Patti located on the northeastern corner of Sicily. The Sicilian Regional Government imposed the fishery reserves in order to "rebuild the severely depleted demersal stocks and eliminate the conflict between the trawlers and the small-scale artisanal vessels operating in the Gulf (Whitmarsh 2000)." Over 70 commercially viable species are caught and sold locally.

Since the establishment of the fishery reserves, numerous biological studies based on annual monitoring of biomass fluctuation have shown a positive reaction by the marine environment inside the Gulf of Castellammare to the presence of the fishery reserve. A study measuring fish biomass increase after a four-year trawl ban indicated an increase in biomass for all species considered, from a 1.2-fold increase for the musky octopus to a 497-fold increase for the gurnard (Pipitone 2000). Similar results were found in biomass studies after eight and ten years of the trawl ban (Badalamenti 2000).

Regulations — In 1990, the Gulf was completely closed off to trawling, from the tip of Capo Rama south of Terrasini to Torre dell'Uzzo north of the town of Scopello on the western side of the Gulf. Current regulation also specifies that artisanal and recreational fishers are the only categories of fishers allowed to fish within the boundaries of the reserve. As a result, the few commercial trawling vessels that remain are registered in Terrasini and San Vito and can be seen trawling in the outer reaches of the Gulf as well as trawling directly along the limits of the fishery reserve attempting to catch any biomass spillover.



Gulf of Castellammare Fishery Reserve



Egadi Islands Marine Reserve

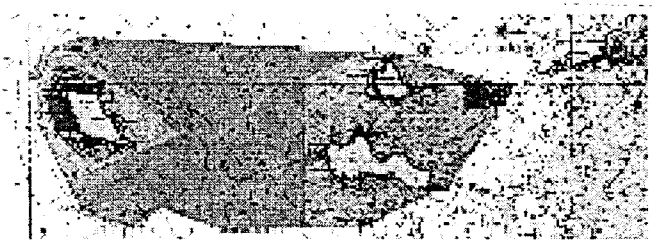


Figure 1. Map of northwest Sicily showing the Egadi Islands and the Gulf of Castellammare

Enforcement was designed to incorporate all local enforcement officials with access to vessels capable of patrolling the area. Enforcement officials include members of the Carabinieri (military police), the Guardia Costiera (coast guard), the Capitaneria (port authority) and the Guardia Finanza (charged with protection of the economic interests of Italy and the EU). Each is responsible for having at least one vessel patrolling local waters.

Egadi Islands Marine Reserve (EIMR)

The Egadi Islands are located directly west of the city of Trapani at the western-most point of Sicily (see Figure 1). The reserve encompasses three islands, Favignana, Marettimo and Levanzo, and two rocky outcroppings, Formica and Maraone. The total length of protected coastline is approximately 22 kilometers and the reserve is approximately 50,000 ha and consists of four zones of increasing restrictions (Kelleher et al. 1995). Fishers in each village have access to ports on each island provided by the provincial government. As in the Gulf of Castellammare, the majority of fishers are small-scale artisanal and recreational fishers from the local villages.

Evolution of the Reserve — The reserve surrounds the archipelago of the Egadi Islands stretching westward from offshore of Trapani in an oval shape encompassing all five of the islands in the archipelago. Law 979/1982 (Agreement on the Defense of the Sea) was the first attempt by the Italian government to protect areas of its national waters. It identified 20 reserves to be established throughout Italy within two years after the law was written. However, there were not sufficient resources to make all 20 a reality immediately; consequently, the EIMR was not instituted until 1991. It is the largest marine reserve established in Italy to date and the second largest marine reserve in the Mediterranean.

To date, few biological studies have examined the effectiveness of the Egadi reserve in terms of its ability to increase the biomass of local marine organisms, and none have been published. The consensus of popular opinion, expressed in interviews with the author, suggests that even though very little research has been done to determine the effectiveness of the reserve, the reserve is completely ineffective. Furthermore, minimal work has been done to determine the economic impacts, and no work has been done on the socio-cultural impacts of the marine reserve on local stakeholders (Bertolino et al. 2001).

Regulations — Political jurisdiction in the reserve falls under the hierarchy of the Region of Sicily, the Province of Trapani and the Commune of Favignana. Each of these entities has some level of responsibility in managing and contributing resources to the reserve. Until 2000 the reserve was directly managed by the port authority of Trapani, which limited its responsibilities to administrative and bureaucratic work in the management of the reserve. In 2000, the responsibility of management was transferred to the Commune of Favignana. The Commune has become a much more

active and dynamic management body. As an example, it nominated a new director of the reserve in 2001, whose first action was to sponsor and promote a research program to determine the efficacy of the current management scheme and the overall success of the reserve. The reserve is partitioned off into four zones, A, B, C and D, with varying levels of restrictions. Zonation within the reserve allows for a multi-use aspect of marine resources in the management plan of any regulated area. The zone restrictions range from permitting only limited types of activity such as diving, research and swimming (zone A), restrictions on navigation within 500 m of the coast, fishing in general, and prohibition of trawling and spearfishing (zone B), prohibition only of using trawling gear (zone C), and allowing almost all stakeholders to use the reserve resources to some extent (zone D).

METHODOLOGY

Sicily is perhaps the ideal setting for an examination of the evolution and performance of marine reserves in Italy and the Mediterranean. Each reserve in Italy was established for unique cultural, sociological, economic, and conservation reasons. There is tremendous diversity in the types of marine resources they are designed to protect and in the degree to which each has achieved that protection. Analysis of the effectiveness of marine reserves in Sicily required the collection of both primary and secondary data. Primary data was gathered through the use of a series of survey instruments and personal interviews in three marine reserves in northwest Sicily. Secondary data was collected through an extensive primary literature review of articles and reports on the effectiveness of marine protected areas in general and in the marine reserves in question.

The present study focuses on the opinions of fishers affected by the GCFR and the EIMR. These three reserves were chosen due to the differences in creation dates, the level of success that has been reported in each reserve as determined by the initial objectives and the regulatory structure between nationally and regionally created reserves.

A personal survey was conducted among small-scale artisanal fishers in the five villages surrounding the GCFR. A second, shorter version of the survey was conducted in the three villages within the EIMR. All data collection took place during the summer of 2001. Interviews were conducted in each village by the author and technicians from the *Istituto delle Ricerche Marine e L'Ambiente* (IRMA). Due to the small size of the total and individual village populations, the questionnaire was directed to the entirety of the fishing population instead of choosing a subset.

In addition, several informal interviews were conducted with fishers to expand and complete information gathered in the formal survey process. Sampling was opportunistic, occurring throughout the course of research activities. To complement these interviews, official documents including laws, ministerial decrees, and educational pamphlets provided to the public were used. One fisher was interviewed per boat. Typically, the interview was held with the owner of the boat.

However, on a few occasions, another crew member was interviewed as the boat owner was not available. The surveys were designed to gather site-specific data regarding the opinions about and knowledge of the management, enforcement, and regulations that apply to the reserve. The questionnaires focused on five categories of questions: demographics, fishing activities, reserve knowledge, legal framework, and concerns.

RESULTS AND DISCUSSION

In the Gulf of Castellammare, a total of 68 of 115 artisanal fishers were interviewed. This accounts for 59 % of the total population of fishers in the Gulf. Three fishers refused to be interviewed. The fewest fishers were interviewed in the port of Terrasini, where it is speculated that a number of fishers have retained their fishing licenses, but have ceased fishing activities. The percentage of active artisanal fishing population interviewed is likely to be higher than 59 %. In the Egadi Islands, 25 of 32 or 79 % of all artisanal fishers were interviewed with no refusals. Lack of data on license holders precludes formal analysis of response bias. However, except as noted below, it can be assumed that the data summarized here is not representative of the respective sampling populations.

In each MPA, the distribution of population demographics, fishing characteristics and fishing gear seem to be fairly similar. As all of the fishers are small-scale artisanal fishers, and this demonstrates a series of generalities that could characterize or define groups of such fishers in Sicily. Fishers in these reserves vary widely in age from 23 to 80, however, fishers' formal educational level is generally very low, and they do not have sources of income other than fishing. Most run fishing vessels alone or with only one other person, the vessels are all in the same size range (4.5 - 12 m in length), and the most utilized piece of fishing gear is the trammel net with occasional use of one or two other gear types. In addition, fishers use purse seines and long-lines to supplement the catch provided by trammel nets. Other gear types used, although much more infrequently, include drift nets, cages, line fishing, and set nets.

Interviews with local fishers in each MPA brought out similar needs for future management within each. The present study found four commonalities between the three MPAs studied in terms of needed management measures. These include:

i) Better communication, especially regarding regulations and boundary delimitation,
ii) Increased enforcement of regulations,
iii) New performance measurements and monitoring along with a commonly agreed definition of 'success,' and
iv) Increased involvement of local communities in decision making. The following is broken up into four sections describing each of these with regards to the major findings in this study along with possible solutions to help resolve each issue.

Communication

One of the most important components of reserve development and establishment is informing the people that utilize the area being managed about the new regulations. This includes explaining where the boundary of the reserve is, any associated zonation and the regulations associated with the reserve. Fishers were asked questions designed to show their level of awareness of their local MPA, including its delimitation, regulations, and management mechanism.

In the Gulf of Castellammare, fishers were relatively well informed. In other locations, however, there was inconsistent knowledge of the boundary and other details of the reserve, which, as described in the next section, has contributed to dissatisfaction with reserve management (Table 1). Most fishers know of the reserve, however, very few are able to exactly identify the boundary of the reserve. Responses were evenly spread between fishers that could correctly identify the reserve boundary, to a close approximation (meaning within a couple of geographic points of the actual boundary), incorrectly, and those that could not identify a boundary at all. Although local fishers were well informed about the establishment of the fishery reserve, few considered themselves well informed of fishing regulations in general.

Table 1. Level of User Awareness

Level of User Awareness	Gulf of Castellammare	Egadi Islands
Aware of reserve	97 %	100 %
Correctly identified the boundary	21 %	47 %
Identify boundary to close approximation	29 %	17 %
Identify boundary incorrectly	24 %	13 %
Cannot correctly identify the boundary at all	22 %	23 %
Feel very informed of regulations	12 %	23 %
Feel somewhat informed of regulations	42 %	43 %
Feel not at all informed of regulations	46 %	32 %

In the EIMR, however, the majority of fishers do not consider themselves very informed about general fishing regulations or the boundary of the zones within the reserve, but the majority of fishers claim that they know where the boundaries of the reserve zones are. Those fishers that could identify the reserve and zone boundaries of only their island claim that the area they showed on the map was the entire reserve, excluding the zones around the other islands. A fairly equal distribution of responses was seen when respondents were asked how informed they feel of the regulations governing activity in the reserve.

It is important for fishers to understand where all of the zones of the reserve are and what the associated regulations are for two reasons. First, once one fisher understands the regulations, he can pass that information on to anyone that asks. This might include tourists, fishers from outside of the reserve and recreational fishers. Once they understand the regulations, they can pass the information on

acting as a public education conduit. Second, most fishers indicated they only fish around their island or near their village. If a given fisher eventually gains the technology to fish beyond his island and village, he will need to know the entire reserve and zone boundaries and regulations that apply to other parts of the reserve. In order to accomplish this, educational programs could be developed to help inform the fishers of the regulations so that they understand them properly.

Involvement in Decision Making

Fishers in all three MPAs were asked questions with regards to their opinions on the whether they have been involved in local decision making and if their interests are represented. In the case of the GCFR, almost all fishers believe that reserve management is effective and they have never felt excluded from the decision making process. Local fishing cooperatives have always been involved in reserve management. A different story is seen in the EIMR. Frequently, MPAs and fisheries management practices have failed and become ineffective because they do not include local stakeholders in the decision making process (Russ and Alcala 1999). This has caused emotions of alienation and anger, as was seen in the Florida Keys National Marine Sanctuary (Suman et al. 1999), and decrease compliance, in the Sumilon Reserve in the Philippines (Russ and Alcala 1999). This is the scenario we see in the EIMR.

The most noteworthy problem in the EIMR is that fishers' do not think that they have a say in management decisions or that they are listened to when they talk to the director or the Commune. Commercial fishers, especially from Marettimo, repeatedly claimed that the Ministry and local communes were trying to force them out of a job by taking away the most profitable fishing grounds. They claim they have not seen any benefits from the reserve, even though it has been in effect for almost a decade, and have concluded that the reserve is just another way for the government to control their access to resources. Many fishers also believe that over the years their concerns have been completely ignored by the director and Commune. They believe that any promises the director makes to them are never kept and they feel that all trust has been broken between them and reserve managers. Successful management of reserve waters will only occur when complete trust is restored between all stakeholder groups and the reserve director.

Animosity expressed towards the reserve director and the Commune in the EIMR suggests that stakeholders have not been consulted enough in management decisions. Development of a co-management or community based management program could alleviate this. By involving the local fishers and community in reserve management, they can learn to help others appreciate the fragility of the resources that they depend on. Moreover, if fishers have a say in regulatory design they will be less hostile towards management and try to get others to follow them, thus increasing compliance (Russ and Alcala 1999, and Pomeroy et al. 1997). If locals are not in agreement with the management institution in place, then no one

will follow the law. Those locals that do not agree with the regulations will continue to violate them and the institution in place will be overridden (Jentoft et al. 1998).

Enforcement

In the GCFR, survey questions were asked concerning the adequacy of enforcement and if it should be more severe. Responses showed that 20 - 50 % of fishers in each village believe the trawling ban is not adequately enforced. The majority also feel that enforcement should be increased. These responses reveal that enforcement officials are not properly enforcing the trawling ban and that management officials should reevaluate enforcement practices. However, the Gulf Reserve is unique in that although enforcement seems to be inadequate, illegal trawling seems to be infrequent enough that it does not negate the benefits of the reserve. Although the reserve can already be considered a success due to the support of the local fishers and the overwhelming increase in biomass, 'success' can only improve by up-scaling enforcement.

In the EIMR, the situation is more severe. All fishers see is a lack of enforcement. However, they believe that they will be penalized economically if they follow the law while others do not. The lack of enforcement is one of the main causes of perceived management failure in the reserve for local fishers. Only two vessels are available for patrol in the reserve, one associated with the port authority in Favignana, the other in Marettimo, neither of which is designated solely for reserve patrol. Furthermore, the local port authority and Commune have not designated personnel that are dedicated to reserve enforcement. The reserve is sufficiently large so that two vessels that work only part-time cannot adequately patrol the entirety of the reserve. But although enforcement is clearly not adequate, few fishers suggest that enforcement should be more severe. Understandably, they did not want to criticize enforcement for fear that their response will backfire and enforcement will become more severe towards them.

Following the lack of enforcement and a lack of support by the local community, compliance with the regulations in the EIMR is very low. Illegal fishing is frequently observed. However, many fishers suggested that if the management regime was modified so that illegal trawlers and other illegal activities were stopped through proper enforcement and stricter regulations, they would be in full support of the marine reserve. Because they are left with recurring illegal activities, the fishers are acting instinctively doing whatever it takes to feed their families and make a living, even if it means illegally fishing in the reserve.

In both case studies it is evident that enforcement should be increased to improve the overall 'success' of the reserves and meet management objectives. Without enforcement, compliance will continue to remain low and the expected benefits of the reserves will be difficult if not impossible to achieve. The only case where benefits have been achieved is in the GCFR where fishers have followed regulations enough that an increase in the biomass of local stocks has been successfully reaped.

Performance Measurements

One of the most important aspects of any MPA is determination of success or failure of the management practices. This can take a variety of forms in what we call performance measurements that are unique to each case. Most frequently, such performance measurements are determined *a priori* through previously designed criteria or based on definitions that they have constructed through experience. What they fail to look at is how the 'success' of a protected area is viewed from different perspectives within each case. In order to shed light on true perceptions of success in each of the case studies in this study, fishers were asked questions about their opinions on management effectiveness, perceptions of related impacts and problems they have experienced as a result of an MPA.

Fishers' opinions of reserve management institutions function as an indicator of the effectiveness and overall success of the reserve with regards to the reserve's objective to improve the local fishery. This has been seen in the Apo Island Marine Reserve in the Philippines (Russ and Alcala 1999) and is expected in the Bunaken Manado Tua Marine Park in Indonesia (Alder et a., 1994). By looking at whether fishers see a reserve as effective from the inside, we can begin to develop a true picture of the 'success' of the reserve. Fishers' overall catch can function as an indicator of the health of local stocks. In regards to their opinions about management, fishers in the GCFR were asked questions regarding their general opinion of the success of their reserve, whether their interests are represented, and if the present management scheme is the best way to manage the area. Fishers in the GCFR tended to respond positively to three questions regarding whether the Gulf should be regulated in general, whether they like the trawling ban, and whether they think that the ban should continue. Almost all respondents answered yes to all three. The overwhelmingly positive reaction by fishers is a good indication that the reserve is accepted and supported by the local fishers that are heavily affected by its presence.

Fishers in the EIMR were asked 'Is the reserve a positive thing for the islands?' In the EIMR, Favignana was the only island where the majority of respondents indicated that the reserve is positive (Table 2). Fishers indicated that the reserve is beneficial for the marine environment, increases fish populations, prevents destructive trawling, creates stability, and stops the use of damaging fishing gear. Those fishers in the islands that do not think it is positive think that it has not done anything for the islands, it limits where the fishers can work and extends the distance that the fishers have to go to fish. Some fishers stated that it is saving the sea for future tourism. But the majority indicated that it is not a real reserve because it only prevents trawling activities and limits the amount of work the small-scale fishers can do.

Closely correlated with opinions about management were perceptions about the increase or decrease in the amount of fish they catch as a result of a given reserve. From the artisanal fishers' vantage point, the reserve is only successful to the extent that they benefit personally and as a user group. Fishers tend to be content if they

perceive these benefits. Yet where fishers do not perceive or reap benefits from the MPA, they tend to express negative opinions about the reserve and comment on large negative impacts they have experienced.

Table 2. Is the reserve a positive thing for the islands? As answered in the EIMR.

		Favignana	Levanzo	Marettimo	Overall
Is the reserve a positive thing for the islands?	Yes	63 %	50 %	25 %	50 %
	No	13 %	50 %	75 %	35 %
	Don't know	19 %	0 %	0 %	12 %
Enforcement is adequate	Yes	19 %	0 %	63 %	31 %
	No	75 %	100 %	38 %	65 %
Enforcement should be more severe	Yes	25 %	50 %	0 %	19 %
	No	13 %	0 %	63 %	27 %
	Don't know	56 %	50 %	0 %	31 %
	Didn't Answer	6 %	0 %	38 %	15 %
Interests are represented	Yes	13 %	0 %	13 %	12 %
	No	63 %	100 %	88 %	73 %

In the GCFR, fishers were asked if the amount of fish they catch has changed at all since the creation of the fishery reserve in the Gulf (Table 3). The majority of respondents indicated that the amount of fish they catch has increased at least somewhat. Fishers were also asked if they believed that this variation was due to the ban (Table 4). A notable characteristic of the GCFR is that the small-scale artisanal fishers of each village tend to fish directly in front of their village or to one side. This in turn creates a build-up of biomass in the center of the Gulf because no fish are being caught there. Because the majority of fishers from the villages in the interior indicated that their catch has increased at least some since the creation of the fishery reserve, it seems that the trawling ban has worked to increase their catch.

Conversely, the majority of the fishers from Terrasini reported that their catch has decreased since the creation of the reserve. Although Badalamenti et al (2000) showed that there have been dramatic increases in the harvest of almost every species in the Gulf of Castellammare; the fishers in Terrasini still are not content. If we look at the geographic placement of Terrasini (Figure 1), we see that it is located to the immediate north of the reserve boundary. Traditionally, in the context of no-take marine reserves, those not allowed to participate in the fishery line up on the boundary in order to catch any biomass spillover that may occur. Off the coast of Terrasini, where the reserve boundary crosses the mouth of the Gulf, this scenario occurs often, eliminating any benefit of the marine reserve to the fishers of Terrasini. Often, trawling vessels from Terrasini, Palermo and villages in between come to the eastern edge of the reserve to trawl because fish from within the reserve move across the boundary line (pers. comm. with Fabio Badalamenti 2001). Consequently, fishery resources along the reserve boundary in front of Terrasini are more heavily exploited than in the interior of the Gulf, leaving very little fish for the

artisanal fishers registered in the port of Terrasini. As a result, many have recently stopped fishing activities because they feel that there are no fish left for them.

Table 3. Responses in the Gulf of Castellammare to the question: How has the amount of fish you have caught changed since the trawling ban started?

	San Vito Lo Capo	Castellammare del Golfo	Balestrate	Trapetto	Terrasini	Overall
Increased a lot	15%	32%	67%	10%	10%	27%
Increased some	46%	36%	22%	50%	10%	34%
Not changed	0%	8%	0%	0%	10%	5%
Decreased some	8%	24%	11%	40%	40%	24%
Decreased a lot	0%	0%	0%	0%	20%	3%
Don't know	23%	0%	0%	0%	10%	6%
No response	8%	0%	0%	0%	0%	2%

Table 4. Responses in the Gulf of Castellammare to the question: Is the variation due to the trawling ban?

	San Vito Lo Capo	Castellammare del Golfo	Balestrate	Trapetto	Terrasini	Overall
Yes	54%	64%	100%	80%	30%	64%
No	8%	20%	0%	10%	40%	16%
I don't know	23%	16%	0%	10%	30%	16%

Turning to the EIMR, a similar question was asked: Were your fishing activities affected by the creation of the reserve? Overall, there were an equal number of fishers that indicated that their activities were or were not affected by the reserve. In Favignana, three-quarters of fishers indicated that their fishing activities were not affected by the creation of the reserve (Table 5). Those fishers indicated that they fish more now with the reserve. The affected fishers, however, said that they now have to go farther from the coast to fish and commented that now there are more dolphins in the area that destroy nets while looking for fish. Moreover, they stated that competition has increased between boats in the islands and those that come from mainland Sicily to fish in the reserve.

Table 5. Responses in the Egadi Islands to the question: Were your fishing activities affected by the reserve?

	Favignana	Levanzo	Marettimo	Overall Egadi Islands
Yes	19 %	50 %	100 %	46 %
No	75 %	50 %	0 %	50 %

The number of fishers in the EIMR has decreased dramatically in recent years. For example, within the past two years, at least five fishers from Levanzo have stopped fishing and changed occupations or left the island to find work, leaving only two active fishers left. In Marettimo, fishers have grounded their vessels and changed occupations or they have converted their vessels for the tourism trade. While this has encouraged tourists to visit the islands, which benefits the local economy, it has left fishers very bitter.

Another aspect of the EIMR is that there seems to be no build up of biomass within the reserve. Generally, one of the central objectives of a marine reserve is to augment the growth of local fisheries resources and/or local biodiversity that have been threatened. As seen in the GCFR, fishers generally fish only around their island, meaning that the fishing grounds around Levanzo and Marettimo, where no-take zones exist, have been limited more than those at Favignana. The central complaint is that since the most productive fishing grounds have been taken away, the catch per unit effort (CPUE) has decreased substantially. Fishers are now fishing for the same amount of time, but catching substantially less. In the areas where they are allowed to fish, resources are further being exploited by long distance trawling fleets that illegally work within the reserve and contribute to the overexploitation of the fishery's resources. Because foreign fishing vessels are allowed to fish within the waters of the reserve, the fishing fleet is exhibiting overcapitalization (Fairlie et al, 1995).

A final consideration in determining the level of performance in an MPA is the analysis of the problems and conflicts that local stakeholders perceive to be created by the MPA. A recurrent issue in MPA management is conflict between stakeholders. In many, if not all MPAs, there are conflicts and problems between different resource users in the area and general resistance to the reserve itself.

In the GCFR, fishers identified a number of problems associated with the local fishery and the reserve. Due to differences in dynamics in the structure of each village in the Gulf, fishers in each village identified different problems that were the most important to them. Fishers from all villages indicated that there is a problem with recreational fishers taking resources and filling up the ports and the lack of regulations that apply to them as compared to commercial fishers. Over the past decade, the number of recreational fishers in the Gulf has substantially increased, placing enormous pressure on the fishery resources. This has created enormous animosity and conflict between the commercial and recreational fishers in the area. The other nemesis of the artisanal fishers is the trawling fleet. Trawling vessels are frequently seen illegally fishing inside the Gulf reserve boundaries at night. The purpose of prohibiting trawling in the Gulf was because of its destructive effect on the mid-water and benthic ecosystems and the local fishery. Artisanal fishers are consequently angered that there is not enough enforcement of the 'no trawling' regulation. However, when asked if they would turn in someone that is in violation of the regulations, the majority of fishers claimed that they would not. This conflict is a product of the *legge dell'omertà*, a long standing value of Sicilian culture that says that even if you are aware of something wrong that another has done, you may not divulge that information without retaliation from the Mafia if the illegal activity was done by an associate of the Mafia, of whom there are reputed to be many in Sicily. With this problem, fishery management can become ineffective simply because of the fishers themselves: the illegal fishers as well as the ones unwilling to speak about the illegal activities of their friends. In order to by-pass this situation, the management regime for the GCFR should step up enforcement so that individual fishers are not put in the position of having to decide whether to turn someone in. In the EIMR, fishers identified a number of similar problems. These include poor enforcement of the law, the continued presence of trawling vessels, fishing for juveniles, decrease in earnings due to bad weather, and decreasing amounts of fish throughout the reserve. Most fishers indicated that they have a big problem with recreational fishers and the absence of local fish markets. Fishers in Levanzo indicated that their biggest problem is the poor quality of the port. Those in Favignana indicated that trawling still exists, and that they must travel further from land to fish now. Many also stated that there are no problems. Most Marettimo fishers claimed that there is nowhere for them to fish anymore or that the amount of fish they catch has diminished substantially.

In the EIMR, there are many more recreational fishers located in each port than there are commercial fishers. As discussed above, commercial fishers feel that there are not as many regulations for recreational fishers and more and more recreational fishers have been claiming space in the ports, consequently squeezing the artisanal fishers into smaller areas of the port. By combining the abundance of recreational and artisanal fishers and illegal trawlers, without proper management and increased enforcement within the reserve, the central objectives of the reserve management plan to protect local biodiversity and augment local fisheries are not being met. This

is undoubtedly contributing to the overexploitation of local fish stocks.

Finally, fishers noted the presence of outside fishing fleets. These vessels are mainly long-distance trawlers from Trapani, Marsala and Palermo. Very few trawlers that actively fish in the EIMR are officially registered in the Egadi Islands. Due to the lack of enforcement within the reserve, these trawling vessels are constantly seen in violation of the regulations. On many occasions, trawlers will come within 300 m of the shoreline consequently interfering with dive sites and destroying fishing gear set by artisanal fishers (pers. obs.). Moreover, not only has trawling been shown to damage the benthic ecosystem (Dayton et al. 1995, Jennings et al. 2001), but it acts as a dangerous hazard to fishing gear and divers. The port authority has not stopped all of the trawlers from entering zones A, B and C. This could be the cause of decreasing fish catch for local fishers.

CONCLUSION AND POLICY RECOMMENDATIONS

In general, marine reserves have had varied success. The success of a reserve is often determined *a priori* through criteria that are determined through previous experience and natural resource management theory (e.g. increased stock biomass, economic efficiency, etc) (Russ and Alcala 1999, Scovazzi 1999, Chiappone and Sealy 1998). What is often missed is whether resource users internal to the reserve believe it is a success. Marine reserves commonly are termed paper parks because stakeholders do not follow regulations and the area that was to be protected is as disturbed and overexploited as before the reserve was instated, in some cases even more so (Bohnsack 1993).

The two case studies presented here show different scenarios that exist for MPAs. The first, the Gulf of Castellammare Fishery Reserve, is demonstrative of a reserve that is widely supported and accepted by fishers, scientists and managers, where all groups believe that the reserve is helping the local fishery and biological studies show enormous increases in biomass. Second, the Egadi Islands Marine Reserve represents a situation where neither the management staff nor the fishers believe that the reserve is successful, but both support it and believe that it would be good for the islands if managed properly.

While both reserves are at different stages in working towards true functionality, interviews indicated that each could benefit from four common modifications to current management strategies. First of all, communication in both reserves has not been sufficient enough to inform resource users of reserve boundaries and regulations. A new line of communication must be created to effectively disseminate this information, theoretically resulting in increased compliance as fishers would be able to better identify the boundaries of where they are allowed to fish.

Second, managers must increase involvement of local communities in the decision making process. This is more the case in the EIMR where stakeholders feel completely isolated from reserve management; however, relations between

stakeholder groups in the GCFR could also be improved through increased involvement. Marine resource managers must recognize that the development of community based or co-management programs can dramatically increase the successfulness of marine reserves through improved compliance and increased support of the reserve by user groups. Resource users frequently do not understand why certain regulations are needed and, when stakeholders are not included in management development, they become agitated and angry towards reserve managers. Fishers, especially, can provide invaluable information to the management process and can share responsibility and authority to promote effective fisheries and reserve management. In the process they become much more supportive. As representatives of the fishing community, fishers' cooperatives in each of the reserves in this study could take on this collaborative role consequently improving their working relationship with managers. Furthermore, managers need to recognize the need to educate the local community about the importance of their resources. By developing a common interest in reaching the objectives of the reserve, the local community can become enthusiastic about the reserve, help others appreciate the environment more and increase compliance with non-fishing regulations.

Third, increasing enforcement in the GCFR and EIMR should decrease the number of violations because resource users will fear being caught. Consequently, compliance will increase and the objectives of the reserve will come closer to being met. In the case of the Egadi Islands, the existing management institution and enforcement regime are inadequate to deal with the special management needs of the area. With the multiplicity of city governments and agencies that management has at one time or another been delegated to, successful management has been ignored and virtually no enforcement exists. By increasing enforcement, especially to catch illegal trawlers, the majority of fishers would view the reserve much more positively and trawling, the most detrimental activity occurring in the reserve would be substantially decreased. To a lesser extent, the same would be true in the Gulf of Castellammare.

Finally, a commonly agreed definition of 'success' must be created and additional performance measurements must be designed and tested in each reserve to verify the overall success of each reserve. The present study showed that overall fishers' catch increased in the GCFR as a result of the reserve, but that fishing activities have generally been negatively impacted by the EIMR . In addition, conflicts exist between resource users in both MPAs, specifically with the trawling fleet, recreational fishers and outside fishing fleets. However, more information is needed in order to determine the true success of these protected areas. This could take the form of ongoing monitoring and in-depth research into the individual definitions of success and relevant measures of success given by different stakeholder group associated with each reserve.

These management institutions, however, will never be perfect unless all scientific information is known about the ecosystems that they seek to protect.

While much research has been done to characterize the environment in the Gulf of Castellammare and determine the reserve's overall success, very little has been done in the Egadi Islands. Scientists and managers must recognize the need for such biological research as well as socio-economic research characterizing the impact of regulations and the reserve on local environment and communities.

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St. Eustatius Marine Park: A Case of MPA Problems and Solutions in the Caribbean

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ABSTRACT

The St. Eustatius Marine Park is relatively obscure in comparison to sister-island Marine Parks, Bonaire, and Saba, partly due to its young status. The Marine Park did not become actively managed until 1998. The park surrounds the island of St. Eustatius from the high water mark to the 30 meter depth contour, and contains two reserves. The park's basic infrastructure is in place, with over thirty (30) dive and yacht moorings installed and maintained, and regulations and user fees are in force. The creation and implementation of the Marine Park occurred without input from the local dive shops, fishers, and other stakeholders. Therefore, STENAPA has many stakeholder challenges to face and community awareness and education are now a primary focus of the Marine Park. Cooperative management and empowerment of stakeholders are slowly being integrated into the park's management scheme. User fees are not sufficient to sustain the Marine Park due to a lack of substantial tourism, and scarcely cover the cost of two (2) full-time employees. Consequently, a worldwide volunteer program was established in order to carry out many of the tasks needed to manage the park effectively. Volunteers use the two (2) to six (6) month experience as an internship or practical training for their university. Although the volunteer program is successful, it does not preclude the need for donors to increase funding availability for permanent staff and, in particular, overhead. Carrying capacity is far from being reached, therefore promotion of the Statia Marine Park as a dive destination is imperative in order to realize self-sufficiency. The Statia Marine Park has excellent potential given its young status combined with a fairly comprehensive infrastructure. If effectively managed, it will achieve its goal of resource protection that will allow appropriate sustainable uses.

KEY WORDS: Reserves, STENAPA, volunteers

Parque Marino De San Eustaquio: Un Asunto De Los Problemas y Las Soluciones Del Parque Marino En El Caribe

El Parque Marino de San Eustaquio es desconocido en comparición con los Parques de las islas hermana Bonaire y Saba en parte causado por su juventud. El Parque no estaba bien administrado hasta 1998. El Parque Marino envuelve la isla de San Eustaquio desde la marca de marea alta hasta la profundidad de 30 metros; además contiene dos reservas. Existe la infraestructura básica con más de trienta ancladeros de submarinismo y de yates establecidos y mantenidos. Preceptos legales

y contribuciones financieras están en vigor. El Parque Marino de San Eustaquio ha sido redactado y autorizado sin participación de los buceadores profesionales, ni de los pescadores ni otros participantes. Se considera El Parque Marino como una dictadura. Por lo tanto el Parque Marino considera que es importante desarrollar la conciencia de la sociedad así como la educación. En este momento se está introduciendo la administración compartida y participación de los interesados en el sistema de administración.

Las contribuciones financieras no alcanzan para sostener el Parque Marino por falta de turismo esencial, tampoco cubren los gastos de los dos empleados. Por consiguiente se organizó una campaña mundial con el fin de entusiasmar a voluntarios para administrar en realidad los sitios. Los voluntarios aprovechan su práctica interna de dos o seis meses como prácticas para sus estudios universitarios. Aunque vinieron más voluntarios de lo que había esperado, eso no excluye la necesidad de encontrar a unos patrocinadores para que se pueda mantener la plantilla fija y especialmente los gastos generales.

Una campaña publicitaria es necesario para conseguir que el Parque Marino pueda valerse por sí mismo. Tomando en consideración el poco tiempo de su existencia, El Parque Marino tiene un potencial excelente combinado con una infraestructura bastante amplia que con una gerencia eficaz alcanzará sus objetivos de proteger los recursos.

PALABRAS CLAVES: Parque marino, San Eustaquio

INTRODUCTION

Socio-economic, Geopolitical, and Historical Background

St. Eustatius (commonly referred to as "Statia") is one of five islands within the Netherlands Antilles. Curacao, Bonaire, St. Maarten, Saba, and St. Eustatius, together with Aruba, which has separated itself from the Netherlands Antilles, form part of the Kingdom of the Netherlands (Figure1). The Central Government resides in Curacao, but there exists a trend towards greater decentralization of government to the respective Island Territories, which decentralization has de facto also included environmental issues. A Lieutenant Governor who is appointed by the Governor General on behalf of the Queen, and who chairs the elected Island Council as well as the Executive Council, heads each Island Territory. The Island Council has legislative powers (Van't Hof 1991).

Tourism is an important source of revenue in St. Eustatius, but it has not been aggressively marketed to reach its potential. Because SCUBA diving offers the greatest potential for sustained revenues, tourism will depend to a large extent on the quality of the marine environment (Van't Hof 1991).

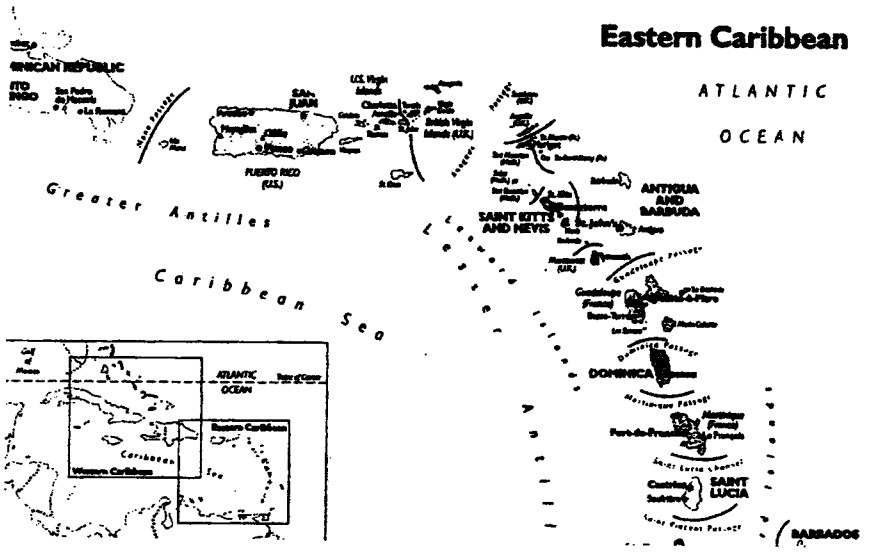

Figure 1. Location of St Eustatius

The first proposal to establish a Marine Park in the Netherlands Antilles dates back to 1971 (Van't Hof 1991). The actual establishment of the first Marine Park did not take place until almost a decade later in Bonaire. The Central Government in Curacao recognized the absence of Governmental agencies that could deal effectively with the planning, establishment and management of Marine Parks, and island governments were asked to appoint a non-governmental agency to develop and manage parks. The St. Eustatius National Parks Foundation (STENAPA) manages the Statia Marine Park, which was created through the Marine Environment Ordinance St. Eustatius in 1996, but did not become actively managed until 1998. STENAPA also manages the terrestrial Quill National Park and is developing a Botanical Garden on St. Eustatius (Figure 2).

Specific Challenges Faced

i) Until March 2001, Marine Park boundaries had been misinterpreted as two small, disjunct areas. STENAPA now manages all the waters surrounding the island of St. Eustatius from the high water line to 30 meters in depth, and the two small areas previously thought to be the Marine Park, are actually Reserves within the park (Figure 2.). Although this realization increased management capabilities, the discovery also posed some problems. Regulations regarding fishing, dive shops, permits, coastal development, etc. stipulated within the Marine Environment Ordinance now apply to all waters surrounding St. Eustatius, not just those within the reserves. This created alarm among stakeholders.

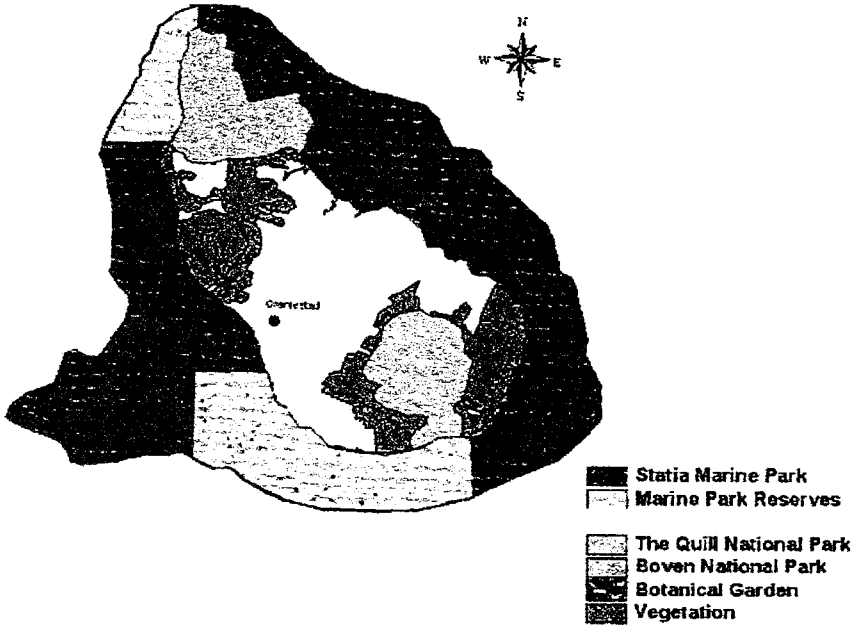

Figure 2. Areas on and around St. Eustatius managed by STENAPA

ii) User fees are in place, but a lack of substantial tourism prevents the Marine Park from achieving self-sufficiency through user fees (Figure3). The only source of steady income for the Marine Park derives from park entry fees (dive fees) and yacht fees (overnight moorings), but these do not generate enough income to pay 2 full-time employees, and falls short of covering any materials and equipment needs or overhead.

iii) Dive shops were not entirely compliant with regulations and Marine Park entry fees.

iv) Conservation is a fairly new concept for the people of St. Eustatius, and many islanders resist conservation initiatives.

v) Communication with fishers is difficult. Regulations and information regarding beneficial results of marine reserves are posted, but many fishers cannot read and others vowed to never support the Marine Park at its onset. One fisher was taking between 100 and 500 Queen Conch (*Strombus gigas)* per week and fishers were placing fish traps (pots) inside reserve boundaries. Both acts are in violation of the Marine Environment Ordinance.

vi) Regulations are in place, but enforcement is minimal and sometimes non-existent. The Marine Environment Ordinance states that the Marine Park will be given a "non-governmental law person," but the Inspector of the

Police Department is apprehensive about giving law enforcement authority to the Marine Park.

vii) Scientific research has played an important part in the development of the St Eustatius Marine Protected Area (MPA). It has served as the basis for surveying and designating the Marine Park reserves and for some of the legislation and regulation involved in protecting the marine environment. It is imperative that scientific interest is maintained to closely monitor the health of St Eustatius Marine Park and to understand the limits and needs of the local environment in order to legislate accordingly.

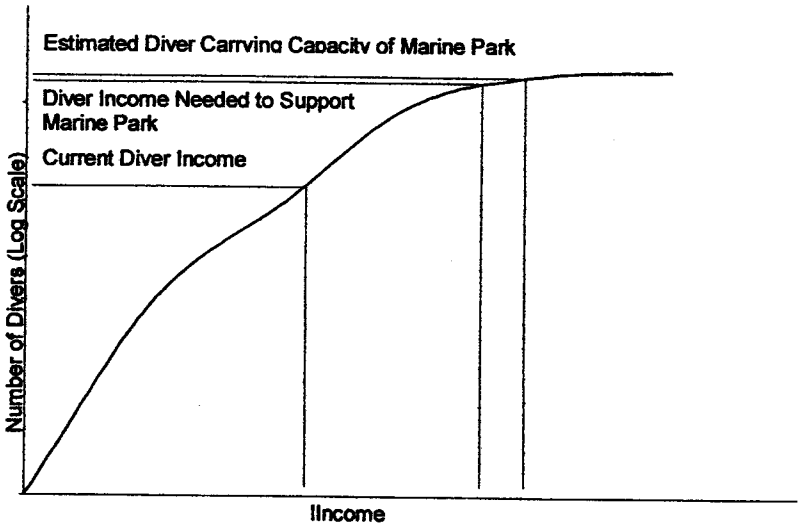

Figure 3. Diver income and carrying capacity of St. Eustatius Marine Park

METHODS USED TO OVERCOME CHALLENGES AND RESULTS

Lack of Funding for Staff

A worldwide volunteer program was established in September 2001 due to a lack of funding and need for Park employees. Seventeen volunteers (from Germany, France, U.S., England, Finland and Austria) have completed from two to six month internships or practical training for universities to work in the Marine Park, the Quill National Park, and the Botanical Garden. The Botanical Garden facilities were converted into a communal living area for volunteers. Volunteers make effective, comprehensive management possible by:

i) Helping maintain the mooring system,
ii) Diver supervision,
iii) Coordinating the sea turtle tagging and monitoring program,
iv) Bi-weekly clean-up of Zeelandia beach,
v) Assisting the Snorkeling Club, an educational program for local school children that provides the children with skills and knowledge to enjoy the marine environment,
vi) Implementing educational projects such as the school coloring contests and marine science lessons,
vii) Creation and distribution of educational and promotional materials,
viii) Improving STENAPA's image through involvement with the local community,
ix) Erosion control and maintenance of Quill National Park trails,
x) Creating trail leaflets,
xi) Website design and maintenance,
xii) Reestablishment and improvement of the "Friends of Stenapa" Program,
xiii) Assisting in creation of the first employee workbook,
xiv) Helping to write proposals,
xv) Assisting Park manager with office tasks, freeing up management to focus on larger objectives,
xvi) Improvement of greenhouse by propagating more indigenous plants and repairing material damaged due to previous neglect and poor planning,
xvii) Improving living conditions at the Botanical Garden for future volunteers,
xviii) Helping to create draft plans for the Botanical Garden,
xix) Creating an identification booklet of local flora, and
xx) Maintaining grounds (mowing, weed-whacking, etc.).

The volunteer program also creates problems such as increasing workload for management, primarily due to more supervisory responsibilities. Also volunteers are generally motivated and ambitious, leading to ideas for new projects which require funding. However, the benefits reaped through the volunteer program far outweigh these manageable issues.

Dive Shop Compliance

In December 2001, the Executive Council issued power to the Marine Park to issue permits that require divers to pay visitor fees as well as to provide accurate dive statistics. This permit serves three purposes:

i) Provides a control mechanism in case growth of the dive industry needs to be limited (Van't Hof 1991),
ii) Enables the Marine Park to set standards for safety and quality of the services rendered by the operator, and
iii) Enables the Government to revoke or suspend permits of operators who do not adhere to those standards or do not comply with Marine Park regulations (Van't Hof 1991).

This provided the first requirement of dive shops to be responsible for assuring each diver in the Marine Park is aware of Marine Park regulations and that user fees are paid. Management cannot strictly rely on permits to insure Marine Park regulations are followed. The Marine Park places surveys at all island hotels, which are to be filled out by every guest. These surveys help to identify gaps in Marine Park awareness, dive shop compliance, and other information important for management effectiveness.

Public Relations and Education

Because the Marine Park was established without stakeholder input, public relations and education are now the primary focus of the Marine Park. More than forty positive articles providing information on STENAPA activities have appeared in regional newspapers within the past eighteen months, informing the general public about activities conducted and provided by the Marine Park. Volunteers create and distribute a tri-annual newsletter. Monthly power-point presentations are given in all four island schools, educating local youth on conservation issues concerning the island, the Caribbean, and globally. Prizes are awarded to those students scoring highest overall on quizzes given at the end of each presentation. A STENAPA radio program will begin in January 2003, providing Statians information regarding local activities, regulations and environmental issues. The community is invited to beach clean-ups and to assist with the sea turtle tagging program. Schools collaborate with the Marine Park on special events. A weekly snorkel club program introduces children to the marine environment by teaching basic snorkel skills while providing a general knowledge of marine conservation. Graduates of the Club receive a PADI Skin Diver certificate. A school-organized work experience program enables high school students to gain experience in the workplace and develop a broader understanding of environmental issues.

Fishers

After reserve areas were outlined, action was taken to provide a new fishing ground for fishers as an alternative to the reserves. STENAPA Reef was created using small ship wreckage as an artificial reef for fishing. Of course, this artificial reef does not provide the same catch the two large areas of natural coral reef once provided, and fishers were not satisfied with the tradeoff. In early May, the detrimental harvesting of the threatened queen conch (*Strombus gigas*) was stopped by Marine Park management and with the support of the local police an arrest was made. The queen conch is a threatened species, and is protected by the Marine Environment Ordinance. Now that the true boundaries are finally recognized by the appropriate authorities, the Ordinance gave Marine Park management the power to see that the conch are protected not only in the Marine Park Reserves, but surrounding the island of Statia. The taking of hundreds of queen conch weekly had been ongoing before the Marine Park was established and five years after, until May of 2001. Fishers were alarmed and threatened Park management almost weekly, and once with a knife. Three meetings were held with local fishers in a six-month period

following the arrest in order to improve relations between the Marine Park and fishers, and to foster a better understanding of fishing restrictions and liberties. However, misinformation continued to spread among the fishing community. A fishers association was discussed, and encouraged, by the Marine Park in order to channel correct information but to date no association has been formed.

One year after the arrest and news of Marine Park boundaries, the Marine Park found that fishers react well by being shown through direct action that the Marine Park can be beneficial for them. Park management discovered that when corrective action must take place (e.g. removal of pots from reserves) it is best for the Marine Park to provide the fishers with some service while working along side one another (e.g. retrieving lost and abandoned traps). If these two acts are coordinated together, fishers tend to accept the arrangement more easily.

Government and Enforcement Authority Relations

The relationship between STENAPA and the Executive Council has fluctuated over the years. Cooperation from the local Government is, of course, imperative in order to achieve certain goals. When relations were good, the Government granted partial salary for one Marine Park employee, granted authority to the Marine Park to issue permits, and allowed the Marine Park to place a sign at Zeelandia beach banning sand mining once an alternative was in place, making the beach a protected area for endangered sea turtles.

STENAPA has been unsuccessful in convincing the Executive Council to implement an Article in the Marine Environment Ordinance that requires ships to pay a fee based on tonnage for anchorage within the Marine Park. Vessels using Statia Terminals frequently anchor inside Marine Park boundaries and applying this fee would make the Statia Marine Park self-sufficient. STENAPA was perhaps too persistent in pursuing this issue, and this could possibly be the cause of a noticeable decline in Government interest. Subsequently, the Island Government has addressed serious issues regarding coastal development and waste management without input from STENAPA.

Although legal framework was in place during the early stages of establishing the Statia Marine Park the fluctuating political climate restricts the longevity of commitments made by governmental bodies. A solution might be to give presentations to newly elected government bodies describing the role and benefit of the Marine Park, and continue a policy of promoting the importance of MPA's.

The island's social and political environment occasionally makes it difficult for local law enforcement to honor the legislation outlined in the Marine Environment Ordinance. The Marine Environment Ordinance states that the Marine Park will be given a "non-governmental law person" either within Marine Park staff/management, or from the police force. In order to achieve law enforcement authority, Marine Park personnel must gain "special police" status. However, this has no yet been attained.

Once management realized the "special police" authority may not be attained in the near future regardless a compromise was reached: One enforcement officer

will accompany Marine Park staff on the Marine Park patrol vessel once per week in order to issue warnings to local users of Park waters (i.e. fishers and dive shops), and tickets to fishers from neighboring islands fishing illegally within Marine Park boundaries. This compromise allows some enforcement of regulations, without Marine Park personnel given enforcement authority.

Scientific Interest

Maintaining scientific interest in the Marine Park is necessary for St. Eustatius to insure the future of its unique marine environment and fulfill the socio-economic requirements of the island's tourist industry. The Marine Park recruits scientifically qualified volunteers to engage in marine research. These volunteers also generate ideas in terms of monitoring the environment and future study within the MPA. The St Eustatius Marine Park actively encourages scientific research from outside organizations and provides them with many of the tools necessary for their research. It is hoped that the knowledge gained from within the MPA will increase public and global awareness of the marine environment as well as promote the protection and enjoyment of the St. Eustatius Marine Park.

SUMMARY

Managing an MPA is a balancing act between the needs of the local community and the sustainable use of the marine environment. Regrettably, when the St Eustatius Marine Park was created it was without the co-operation and support of the local community, and as a result, much of the work of STENAPA is centered around the community in order to educate and involve local people in the conservation of their environment. Education of children is key to assuring the future success of the MPA and also gains community support by showing an active interest in the island by providing a variety of activities for children. A strong volunteer program provides a successful solution to a shortage of staff due to a lack of funding. Applying a more stringent system of collecting diver fees and assuring that divers are aware of the Marine Park and its regulations was necessary in order to gain dive shop compliance. Recognition that fishers need to see positive direct action taken by the Marine Park on their behalf, and that working along side them when dealing with fishing gear eliminates some ill feelings and proves to be a more successful strategy when communicating, than posted flyers of regulations and formal meetings. Improving the enforcement authorities' involvement through compromise was imperative in assuring MPA regulations are respected. The improving relationships with the stakeholders, government, and law enforcement allows the Marine Park to dedicate more time and energy to the study, conservation, and protection of the local marine environment and more active management of the MPA for sustainable use. The combination of funding through user fees, improving local relations, and a strong volunteer program enables the Marine Park to fulfill its commitment to the environment and community. However, the Marine Park is far from self-sufficient. Although some problems facing the St Eustatius Marine Park

have been solved, many steps need to be taken to develop solutions to ensure the future of the St Eustatius MPA.

The most effective tool in managing an MPA successfully, at least within the Lesser Antilles, seems to be the realization and application of flexibility and creative thinking when dealing with local Government, communities and stakeholders.

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Diagnóstico para la Creación de una Reserva de la Biosfera en los Arrecifes de Campeche, México

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RESUMEN

Campeche es uno de los cuatro estados de la vertiente del Atlántico que posee un desarrollo arrecifal con características únicas en el Golfo de México. El área de análisis incluyó una superficie de 12,437 km^2, la zona pertenece a la provincia fisiográfica conocida como Carso Yucateco, cuyo accidente fisiográfico más notable es la barrera coralina que se desarrolla desde arrecife Alacranes en Yucatán hasta Cayo Arenas en Campeche. Se analizan seis estructuras arrecifales emergentes que forman un arco desde el oeste hacia el nordeste con crecimientos arrecifales a 18,35,70,80 y 90 m de profundidad. En cada estructura arrecifal se realizaron transectos batimétricos con equipo de sondeo y radar. A excepción de Arcas y Arenas los afloramientos están formados por restos coralinos. El relieve topográfico fue de 1.6 m en promedio con pendientes abruptas a moderadas. La vegetación insular es diversa con 29 especies de plantas, incluyendo exóticas e introducidas, en algunos cayos arenosos es incipiente o inexistente. La flora marina está representada por 14 especies de macroalgas. En la fauna se registraron 30 especies de corales escleractínios, 11 octocorales, 19 esponjas, 2 hidrozoarios, 2 poliquetos y un número considerable de peces, varios de los cayos son zonas de desove para tiburones y tortugas. En la mayoría de los cayos se presentan poblaciones importantes de aves marinas principalmente *Sula* y *Fregatas*. Estos arrecifes son áreas importantes para la pesca comercial de Langosta, Caracol y Mero las cuales están reguladas por leyes pesqueras vigentes y en donde es necesario una reglamentación más específica. De acuerdo a las características morfo-fisiográficas, faunísticas y florísticas registradas se define la zonación específica del polígono propuesto con zonas núcleo, z. de amortiguamiento y z. de restauración.

PALABRAS CLAVES: Arrecifes, Áreas protegidas, Campeche, Golfo de México.

Diagnosis for Creation of a Biosphere Reserve in the Reefs of Campeche, Mexico

Campeche is one of the four states in Mexico on the Atlantic slope having reef development unique within the Gulf of Mexico. The area within this analysis includes a 12,437 km^2 surface in the Yucatan Karst physiographic province, whose most notable aspect is the coral barrier that runs from the Alacranes Reef in the state of Yucatan to Arenas Key in Campeche. Analysis is made of six emergent reef structures that form an arc from west to northeast, with reef growths at 18, 35, 70,

80 and 90 m depth. Using radar and sounding equipment, bathimetric transects were made of each reef structure. With the exception of Arenas and Arcas keys, the islands are formed of coral remains. Average topographical relief was 1.6 m with abrupt and moderate slopes. Insular vegetation is diverse, including 29 plant species, some introduced or exotic; on some of the sand keys vegetation is incipient or nonexistent. Marine flora is represented by 14 macroalgae species. Marine fauna includes 30 scleractin coral species, 11 octocorals, 19 sponges, 2 hydrozoas, 2 polychetes and numerous fish; many of the keys are spawning zones for sharks and turtles. Most of the keys are also host to sizable marine bird populations, principally *Sula* and *Fregatas*. These reefs are important areas for commercial capture of lobster, conch and grouper, which is currently regulated by fishing laws, though more specific regulation is needed. Utilizing the recorded morpho-physiographic, faunal and floral characteristics, a detailed zonation is defined for the proposed reserve polygon, with nucleus, buffer and restoration zones.

KEY WORDS: Reefs, Protected areas, Campeche, Gulf of Mexico

INTRODUCCIÓN

Las costas de México tanto del Pacífico como del Atlántico, poseen ecosistemas sumamente importantes como son los arrecifes coralinos, lagunas costeras, estuarios, humedales y manglares. Estos recursos costeros son desde el punto de vista diversidad y economía un patrimonio esencial para el país (Ferre-D'Amare 1985).

Actualmente, en la Península de Yucatán se han llevado acabo acciones concretas con respecto a la conservación y el desarrollo sustentable de los ecosistemas marinos. El estado de Quintana Roo, ya cuenta con las siguientes cinco áreas naturales protegidas: Isla Contoy, Costa Occidental de Isla Mujeres, Punta Cancún y Punta Nizuc, Cozumel, Sian Ka'an y Banco Chinchorro, en sus modalidades de Parques Nacionales y Reservas de la Biosfera o Reservas Especiales.

En lo que se refiere al Golfo de México, ya existen áreas arrecifales protegidas como son el caso del Parque Nacional Arrecifes de Veracruz en ese Estado y el Parque Nacional Arrecife Alacranes en Yucatán. En cuanto a los arrecifes de Campeche, debido a su alto valor ecológico, genético, estético y a sus recursos naturales es necesario todo esfuerzo institucional a nivel: federal, estatal y local, que asegure su conservación, manejo y sustentabilidad en el tiempo.

El Laboratorio de Arrecifes Coralinos de la Unidad Mérida del CINVESTAV-IPN realizó los estudios para que el Gobierno de Campeche, por conducto de la Secretaría de Ecología-Medio Ambiente-Recursos Naturales y Desarrollo Pesquero del estado de Campeche, solicitará su declaratoria como un Área Natural Protegida y su inclusión en el SINAP (Torruco y González 1997a). En el presente trabajo se analiza la superficie general propuesta para su conservación, así como la importancia de su amplio potencial ecológico y económico.

MATERIAL Y MÉTODOS

El área esta ubicada en las costas del estado de Campeche que pertenecen a la provincia fisiográfica conocida como el Carso Yucateco (Novak et al. 1992). Cuenta con cuatro estructuras arrecifales emergentes y sumergidas respectivamente: Cayo Arenas, Cayo Nuevo, Triángulos, Arcas, Banco Nuevo, Banco Pera, Bajo Obispos y Bancos Ingleses (Figura 1).

En la definición de la poligonal del área propuesta, fue necesario delimitar las zonas arrecifales de las costas de Campeche, los vértices se establecieron mediante campañas de muestreo en el Barco Marsep-1 del Cetmar de Campeche. En cada cayo se realizaron transectos batimétricos utilizando el ecosonda y radar FURUNO de la embarcación. Adicionalmente, al inicio y al final de cada cayo y transecto batimétrico se obtuvo el posicionamiento satelital con un GPS portátil Magellan NAV5000.

Se realizaron perfiles de relieve en los cayos, la descripción submarina se realizó mediante fototransectos y las observaciones del fondo con buceo libre y autónomo en un intervalo de profundidad de 1 a 50 m (Torruco 1995). Se utilizaron cartas de navegación de la Secretaría de Marina (SM 1981 a y b) y topográficas del INEGI (INEGI 1981). En los cayos se realizaron perfiles del relieve con métodos topográficos estándar con el conteo respectivo de aves marinas y cobertura vegetal (González y Torruco 2000a).

RESULTADOS

Relieve Topográfico

El relieve en todos los cayos es bajo con un promedio de 1.6 m y pendientes de abruptas a moderadas, la mayoría de las islas, son alargadas con una forma de media luna originada por la influencia de las corrientes, la estructura arrecifal sigue el mismo patrón de media luna en la mayoría de ellos. Todas las islas de Triángulos poseen una vegetación incipiente y en algunos casos inexistentes, sin embargo Triángulos Este y Sur presentan poblaciones importantes de aves, particularmente pájaros bobos y rabihorcados: *Sula* spp., *Fregatas magnificiens* y *Larus* spp. Presentan una vegetación extensa y más diversa con algunas especies introducidas como: Casuarinas, Palmas de coco y Uva marina, entre otras. Su topografía muestra dos montículos con dos depresiones en la isla, los cuáles son las áreas preferidas por los rabihorcados para asentar sus nidos. Los pájaros bobos, habitan en la zona central que presenta una menor pendiente.

Características Biológicas

El Arrecife Arenas incluye asociaciones de las especies: *Porites porites, Porites astreoides, Acropora cervicornis, Acropora palmata, Favia fragum, Diploria strigosa, Millepora alcicornis, Halimeda incrassata* y *Penicillus dumetosus.* Cayo Nuevo: *A. palmata* con *Palythoa* y algas filamentosas. Arrecife Triángulos: *A. palmata, P. asteroides, F. fragum, Agaricia agaricites*, algas coralinas incrustantes, anémonas coloniales: *Palythoa caribbeaerum* y *Zoanthus sociatus, Halimeda, Diploria* y *Montastrea.* Cayo Arcas: formado por *A. palmata* arborescente, *Diploria,*

Montastrea, P. porites y *A. cervicornis.* Banco Nuevo y Pera: son los arrecifes sumergidos más cercanos al continente con *A. agaricites, Montastrea sp.,* algas calcáreas del género *Lithothamnium, P. astreoides, Diploria,* hidrozoarios del género *Millepora,* anémonas coloniales *P. caribbeaerum y Z. sociatus.* Bajo Obispo: este sistema arrecifal presenta paredes simples y fusionadas con taludes externos de fuertes pendientes. Bancos Ingleses: son también paredes arrecifales simples y fusionadas con taludes externos de pendientes moderadas (Torruco y González, 1997b).

Figura 1. Ubicación geográfica de los Arrecifes de Campeche, México

Comparación Biótica

Los arrecifes de Campeche presentaron 207 especies con una alta biodiversidad y grado de desarrollo con respecto a: Isla Cozumel, Costa Occidental Isla Mujeres, Punta Nizuc, Punta Cancún, Alacranes, Isla Contoy, Puerto Morelos y Tulúm, en la mayoría de los siguientes grupos funcionales: Hexacorales, Octocorales, Hidrozoarios, Anémonas, Esponjas, Macroalgas, Poliquetos y Equinodermos, es importante señalar que estos sistemas presentan diferentes esquemas de protección (González 2000b).

Aspectos Histórico

La zona presenta una gran importancia sobre todo en los encallamientos de barcos en los bajos arrecifales. Se registraron los siguientes 12 pecios con su geoposicionamiento: Wachos, Don Francisco, Santa Fé, Namditos, Atoradero, Cheroquee, Lorencillo, Cubano, Malujoca, Mario Quemado, Jaina, Catalán.

Aspectos Socioeconómicos

Es difícil establecer para los arrecifes coralinos un *estatus* socioeconómico real, sobre todo en los arrecifes de Campeche en donde su principal giro es la utilización pesquera y la extracción de crudo (Ferre-D'Amare 1995). Por otro lado, el arrecife y sus zonas emergentes no presentan un asentamiento humano permanente, los islotes de Cayo Nuevo, Triángulos Este y Sur no presentan ningún asentamiento, los Cayos de Arcas y Arenas son los que presentan una mayor población que incluye a dos guardafaros, un destacamento de infantes de marina de cuatro elementos, que en el caso de Arcas el destacamento es más numeroso: tres infantes más y un radiocomunicador, además en ambas islas se presentan con frecuencia pescadores que realizan estancias de poco tiempo, la isla de Triángulos Oeste tiene sólo dos guardafaros.

Las islas actualmente sirven como bases esporádicas de pesca y refugio de pescadores de escama y de algunos invertebrados de importancia comercial. En los alrededores de Cayo Arcas se presenta la construcción y funcionamiento de plataformas de extracción de crudo y estaciones de bombeo, de donde se extrae hasta el 70% de la producción nacional. El uso tradicional de la flora y fauna en algunos cayos es inexistente, la fauna generalmente tiene implicaciones alimenticias y ornamentales, en algunos casos con especies de moluscos y corales. Es conveniente considerar que aunque el material arrecifal no es utilizado para la construcción de edificios o estructuras como ocurrió en el pasado con otros sistemas arrecifales, la mayoría de las islas están construidas por restos coralinos.

Asimismo, no existe algún antecedente sobre la protección del área, sin embargo esta regida tanto por: la ley federal del mar, la ley de pesca, la ley general del equilibrio ecológico y la protección al ambiente, la ley orgánica de la Armada de México, así como las leyes aplicables a estas zonas.

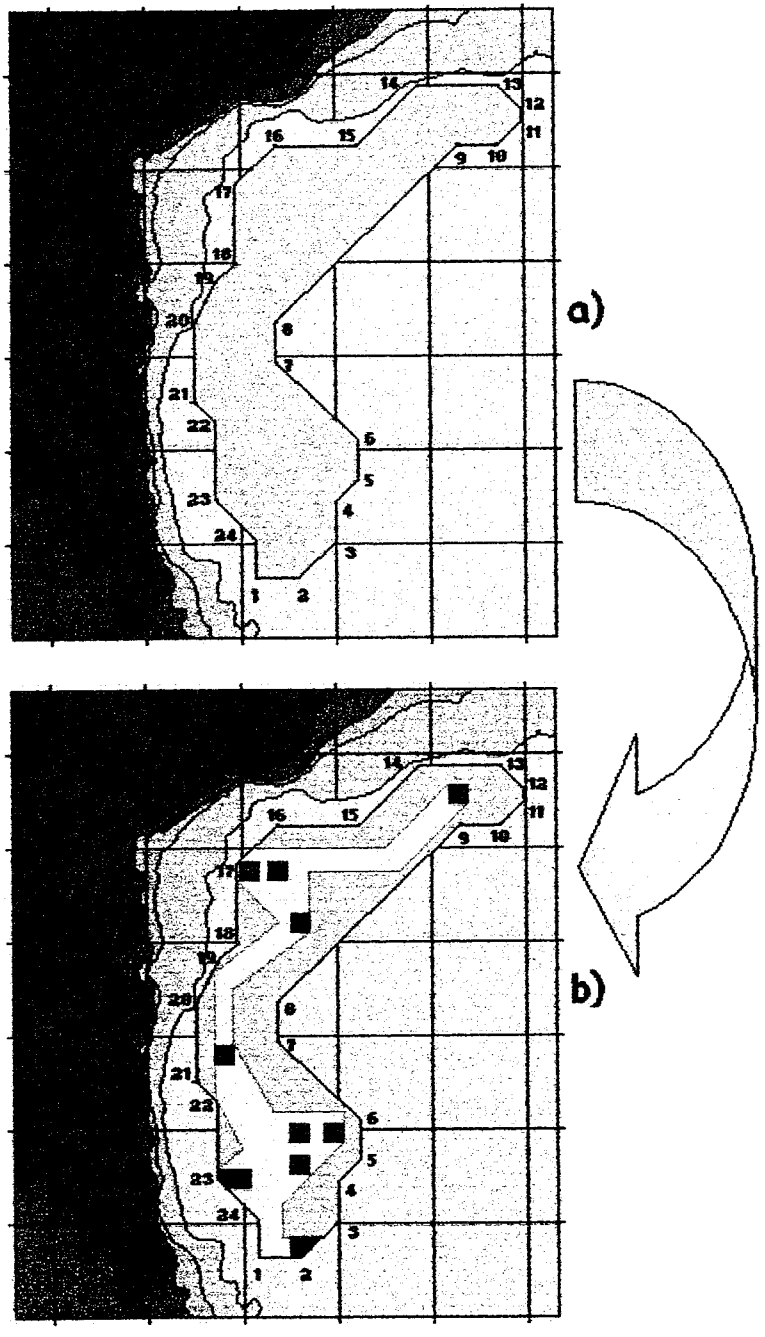

Figura 2 a y b. Poligonal propuesta y coordenadas extremas para el ANP: Arrecifes Coralinos de Campeche.

Superficie Propuesta

Las coordenadas extremas utilizadas en la formación de los vértices del área total propuesta siguieron la isobata de las 28 brazas (51.24 m) y son: hacia el norte 22°15'N-91°10'W, hacia el sur 20°10'N-92°00'W, al este 22°05'-91°05'W y al oeste 21°15'N-92°25'W, con ello se delimitó la poligonal con una área de 12 437 km^2 (Figura 2a). El área propuesta involucra el 9.6% de la Sonda de Campeche, lo cual significaría una área protegida 8.6 veces mayor que la Reserva de la Biosfera de Banco Chinchorro, hasta hoy la más grande en aguas marinas Mexicanas (Torruco et al. 1996). No obstante, debido a los problemas que implicaba en cuanto a la vigilancia y coordinación de sus acciones, así como a la protesta de la CANAINPES por las restricciones a la pesca, fue necesario redefinir los límites con diez áreas núcleo y una área de amortiguamiento que interconecta a todas las áreas, lo que disminuyó considerablemente los conflictos con los sectores pesquero e industrial (Figura 2b).

DISCUSIÓN

Está propuesta planteó un esquema de zonificación de sus áreas arrecifales, con la finalidad de proteger mediante zonas núcleo a la mayoría de los sistemas arrecifales sumergidos, lo que implicó el 37.85 % del total. Está área fue definida considerando sus fronteras con el mar territorial, lo que permitirá una continuidad hacia los arrecifes en sus procesos oceánicos y biológicos, asimismo permitirá establecer normas de utilización concretas en relación a la navegación, transporte de materiales y disposición de desechos, entre otros.

Estás zonas núcleo incluyen los niveles de biodiversidad más altos de estos sistemas arrecifales, además de estar ubicadas en posiciones cercanas a los cayos emergentes, lo cual es una medida necesaria para la recolonización y repoblación de estas zonas, cuyo papel puede ser de amortiguamiento y de utilización más intensa.

La elaboración de un programa operativo eficiente es complejo, ya que debe amalgamar concertaciones con los diferentes sectores que hasta ahora hacen uso de estos sistemas arrecifales, además de identificar sectores de utilización racional. Es por ello, que es indispensable la participación activa y comprometida de todos los sectores interesados en la conservación y aprovechamiento de estas áreas arrecifales. Actualmente, se cuenta con la caracterización, delimitación y zonificación con límites precisos de estos sistemas. No obstante, es de vital importancia seguir con el proceso de su declaratoria e incluirlas en el SINAP, debido a que son zonas con alta biodiversidad y ocupan un lugar importante con respecto a otras áreas protegidas.

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Project Workshop:Institutional Arrangements for Caribbean MPAs and Opportunities for Pro-poor Management

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INTRODUCTION

Marine Protected Areas (MPAs) are seen as a prominent means of addressing coastal resource management issues in the Caribbean. Studies on the impacts of MPAs (which have tended to focus on ecological changes, particularly on abundance and size of fishes) have usually shown them to be positive for biodiversity (Dixon *et al.*, 1993) and fisheries management (Roberts and Polunin 1993, Wantiez et al. 1997). Amongst advocates of MPAs there has been a tendency to extol their potential value in socio-economic terms. In reality, the establishment of protected areas often generates deep resentment in communities that find themselves excluded from resources to which they have traditionally had access, undermining the viability of those protected areas (Horrill et al. 1996). Over the last ten years, management of MPAs has evolved from being a preservation tool to integrating considerations of development, sustainable use of resources and stakeholder participation (Meffe et al. 1997). With this focus, it is believed that they can play a key role in conserving natural ecosystems and contribute substantially to sustainable development (IUCN 1997).

The purpose of the research project *Institutional Arrangements for Caribbean Mpas and Opportunities for Pro-poor Management* has been to identify current institutional constraints to, and development options for, successfully implementing MPAs in a way that leads to a sustained improvement in the livelihoods of poor coastal communities in the Caribbean. A key premise of this work is that successful implementation and beneficial stakeholder outcomes, including outcomes for the poor, are inextricably linked, and priority has been given to understanding the dynamic relationship between processes and outcomes. Particular attention has been paid to systems that include community participation in decision-making to see what benefits this brings to the poorer groups and to understand the structures and processes needed to achieve it.

An initial review of institutional and ecosystem characteristics of 80 MPAs in the Central and Antillean biogeographic zones of the Caribbean took place in 2001 (Geoghegan et al. 2001) and was followed by an analysis of operational and non-operational MPA case studies in Belize, Jamaica, Turks & Caicos Islands and Dominica to investigate factors contributing to successful and unsuccessful outcomes of MPA management. Research at the operational MPA case studies involved evaluation of the impacts of successfully implemented MPA management on poor people's livelihoods and included PA (participatory appraisal) exercises to understand poorer groups' perceptions of MPA impacts. A series of biophysical and socio-economic studies were undertaken by Masters students at the University of the West Indies (UWI) to assess the ecological and socio-economic impact of MPAs. A legal and policy review was also conducted to understand how the external policy environment influences MPA management. The project will culminate with development of guidelines promoting pro-poor management of MPAs.

WORKSHOP OBJECTIVES

This one-day workshop on institutional arrangements for Caribbean MPAs was hosted by MRAG Ltd in association with University of the West Indies (UWI), CANARI, and the Caribbean Conservation Association (CCA) at the 55th Annual Meeting of the Gulf and Caribbean Fisheries Institute (GCFI). The workshop is a key activity of the 18-month research project (#R7976) described above that has been funded by the Natural Resources Systems Programme (NRSP) of the United Kingdom Department for International Development (DFID). There were three workshop objectives, as highlighted below:

i) To disseminate research findings from the case study MPAs;
ii) To verify that the research findings (in terms of what would enable "pro-poor" management of MPAs) are as complete and relevant as possible (through sharing of experience and checking that issues raised by our research are relevant to the wider Caribbean); and
iii) To identify or verify that the means of dissemination and type of Guidelines are relevant and accessible.

WORKSHOP ACTIVITIES

The workshop was limited to 43 participants due to the nature of working group discussions and room space and was divided into four key sessions, as outlined below:

i) Introduction, overview and setting the scene,
ii) Identifying relevance of poverty to MPA management,
iii) Identifying pro-poor opportunities, and
iv) Guidelines for pro-poor management.

After introductions, presentation of project activities and an overview of the 54th GCFI MPA session, the key presentation of Session 1 was a review of Caribbean legal and policy frameworks. This included international and regional legislation and policy as well as national and local legislative and policy arrangements for the MPA case studies (Anderson et al. 2002). Key results from project activities were highlighted during this session (see also Best 2002, Cummings 2002, Francis 2002, O'Sullivan 2002, Richards 2002, Francis et al. in press). Session 2 commenced with a presentation on opportunities and constraints for successfully implementing pro-poor MPAs (Garaway and Esteban 2002) which was based on participatory appraisal fieldwork at four case study MPAs. The participants divided into working groups to focus on identifying pro-poor opportunities in Session 3. The final session started with feedback from the working groups and then focused on the Guidelines for pro-poor management of MPAs.

CONCLUSION

The workshop provided an excellent opportunity for discussion between a wide cross-section of MPA managers, policymakers, researchers, users and other interested parties from 16 Caribbean countries. Discussions focussed on issues raised during presentations and are reported in the Executive Summary from the workshop report (see below). The workshop report is available on www.mragltd.com and is also on the GCFI web site. Feedback on the report, and information on initiatives relevant to issues raised during the workshop, would be very welcome.

EXECUTIVE SUMMARY

(Excerpt from Workshop Report: Esteban et al. 2002)

Background

This one-day workshop on institutional arrangements for Caribbean MPAs was held on 12th November 2002 as a concurrent session at the 55th GCFI Annual Meeting in Mexico. It was hosted by MRAG Ltd in association with UWI, CANARI and CCA. The workshop was one of the final activities within the DFID funded research project *Institutional arrangements for Caribbean MPAs and opportunities for pro-poor management* (NRSP R7976).

The workshop was attended by 43 people, representing 16 countries and 28 agencies. They included MPA managers, fishers, policymakers, donors, NGOs and scientists. The objectives of the workshop were to disseminate research findings, assess relevance of findings to the wider Caribbean and identify means of dissemination.

Research Findings

The workshop focussed on two of the research activities that were seen to be particularly relevant to identifying institutional opportunities for pro-poor MPA management. These included results of a legal and policy review and results from a study investigating the impacts of MPAs on poorer "communities".

Three legal typologies were identified in the legal and policy review: traditional resource conservation laws, *ad hoc* legislation relating to the creation and operation of specific MPAs, and generic regulations providing a framework for the designation of such areas whilst injecting some degree of flexibility into the management arrangements applicable to specific MPAs. Whilst the latter may be a preferred regulatory regime, it is neither sufficient, nor necessary, for achieving operational management of an MPA.

Other factors contributing to operational management were found to include development of systems to implement specific international obligations, rationalization and clarification of governance structures, the articulation and effective operation of area-specific policies to guide administrative action in respect of all activities impacting the protected area, availability and effective deployment of human and material resources, and meaningful community participation.

Where it exists, poverty was identified as a factor that, at the very least, exacerbated management performance and therefore, in these cases, the issue of poverty should be relevant to MPA managers.

Five specific areas were identified as providing opportunities to address needs of poorer user groups, thereby improving management performance and ultimately the natural resource base itself. These areas were:

i) Empowering poorer communities leading ultimately to co-management,
ii) Providing new alternatives,
iii) Improving access to existing ones (in particular tourism),
iv) Improving fishery related livelihoods, and
v) Improving the natural environment (recreation, health and safety).

Results from case studies suggested that, whilst there were many successful initiatives from which lessons could be learned, there was still a lot to do to address the needs of poorer groups, and improvements needed to be made in all areas and relationships that make up MPA management, i.e., relationships between the legal, policy and funding environment, the "service delivery" organisations, community based organizations, and user groups.

Working Group Findings

Five working groups looked at possible areas for improving MPA performance. Priority was given to areas that would do so by improving impacts on poorer user groups. These included co-management and community empowerment, ICZM and legal and policy arrangements for MPAs, funding options, providing alternatives and improving existing ones, and fisher livelihoods.

i) Co-management was seen as a route to addressing needs of poorer groups

but that there was a need to realise that achieving co-management was only the beginning of an ongoing process.

ii) Legislation could have a role in all areas of MPA management, from requiring that local communities have a voice in, and benefit from, MPA management, through to the implementation of international agreements.

iii) Funding was considered a major issue by all, and a significant constraint. New and innovative approaches to "selling the MPA product" were required.

iv) Tourism has substantial potential to provide alternatives and therefore compensate for loss of access to traditional resources. To do this, creative financing and capacity building were crucial.

v) The main identified route to helping fishers was involving them at all stages. There was a need for improved communication, and for an understanding that fishers have the ability to solve their own problems if they were given the opportunity.

Other Points Raised Throughout Workshop

The term "pro-poor" was not favoured and it was felt that it would not be useful in conveying project findings and Guidelines. Indeed, the extent to which poverty reduction should be an explicit objective of MPA management was questioned. Whilst there was agreement that sustainable livelihoods were a component of sustainable management, the emphasis on poverty was not a priority.

Designing areas as Marine Protected Areas as opposed to Integrated Coastal and Marine Management Areas may be a significant design flaw and legal constraint.

The project Guidelines should be developed collaboratively bringing in the experiences of the wide range of participants at the workshop.

ACKNOWLEDGEMENTS

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Presence of Juvenile Blackfin Snapper, *Lutjanus buccanella*, and Snowy Grouper, *Epinephelus niveatus*, on Shallow-water Artificial Reefs

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ABSTRACT

The inshore environment of Broward County, Florida consists of three reef tracts, each separated by sand substrate, running parallel to the coastline in sequentially deeper water. A wide variety of artificial reef designs have been deployed in Broward County, many lying in sand flats between the reef tracts. From 1995 through 2002, over 1,100 visual fish censuses (predominantly point-counts) were completed on the three natural reef tracts in water depths from 3 m to 30 m and over 1,100 censuses were done on artificial reefs at depths of 7 m to 23 m. Curiously, the juvenile stages of two deeper-water species of the snapper/grouper complex, the blackfin snapper (*Lutjanus buccanella*) and the snowy grouper (*Epinephelus niveatus*), appear to prefer artificial reefs located in the sand flat separating the second and third reef tracts to nearby natural reef areas. Five hundred and forty blackfin snapper have been recorded in 64 visual censuses and nine snowy grouper have been observed in seven counts on artificial reefs. Despite the large volume of visual census data collected thus far, these two species have never been recorded on nearby natural reef tracts. The reasons for this unanticipated observation is unclear but it provides an excellent launch-point for an examination of juvenile habitat requirements, natural availability of these requirements, and the potential for artificial substrate to be used in managing these species

KEY WORDS: Artificial reefs, blackfin snapper, snowy grouper

Presencia de Juveniles del Chillo Oreja Negra (*Lutjanus buccannella)* y Mero (*Epinephelus niveatus)* en Arrecifes Artificiales Someros del Sureste de Florida (Eua)

Entre 1995 - 2002, 1100 conteos de peces fueron llevados a cabo en arrecifes natural (3 -30 m de profundidad) en el condado de Broward, Florida. Así mismo, 1100 conteos de peces también fueron realizados en varios arrecifes artificiales (7 - 25 m de profundidad) en la misma área. A pesar de las numerosas observaciones,

buccanella, y mero, *Epinephelus niveatus,* se han registrado solamente en los arrecifes artificiales del area. Estos y parecen preferir habitats artificiales a los arrecifes naturales más próximos. La razón de esta preferencia a aun se desconoce pero puede ser debido a la competencia por recursos a la disponibilidad alimento entre los arrecifes naturales y artificiales.

PALABRAS CLAVES: Arrecifes artificiales, chillo oreja negra, mero,

INTRODUCTION

The blackfin snapper (Lutjanidae), *Lutjanus buccanella,* and the snowy grouper (Serranidae), *Epinephelus niveatus,* are economically important deepwater species along the Atlantic coast in the southeast U.S. (Parker and Ross 1986, Parker and Mays 1998). The high demand for these fish combined with naturally slow growth rates make them extremely susceptible to overfishing. Fisheries data have shown a steady decline in catch for both species since the early 1980s, and the snowy grouper has recently been listed as vulnerable by the International Union for Conservation of Nature and Natural Resources (IUCN) (Matheson and Huntsman 1984, Moore and Labisky 1984, Parker and Mays 1998).

Commercially important deepwater fish species are the least studied of all fish supporting a major fishery (Parker and Mays 1998). To properly assess the habitat characteristics and fish assemblages below a depth of 45 m, costly specialized equipment is needed. The costs associated with this type of research continue to limit the information available on deepwater species (Matheson and Huntsman 1984, Moore and Labisky 1984, Parker and Ross 1986, Parker and Mays 1998).

Many juvenile fish species display ontogenetic habitat shifts with growth, maturing and then migrating to deeper waters (Hixon 1991, Perrson et al. 1997, Lindeman 1999, Nagelkerken 2000, Wilbur 2000). However, little is known about juvenile habitat requirements of many commercially important fish species and possible ontogenetic variations in habitat preference. Fisheries managers need to understand juvenile habitat requirements to ensure the survival of juveniles, which may, in turn, increase adult populations (Able 1999). There are only a handful of publications which provide information on blackfin snapper or snowy grouper (Sylvester 1974, Grimes et al. 1977, Matheson and Huntsman 1984, Moore and Labisky 1984, Acero and Garzon 1985, Parker and Ross 1986, Gutherz et al. 1987, Jones et al. 1989, Cuellar et al. 1996, Dodrill et al. 1993, Bohnsack et al. 1994, Tabash and Sierra 1996, Parker and Mays 1998, Wyanski et al. 2000). Most of these studies describe reproductive patterns, or age and growth of adults caught from recreational or commercial fisheries. No studies have been published concerning the juvenile life history stages of either species. Descriptions of juvenile habitat for these two species have been sketchy at best and have generally been described as shallow hardbottom areas. We examined fish distribution data sets from Broward County, Florida USA in order to gain some insight on the distribution of juvenile blackfin snapper and snowy grouper in this area.

METHODS

The inshore environment of Broward County, Florida consists of three reef tracts (inshore, middle, and offshore), each separated by sandy substrate, running parallel to the coastline in sequentially deeper water (Lighty et al. 2001). A wide variety of artificial reef designs have been deployed in Broward County and many lie on the sand flats between reef tracts. During an eight-year period (1995 to 2002) over 1,100 visual censuses were completed on the three natural reef tracts at water depths from 3 m through 30 m, and well over 1,100 counts on artificial reefs at depths of 7 m through 23 m. The data from these censuses are available elsewhere. Portions of these data have been published in various scientific journals (Gilliam et al. 1995, Sherman et al. 1999, Sherman et al. 2001a,b), gray literature (Spieler 1995a,b, Spieler 1998a,b,c, Spieler 2000), theses and dissertations (Gilliam 1999, Sherman 2000, Jordan 2002), or is archived (Spieler 2002), in manuscript (Baron and Spieler in prep.), or in some combination of the preceding.

The census of natural hardbottom consisted of two studies. Between 1998 and 2002, 751 point-counts (Bohnsack and Bannerot 1986) were completed (Ettinger et al. 2001, Spieler 2002). The counts were taken at the edges and crests of all three reef tracts at 0.463 km (0.25 nautical mile) intervals along the entire Broward County shoreline (35.2 km). The counts were completed throughout the year but predominately during summer months. Also, from June to August 2001, 200 30x2x1 m belt transects, 100 point-counts, and 98 rover diver counts were made in the first 30 m of the nearshore hardbottom of Broward County (Baron and Spieler in prep.).

The artificial reef censuses consisted of five studies from Broward County, Florida. From April 1995 to October 1996 a total of 584 fish surveys were completed on 40 small artificial reefs, Gilliam-Spieler modules (aka fish-condo modules), in 7 m of water (Gilliam 1999). Between March 1995 and October 1996 a total of 144 fish counts on 20 Reefball® modules were performed at depths of 7 m and 23 m (Sherman et al. 1999). From October 1998 to September 2000 a total of 528 fish counts were also completed in the same shallow inshore area (7 m) of Broward County using various spatial arrangements of 30 Gilliam-Spieler modules (Jordan 2002). An additional study, which began in April 2002, has thus far completed 120 fish counts on Reefballs in 13 m of water (Quinn, unpubl. data). These four studies documented fish species, total number of individuals per species, and estimated total fish length (TL) into five size classes (0 - 2, 2 - 5, 5 - 10, 10 - 20, > 20 cm TL). Lastly, an ongoing study censussing the fish assemblages on seven shipwrecks off Broward County has completed 182 visual point-counts over 19 months (Arena unpubl. data). Data were collected from March 2000 to March 2001 and from March 2002 to September 2002. Six ships were censussed four times during the year, two ships each month and four monthly surveys have been completed on the seventh vessel, which was deployed in April 2002. Total abundance, as well as mean, minimum, and maximum size of each species was recorded at each shipwreck site.

RESULTS

Curiously, juvenile stages of two deepwater species, the blackfin snapper and snowy grouper, appear to prefer artificial reefs located in sand flats separating the reef tracts to nearby natural reef areas.

A total of 586 juvenile blackfin snapper individuals (556 on sunken vessels, 30 on small concrete artificial reef modules) have been recorded in 86 visual censuses and a total of eight juvenile snowy grouper has been recorded in seven counts (Table 1). Although these are not overwhelming numbers, especially for snowy grouper, no individuals of either species have been recorded in fish counts on nearby natural reefs. The majority of blackfin snapper juveniles (95 %) have been recorded on sunken vessels. Snowy grouper juveniles are more evenly dispersed between artificial reef types, but have been seen more often on the small concrete modules (three on sunken vessels and five on small concrete modules).

Table 1. The abundance and size class of snowy grouper. RB = Reefball SV = Sunken Vessel

Date (mo/yr)	Reef Type	N	Size Class (cm)
7/1995	RB	1	5-10
9/1995	RB	2	5-10
11/1995	RB	1	2-5
8/1996	RB	1	2-5
10/2000	SV	1	10-20
1/2001	SV	1	10-20
5/2002	SV	1	10-20

Blackfin Snapper

The minimum size class observed for blackfin snapper on concrete modules was 2-5 cm. The smallest fish observed on a ship was a 4 cm individual, found on a newly deployed vessel. The maximum size observed for blackfin snapper was 40 cm, this was not typical and was observed for only one fish on a sunken vessel. The mean size of blackfin snapper observed on ships was 19 cm. The largest size class observed on the smaller artificial reef modules was >20 cm. The highest abundance of blackfin snapper on ships was found from September to December 2000 (Figure 1). From January to March 2001 the largest mean sizes of blackfin snapper on ships were recorded (Figure 2). Ninety percent of all individuals on ships were between 15 cm and 30 cm and of these fish 60 % were from 15 - 20 cm. The most common size class for the smaller artificial reefs was 5 - 10 cm.

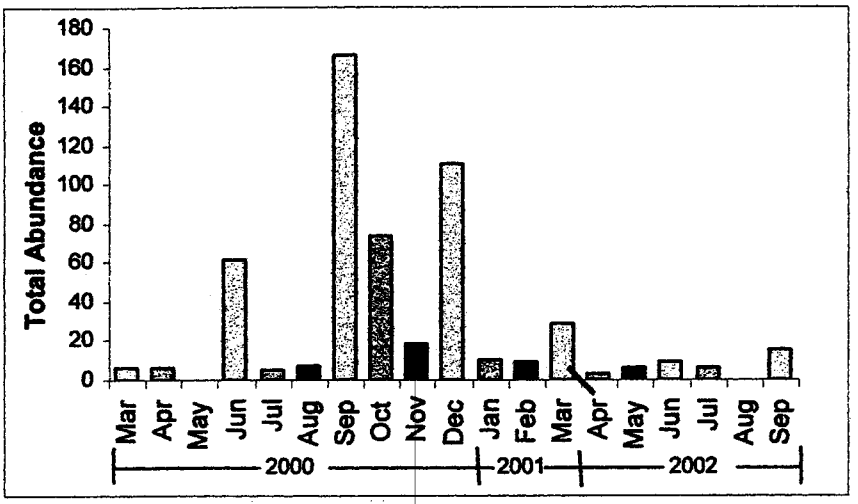

Figure 1. Blackfin snapper monthly abundance on a pair of ships. Bar shades indicate one of three specific pairs of ships, which were censused repeatedly. The oblique line after March 2001 indicates a gap in data collection.

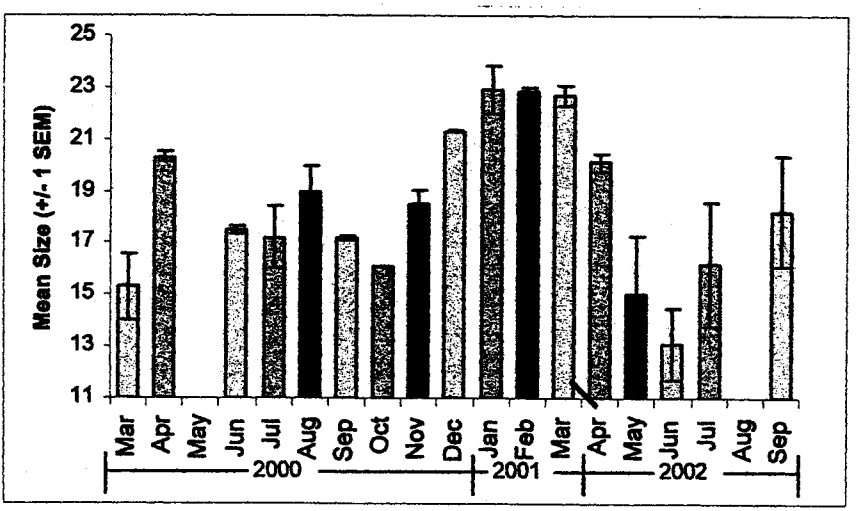

Figure 2. Blackfin snapper monthly mean size (+/- 1 SEM) on a pair of ships. Bar shades indicate one of three specific pairs of ships, which were censused repeatedly. The oblique line after Mar. 2001 indicates a gap in data collection

Snowy Grouper

The minimum size recorded for snowy grouper was 10 cm on a sunken vessel and the 2 - 5 cm size class on the Reefballs. The maximum size observed was 12 cm on a sunken vessel and the 5 - 10 cm size class for the Reefballs. The largest number of individuals seen in any one count was two individuals on the Reefballs (Table 1).

DISCUSSION

The presence of juvenile blackfin snapper and snowy grouper on artificial reefs and their apparent absence from surrounding natural reefs is an unexpected and important observation. This one-sided distribution may be an indication that the artificial structures supply these species with ancillary, possibly unique, nursery/juvenile habitat in water depths of less than 30 m. The importance of juvenile nursery areas to fisheries populations is well established. Many studies have been conducted in commonly known nursery habitats, such as mangroves and seagrasses (Austin 1971, Thayer et al. 1987, Sedberry and Carter 1993). Recently, shallow reefs and nearshore hardbottom areas have also been shown to have nursery potential, and it is now clear that biotope utilization can be very specific for individual species and size classes (Lindeman 1997, Nagelkerken et al. 2000, Wilbur 2000). It has been suggested that juvenile associations with habitat may be based on avoidance of predators, abundance of food, and interception of larvae (Nagelkerken et al. 2000). The presence of the blackfin snapper and snowy grouper on artificial reefs suggest these habitats meet at least some of these criteria.

Blackfin Snapper

Ontogenetic habitat shifts of juvenile fish to intermediate life stage habitats with increasing size have been recorded for many species (Leis 1987, Hixon 1991, Lindeman 1997, 1998, Nagelkerken et al. 2000, Wilbur 2000). Based on the size distribution data of the blackfin snapper, they seem to be utilizing artificial habitats (primarily sunken vessels in 21 - 23 m of water between the middle and offshore reef tracts) as an intermediate or secondary nursery habitat. The majority of blackfin snapper on vessels were in the 15 - 30 cm size range. It appears these fish may be settling elsewhere and when reaching a certain size (approximately 15 cm) they move onto sunken vessels.

Smaller individuals (< 10 cm) were recorded on a recently deployed vessel and smaller artificial reef modules at a depth of 21 - 23 m, as well as on Reefballs on the sand terrace of the middle reef tract in 13 m of water. The sand flats between reef tracts, as well as the sand terrace of the second reef tract, contain small sections of hardbottom and an abundance of small rubble and shell debris patches (authors, personal observation). These structures may be providing microhabitat areas for settling fish. Lindeman (1999) indicates that Lutjanids settle near interfaces of hardbottom structure and sand; this may be the case for settling blackfin snapper as well. The rapid appearance of these smaller juveniles to newly deployed artificial

reefs in sand flat areas may be an indication of their presence nearby before reef deployment.

Specific habitats where the juvenile blackfin snapper are settling is still in question, but data collected thus far clearly indicates recruitment of these individuals to artificial reefs at sizes around 15 cm and residency until reaching a larger size (20 - 40 cm). The upper size limit may be related to sexual maturity. Past studies have shown blackfin snapper reach sexual maturity at sizes from 20 - 40 cm (Sylvester 1974, Thompson and Munroe 1974, Grimes et al. 1977, Boardman and Weiler 1980, Froese and Pauly 2002). Blackfin snapper may, therefore, be utilizing the artificial reefs as intermediate nursery habitat, growing to maturity and then migrating to deeper waters.

The data show a high abundance of juvenile blackfin snapper on sunken vessels during winter months (Sep. - Dec. 2000) (Figure 1). There is also an increase in mean size of juveniles toward the end of this period and in subsequent months (Figure 2). This decrease in abundance with increasing mean size may be due to predation, fishing mortality or migration of these larger juveniles/sexually mature adults to deeper waters. Bohnsack and coauthors (1994) found a similar peak in abundance of juvenile blackfin snapper (mean size 4.3 cm) from August to December 1988, on small artificial reef modules in 10 - 12 m of water off Miami, Florida.

The reasons for the association of juvenile blackfin snapper with artificial reefs could involve a number of factors. Lutjanids are known to be voracious predators of newly settled fish (Hixon 1991). Colonization of newly deployed artificial reefs is a rapid process and newly settled juvenile blackfin snapper may benefit from increased food resources as juvenile fish settle to this vacant habitat (Gilliam et al. 1995, Gilliam 1999, Sherman 2000). By reducing foraging distances juvenile blackfin snapper may be conserving energy and maximizing growth (Stephens and Krebs 1986).

Predator susceptibility is another factor that may be structuring the spatial distribution of this species. The artificial reef habitats are all located on sand flats between reef tracts and previous studies have revealed lower predation risks at small distances (< 25 m) away from the reef (Shulman 1985). This habitat may be reducing predation risks because of its off-reef locality.

In addition, artificial reef siting may reduce foraging distances for the blackfin snapper, thereby increasing feeding efficiency and ultimately growth rates. Snappers are known to spend the day on reef and forage among sand flats nocturnally (Leis and McCormick 2002). Providing habitat close to food resources increases the optimal value of the habitat (Stephens and Krebs 1986).

Deep habitat may also be a factor to consider when trying to understand juvenile distributions of this species in Broward County. The continental shelf of southeast Florida is extremely narrow and drops off quickly to great depths (Chiappone 1996). This deep environment appears to be mainly low-relief habitat with an abundance of fine sediment areas and there seems to be a small percentage of suitable habitat (hardbottom ledges and cliffs) for blackfin snapper (Ken Banks, personal comm.).

Juveniles may be utilizing the shallow artificial environment due to the limited availability of deeper juvenile habitat and increased competition with adults as space requirements overlap (Jones et al. 1989, Hixon 1991).

The apparent absence of blackfin snapper and snowy grouper on shallow natural reefs and their presence on artificial reefs at depths less than 30 m does not appear to be restricted to Broward County. In a study to the south of Broward in Dade County, Florida, 462 fish counts were completed on small artificial reefs and 83 counts on nearby natural reefs (Bohnsack et al. 1994). Blackfin snapper and snowy grouper were observed settling on artificial reef sites at depths of 10 - 12 m, but none were recorded on natural reefs. The authors reported that juvenile blackfin snapper did well and grew at these sites before disappearing, which they suspect was due to an ontogenetic migration to deeper water. Another study in the Florida Keys which censused natural reef fish assemblages off Monroe County, Florida observed one blackfin snapper from a total of 6,673 surveys (Bohnsack et al. 1999). The REEF (Reef Environmental Education Foundation) database was also accessed to compare blackfin snapper distributions (REEF 2002). Their data show all observations of blackfin snappers in Broward County were at artificial reef locations. Interestingly, contrary to Broward, Dade, and Monroe Counties, REEF's database indicates Palm Beach County had an even distribution of blackfin snapper on natural and artificial reefs. The natural reef locations were described as high profile reefs. However, a preference for high profile reefs does not adequately explain the differences in distribution, as there are also high profile areas in Broward, Dade, and Monroe Counties.

Snowy Grouper

Although juvenile snowy groupers were seen less frequently and in lower abundances than the blackfin snappers, they too were only seen at artificial reef sites. Juvenile snowy groupers were observed at several size classes, but no individuals were larger than 12 cm. There appears to be some similarity in habitat selection between juvenile and adult snowy grouper. The larger juveniles (10 cm - 12 cm) were all observed near sunken vessels. All the juveniles seem to prefer two artificial reef types: Reefballs and rock/coral covered burrows near sunken vessels. Both of these artificial reef habitats are similar in structure to reported natural adult habitats. Adults have been reported from deeper areas in habitat consisting of irregular sized boulders (Matheson and Huntsman 1984, Parker and Ross 1986, Gutherz et al. 1987, Parker and Mays 1998). Thus, Reefball structure may be similar to these adult habitats. Groupers (Serranidae) are heavily dependent on habitat structure due to their sedentary behavior (Leis 1987). Reefball complexity may increase the feeding efficiency of the juvenile snowy grouper, aiding in its ambush style feeding behavior (Dodrill et al. 1993). Also, fish settling to these small artificial reefs are presumably easy prey for a juvenile grouper, which may increase available food resources.

Adults, as well as one juvenile have been observed utilizing blueline tilefish (Malacanthidae), *Caulolatilus microps*, burrows as habitat in deeper waters (Parker

and Ross 1986, Jones et al. 1989). Similarly, all juvenile snowy grouper on the shallow sunken vessels were observed near burrows in the sand covered by a small rock or coral head and would retreat into the burrow when a diver approached. Adults have also been reported to utilize wreck habitats in deeper waters on the upper continental shelf and slope (Dodrill et al. 1993). The presence of adult and juvenile snowy grouper on sunken vessels may be related to natural habitat preferences, as the vertical relief provided by vessels (~10 m) is comparable to the relief found near natural adult habitats (Parker and Ross 1986, Dodrill et al. 1993, Parker and Mays 1998).

CONCLUSION

The fish census data collected thus far in Broward County on natural and artificial reefs represents a baseline of fish populations for the region. It is clear that blackfin snapper and snowy grouper juveniles prefer artificial substrate to that which is naturally available. The reasons for this unanticipated fact are unclear but provide an excellent launch-point for an examination of juvenile habitat requirements, natural availability of these requirements, and the potential for artificial substrate to be used in managing these species.

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The Significance of Adjacent Habitats on Reef Fish Assemblage Structure: Are Relationships Detectable and Quantifiable at a Landscape-Scale?

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ABSTRACT

Shallow tropical marine habitats are being degraded at an alarming rate and new science-based approaches are needed to reverse this trend in order to ensure their long-term conservation. Landscape ecology principles, though rarely tested in marine systems, have proven extremely useful in addressing "real-world" management issues in terrestrial systems. In fact, the successful design and management of many terrestrial reserves is largely dependent on insights gained from the application of landscape-level analyses. Tropical coral reef ecosystems, which exist as a complex mosaic of interacting habitats, e.g., fringing reefs, surrounding seagrass patches and mangrove stands, may be well suited for study using a landscape ecology approach. We explored the utility of two terrestrially proven landscape metrics; a measure of adjacent habitat diversity and measures of the areal coverage of critical adjacent habitats, to predict specific characteristics of reef fish assemblage structure. Adjacent habitat diversity was not a good predictor of total fish abundance or of species richness. However, the areal coverage of specific habitat types, seagrass in particular, was positively related to the abundance of several groups of commonly exploited fishes. Preliminary results suggest that this approach might be used to facilitate the design of marine protected areas, and thus will be of interest to a broad group of marine ecologists and resource managers.

KEY WORDS: Marine Protected Areas, seagrass habitat, coral reef fishes

La Significación del Habitat de Seagrass a las Ensambladuras de los Pescados del Arrecife Coralino: ¿Son los Efectos Perceptibles y Cuantificables en una Escala del Paisaje?

Al decidir a donde localizar las áreas protegidas marinas (MPAs), es esencial que los encargados de recurso entienden cómo su funcionamiento se pudo influenciar por el arreglo de los habitat interior y exterior sus fronteras. Hacia este extremo, un acercamiento de la ecología del paisaje fue probado en St. Juan, islas de la Virgen de los E.E.U.U. para del como los medios de predecir > los hotspots = la abundancia de los pescados del filón y diversidad en una escala apropiada el diseño de MPA y gerencia. Los mapas recientemente desarrollados, digitales usados para cuantificar la distribución espacial del mosaico complejo de los habitat asociados con arrecifes (e.g., arrecife, camas de los seagrass, mangles) eran la fundación para desarrollar un espacial-estratificado y análisis robusto para estudiar estadístico la relación entre los parámetros seleccionados de la ensambladura de los pescados del filón y características del habitat traz de imágenes aéreas. Específicamente, deseamos determinarnos si los habitat adyacentes tales como el área total de los seagrass adyacentes o en proximidad cercana a los arrecifes se puedan utilizar para predecir parámetros de la ensambladura de los pescados del filón. En veinte arrecifes discretos (10 que franjan y el remiendo 10), seleccionados basado en un gradiente del punto bajo al alto grado regional de seagrass, las cuentas visuales al azar-generadas del punto de los pescados del filón fueron conducidas. Los resultados preliminares apoyan nuestras hipótesis generales que la riqueza y la abundancia totales de la especie, tan bien como la estructura de la abundancia, de la diversidad y del tamaño de la especie apuntada, es decir, roncos, groupers y snappers, crecientes con el grado regional (m^2) de seagrass adyacente al filón remiende. La fuerza de esta relación creciente como el grado regional de seagrass en cuatro distancias de los arrecifes del estudio (es decir, 100, 250, 500 y el 1000 m) aumentó. Los resultados finales son probables confirmar la importancia de los acoplamientos del habitat entre los seagrass y las comunidades del filón coralino, proporcionando la justificación científica para la inclusión del habitat de los seagrass en MPAs para proteger la conectividad del habitat requerida para diversas etapas de la historia de la vida de los pescados del filón.

PALABRAS CLAVES: Las áreas protegidas marinas, habitat de los seagrass, el filón coralino pescan.

INTRODUCTION

The management of tropical marine environments calls for radical large-scale approaches that require collaboration beyond traditional fields (Murray et al.1999, Allison et al. 1998, Bell et al. 1997). Landscape ecology is interdisciplinary by nature, with a focus on patterns and ecological processes that occur over broad spatial scales (Forman and Godron 1986). A landscape refers to a heterogeneous area composed of interacting ecosystems (Forman 1995) made up of homogenous units called habitat patches. Habitat patches can differ in their size and structure with consequences on the distribution and abundance of species. The spatial arrangement (i.e. pattern) of habitat patches within the landscape, in turn, influences the function of that landscape, particularly with regard to the flow of energy through interacting ecosystems and among habitat patches. Through the use of georeferenced maps of vegetation, soils and elevation, terrestrial landscapes have been described with a number of metrics that incorporate such attributes as patch size, shape, and/or habitat complexity (Forman 1995, Turner 1989). Landscape metrics quantify large-scale habitat patterns and can be used to more fully understand ecological processes and, in some cases, predict responses such as dispersal success (Gustafson and Gardner 1996, Schumaker 1996), abundance (McGarigal and McComb 1995), distribution (With and Crist 1995), and survival probability (Fahrig 1997) of organisms.

Several landscape metrics have proven to be of value in the design and management of terrestrial reserves (e.g., Simberloff 1986; Diamond 1975; MacArthur and Wilson 1967) and similar metrics might be used to guide the development and implementation of marine protected areas (MPAs) in shallow tropical waters, especially if the responses of reef fishes to varying "seascapes" can be predicted with some degree of confidence. Until recently, we lacked the technology to test landscape ecology principles in marine systems. However, advances in subtidal mapping techniques provide the opportunity to explore the relationship between habitat patterns and species distribution (e.g., Irlandi et al. 1995, Robbins and Bell 1994, Bell and Hicks 1991). Coral reef environments exist as complex mosaics of interacting ecosystems (e.g., patch reefs, seagrass communities, sand, and fringing mangroves), which make them logical candidates for large-scale habitat-based conservation strategies (e.g., MPAs) (Wilkinson 2000, Allison et al. 1998).

Large-scale measures of habitat diversity have been positively correlated with terrestrial species richness and abundance of birds, butterflies, reptiles and amphibians (Ricklefs and Lovette 1999, Rosenzweig 1995, Rafe et al. 1985) and with more complex trophic structures (Rahbek and Graves 2001) in virtually all terrestrial ecosystems (Huston 1979), proving useful in selection of conservation reserves. Spatially and temporally diverse areas are considered superior to homogenous areas (Meffe and Carroll 1997), in part because the species-area relationship is thought to be related to habitat diversity. As size of an area increases, so does the diversity of habitat types (Lack 1976, Williams 1943). Although landscape-scale measures of habitat diversity have yet to be tested in coral reef

ecosystems, fine-scale studies have demonstrated a positive relationship with reef fish diversity and abundance and habitat heterogeneity, measured by parameters such as spatial complexity (Hixon and Beets 1989), living coral (Reese 1981), coral reef zonation (Friedlander and Parrish 1998), and reef surface area (Gladfelter et al. 1980).

This study is one of the first to explore the utility of landscape ecology principles as predictors of species distribution and abundance in coral reef environments. Existing reef fish census data made available through the Virgin Islands National Park, St. John, United States Virgin Islands (USVI), were used to examine the relationship of landscape metrics that describe the spatial distribution of benthic habitats with reef fish assemblage parameters of interest to resource managers. Two questions were addressed:

i) Is habitat diversity, at the landscape-scale, a good predictor of the abundance or richness of reef-associated fishes? and

ii) Are landscape-scale metrics of the areal coverage of specific habitat types (e.g., measures of the area of seagrass or hard-bottom) predictors of abundances of reef fishes within trophic guilds and/or specific taxa of reef fishes?

To validate the use of the existing reef fish data, a separate *heterogeneity* study was conducted in 2002 to ensure that our dataset did not violate assumptions inherent to a landscape ecology approach.

METHODS

Existing reef fish monitoring data from St. John, USVI was used to explore the relationship of large-scale measures of habitat diversity and the areal extent of specific habitats with reef fish assemblage structure parameters of interest to resource managers. Of 20 reef fish monitoring sites available, only 11 reefs with similar characteristics, i.e. depth, reef morphology, and dominant live coral (*Montastraea annularis*), were selected for further analysis to reduce variability associated with reef characteristics and to enhance the ability to detect variation associated with landscape features (Figure 1). Reef fish monitoring sites were determined to be sub-sections of larger mapped reef polygons. To account for the possible bias of sampling a section of a larger mapped polygon, reef polygons were modified using ArcView 3.2 to reflect the standardized 25,000-m^2 sub-sections where fish data were collected (ESRI 1996). In addition, a heterogeneity study was conducted in 2002 to determine whether reef fish assemblage structure differed between reef sections and entire polygons. Several precautions helped ensure assumptions inherent to a landscape ecology approach were not violated. First, landscape metrics were calculated with respect to polygon sections where fish data were collected. Second, the areal extent of reef (including adjacent reef) and original reef polygon size were tested as habitat variables. Third, since patch dynamics are predicated on assumptions of similar patch shape, a paired sample T-

test was used to test whether the Perimeter to Area ratio (P: A) of the reef sections differed significantly from the P:A ratio of original polygons (Zar 1984).

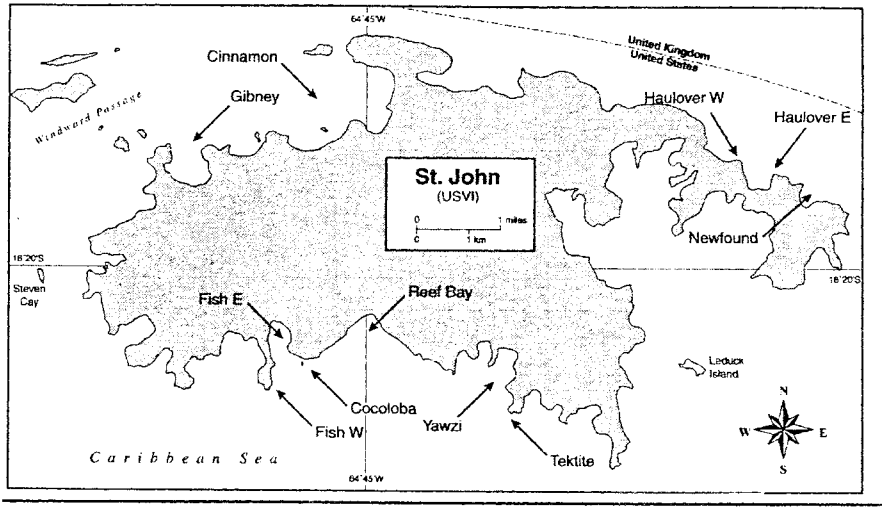


Figure 1. Location of 11 study reefs around the island of St. John, United States Virgin Islands.

Landscape metrics were calculated with ArcView 3.2 software (ESRI 1996) using benthic habitat maps created from aerial photographs acquired in 1999 (Kendall et al. 2001). The original map classification scheme (see Kendall et al. 2001) was condensed from 27 to 9 distinct and non-overlapping habitat classes, i.e. mud, mangrove, sand, reef, hard-bottom, bedrock, seagrass, macroalgae and deep water, to be more broadly applicable for resource managers. Reefs served as focal units, since MPAs are typically designed around individual reefs. A buffer was placed at 100 m (to include the daily range of most reef fishes) from the leading edge of the reef. Buffer shape files and the modified benthic habitat maps were intersected to quantify landscape metrics for each reef (Table 1).

Reef-associated fishes were sampled in 1994 (Beets and Friedlander, unpubl. data) using a modified point count census method (see Bohnsack and Bannerot 1986). The modification involved a reduction in the sample radius from 7.5 m to 5.0 m. In 2002, reef-associated fishes were sampled using the originally described point count method (see Bohnsack and Bannerot 1986). During both data collection efforts, standard lengths of fishes were estimated to the nearest cm. Mean abundance values based on replicate samples at each reef site were calculated and used in subsequent analyses, whether by taxa or trophic guild. Randall (1967) and FishBase (2002) were used as references to classify fishes as either piscivores, herbivores, mobile invertebrate feeders (MIFs), sessile invertebrate feeders (SIFs), planktivores or omnivores. Taxonomic groupings of fishes for commercially and recreationally important species were also examined. Fishes were further subdivided into juvenile and adult categories.

Table 1. Landscape metrics, habitat diversity and areal coverage (ha) of major habitat types, within 100 m of each reef. Areal coverage of mud and mangrove were not included as these habitats were largely absent at the 11 study sites.

	Newfound	Cinn	Cocco	Haul E	Haul W	Gibney	Tektite	Yawzi	Reef W	Fish E	Fish W
Reef size	9.33	7.86	6.92	9.33	7.48	0.54	5.57	4.06	6.92	15.74	10.95
Habitat diversity (H')	0.48	0.41	0.54	0.44	0.67	0.23	0.59	0.43	0.56	0.61	0.47
Reef	10.38	12.0	5.2	8.58	3.67	0.82	3.16	3.20	3.09	4.41	3.69
Seagrass	0.97	0	4.37	0	1.02	5.46	3.16	7.81	1.78	0.31	0
Hard-bottom	9.87	9.24	8.29	12.14	4.98	1.07	5.59	5.34	8.89	7.98	6.52
Bedrock	0.16	0	1.75	0	0.75	0	2.53	1.07	0	3.56	2.83
Sand	0	0	0	0	3.98	0	0	0	6.03	2.22	4.54
Macro-algae	< 0.01	3.42	0	0	0	0	0	0	0	1.48	< 0.01
Deep-water	2.02	0	0	3.91	1.98	0	1.92	0	0	0	0

Habitat Diversity

To test the hypothesis that landscape-scale habitat diversity (H') is a positive predictor of entire assemblage parameters, a modified Shannon-Weiner index (Krebs 1989) was employed using the following equation:

$$H' = - \Sigma p_i \log p_i \text{ (eq. 1)}$$

where the proportion of area of each habitat type i within 100 m of the focal reef is summed for all habitat types. For each 25,000 m^2 reef section, at least 16 modified point counts per replicate reef were located haphazardly in July 1994, using the same five observers. Simple linear regression was conducted using the reef fish parameter of interest as the dependent variable (e.g., species richness, total abundance) and habitat diversity (H') within 100 m as the independent variable.

Adjacent Habitats

To test hypotheses that landscape metrics that quantify the areal coverage of a specific habitat are positive predictors of abundances of reef-associated fishes by taxa or within trophic guilds, stepwise multiple regression analyses was conducted. The areal coverage of the seven major habitat types within 100 m of each reef was used as independent variables for each of the dependent reef fish variables. P-values for accepting a variable into the model was set at $p < 0.15$ to reduce Type II error. Results of stepwise multiple regression analyses were used to test simple linear regression relationships between habitat types and reef fish assemblage parameters accepted into the stepwise regression model.

Heterogeneity Study

To ascertain the validity of using the existing 1994 dataset, random reef fish samples were conducted in 2002 at the two largest monitoring reef sites, i.e. Newfound Reef (93,300 m^2) and Coccoloba Reef (69,200 m^2). Each polygon contained two monitoring sites (e.g., Newfound polygon is comprised of Newfound and Haulover East, Coccoloba polygon has Coccoloba Reef and Reef Bay). Each polygon was redigitized in ArcView and divided into three sections at Coccoloba Reef and four sections for Newfound Reef, of approximately equal sizes to determine whether there were significant differences in reef fish abundances between different, but approximately equal-sized sections of a single mapped reef polygon. Differences in reef fish parameters between reef sections and entire polygons were tested using a Poisson Chi-square statistic with a 0.05 level of significance.

RESULTS

Habitat Diversity (H')

Simple linear regression analyses revealed no detectable relationship between H' and entire assemblage level parameters (e.g., species richness and total

reef fish abundance) (Table 2, Figure 2). H' values ranged from 0.23 to 0.67 for the 11 reefs, but this intermediate range in variability of H' may have constrained a more robust analysis (Figure 2). There was a negative relationship between H' and mean abundance of juvenile herbivores and SIFs (Table 2, Figure 3). There was a statistically significant, negative relationship between H' and juvenile serranids, juvenile haemulids and juvenile scarids (Table 2, Figure 4). There was no statistically significant positive relationship for any reef fish assemblage level parameter of interest (e.g., entire assemblage level parameters, trophic guilds or commercially and recreationally important taxa, except a weak positive relationship with mean abundance of juvenile piscivores) with landscape-scale measures of H' at this scale (Table 2).

Table 2. Results of linear regression analyses indicating the relationship between habitat diversity and reef fish assemblage parameters. Parameter estimates for statistically significant ($p < 0.15$) regressions are given.

Fish parameter	R^2	p-value	Parameter estimate
Total abundance	<0.01	NS	
Species richness	0.03	NS	
J SIF	0.57	<0.01	-4.96
A SIF	0.10	NS	
J herbivores	0.35	0.06	-43.53
A herbivores	0.04	NS	
J MIF	<0.01	NS	
A MIF	0.009	NS	
J piscivores	0.29	0.08	18.71
A piscivores	<0.01	NS	
J serranids	0.37	0.04	-2.95
A serranids	0.00	NS	
J haemulids	0.44	0.03	-55.24
A haemulids	<0.01	NS	
J lutjanids	0.01	NS	
A lutjanids	0.04	NS	
J scarids	0.26	0.11	-53.25
A scarids	0.04	NS	
J acanthurids	0.06	NS	
A acanthurids	0.09	NS	

NS = Not Significant; SIF = Sessile Invertebrate Feeders; MIF = Mobile Invertebrate Feeders; J = Juvenile; A = Adult

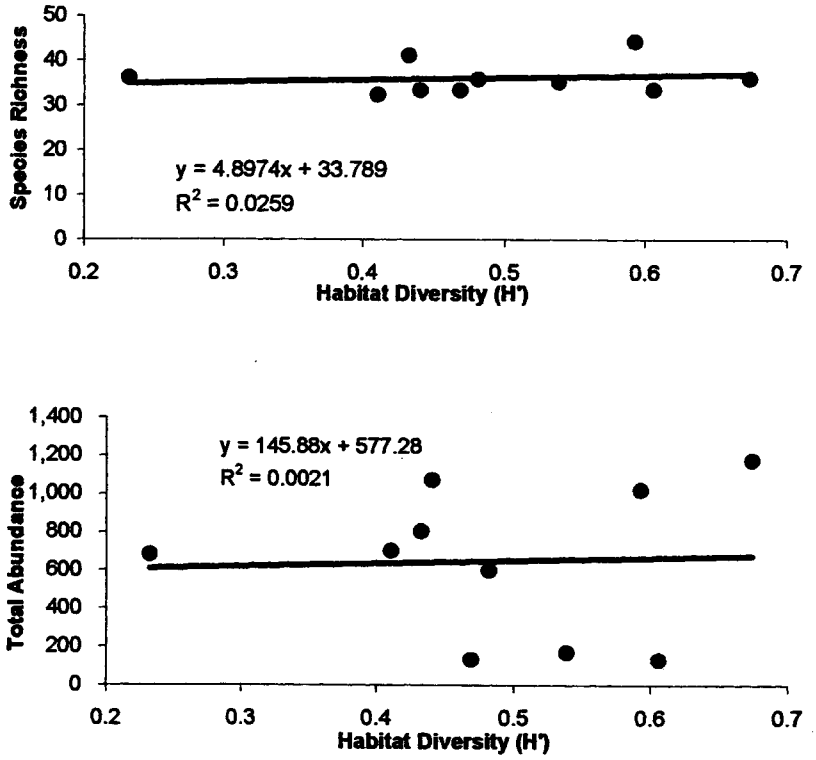
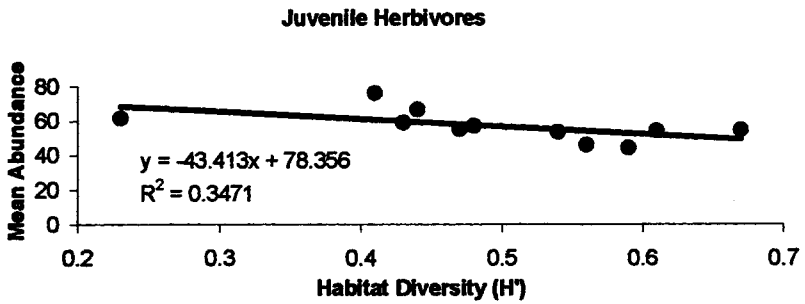
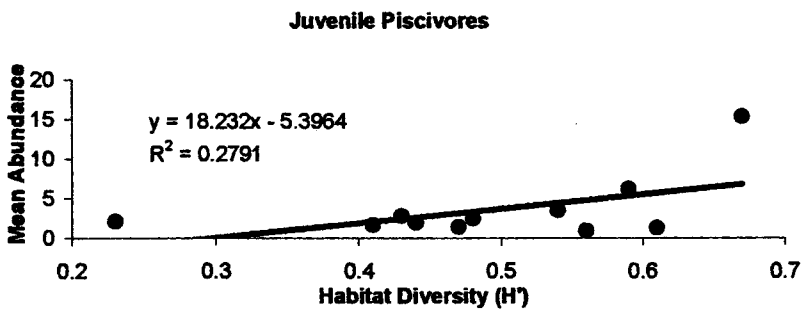


Figure 2. Relationship of habitat diversity (H') within 100 m of study reefs (n=10) and species richness and total fish abundance at St. John, United States Virgin Islands.





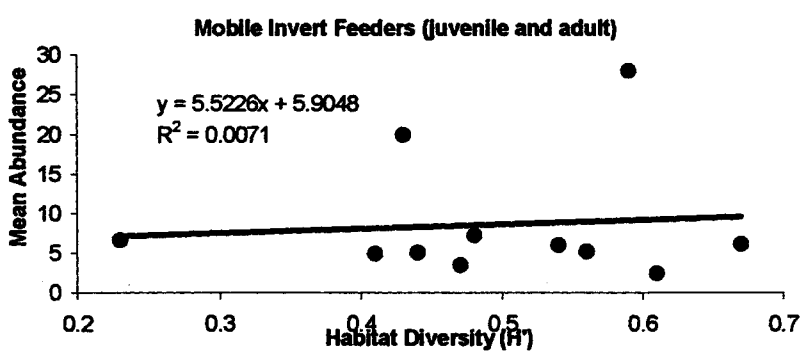


Figure 3. Simple linear regression results of habitat diversity (H') within 100 m and mean abundance within trophic guilds, divided into juvenile and adult components, sampled on 11 reefs around St. John, United States Virgin Islands.

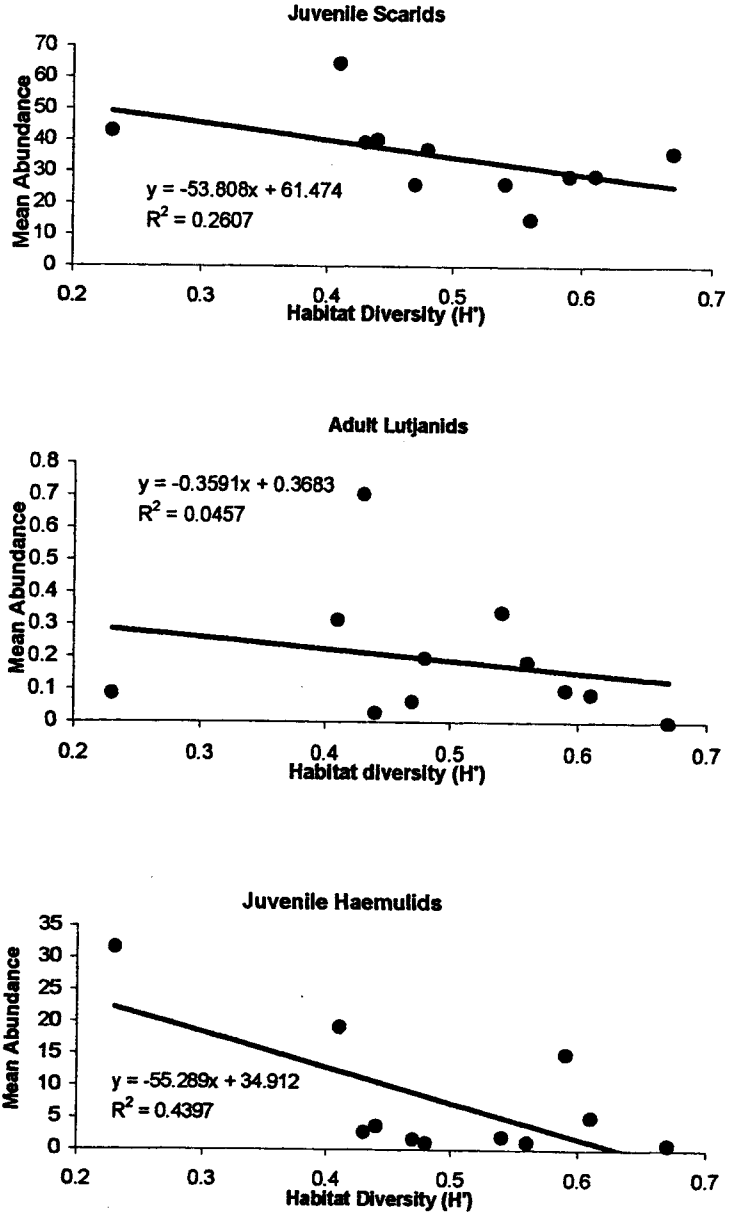


Figure 4. Simple linear regression results of habitat diversity (H') within 100 m and mean abundance within taxonomic groupings, divided into juvenile and adult components sampled on 11 reefs around St. John, United States Virgin Islands.

Adjacent Habitats

Stepwise multiple regressions revealed positive relationships between reef fish assemblage parameters (e.g., total abundance and species richness) with landscape-scale measures of the areal coverage of surrounding habitats (Table 3, Figure 5). Entire assemblage parameters were positively correlated with the total areal coverage of seagrass within 100 m (Table 3). Adult MIFs were positively correlated with the areal coverage of seagrass (Table 3). In addition, some taxonomic groups that we predicted based on their life history to be associated with seagrass habitat, were positively correlated with areal coverage of seagrass, including adult serranids, adult haemulids, and adult lutjanids (Table 3, Figures 5 and 6). Juvenile lutjanids were positively correlated with areal coverage of seagrass and deep-water habitats and juvenile serranids were positively correlated with areal coverage of reef habitat (Table 3). To check for spurious correlations, we verified that there were no relationships between specific taxa and habitats for which a relationship was not expected (e.g., SIFs and seagrass). For statistically significant multiple regression parameters, linear regressions illustrate relationships (Figures 5 and 6).

Heterogeneity Study

There were no statistically significant differences for entire assemblage level or trophic level measures when comparisons were made between entire reef polygons and reef sections (i.e. the historic monitoring sites). However, at Newfound Reef, there were significant differences in mean abundance of lutjanids, haemulids, scarids and labrids between reef sections (W and/or E) and the entire reef polygon (A); there were no statistically significant differences for other reef sections (Table 4). At Coccoloba Reef, only haemulids were found to differ in abundance between reef sections (Table 5). Reef shape, as reflected by the P:A ratio, was not significantly modified as a consequence of standardizing reef area ($t = 4.23$, $df = 10$, $p = 0.77$).

DISCUSSION

Habitat Diversity

A strong experimental approach to reef fish ecology has historically resulted in studies at a small spatial scale (e.g., meter plots), leading reef ecologists to conclude that habitat diversity (defined by various measures of benthic community structure, complexity and reef rugosity) is a predictor of reef fish assemblage structure (Sale 2002, Hixon and Beets 1989, Reese 1981). Our empirical results suggest that, contrary to predictions, habitat diversity as a predictor of reef fish assemblage structure may not scale up at the landscape level (i.e. 100's of meters scale). Therefore, landscape-scale measures of habitat diversity may not prove useful in discerning the value of individual reefs as candidates for protection. In fact, there was frequently a negative relationship between habitat diversity within 100 m and abundances of specific trophic guilds and taxa. We note, however, that at an even larger spatial scale (e.g., at the scale of tens of kilometers), NOAA's Biogeography

Team has demonstrated a positive relationship between reef fish diversity and abundance and habitat diversity (J. Christensen, NOAA, pers. comm.). This larger scale measure of habitat diversity, however, appears to be useful in that it predicts the location of reef habitat (where reef habitat exists is typically the highest abundance and diversity of reef-associated fishes).

Table 3. Results of stepwise multiple regression analyses. Input variables consist of each of the habitat types: hard-bottom, reef, bedrock, seagrass, macroalgae, sand, deep-water and mud, which occur within 100 m of each reef. Parameter estimates for statistically significant ($p > 0.15$) regressions are given. All parameter estimates are positive except where indicated by a negative sign in parentheses.

Fish parameter	R^2	p -value	Habitat estimate
Total abundance	0.16	0.02	Seagrass
Species richness	0.42	<0.01	Seagrass
J SIF	0.79	<0.01	Bedrock (-) Hard-bottom
A SIF	0.88	<0.01	Reef Hard-bottom (-)
J herbivores	0.56	0.04	Hard-bottom Reef
A herbivores	—	—	
J MIF	—	—	
A MIF	0.31	0.07	Seagrass
J piscivores	—	—	
A piscivores	—	—	
J planktivores	0.65	0.05	Reef Bedrock Deep-water
A planktivores	0.55	<0.01	Deep-water
J serranids	0.42	0.03	Reef
A serranids	0.34	0.06	Seagrass
J haemulids	0.47	0.08	Reef Hard-bottom
A haemulids	0.44	0.02	Seagrass
J lutjanids	0.95	<0.01	Seagrass Deep-water Bedrock (-)
A lutjanids	0.69	<0.01	Seagrass
J scarids	0.77	<0.01	Hard-bottom Reef
A scarids	—	—	—

SIF = Sessile Invertebrate Feeders; MIF = Mobile Invertebrate Feeders; J = Juvenile; A = Adult

Table 4. Results from Newfound Reef to determine whether there was a statistically significant difference in the mean abundance of target taxa between the entire reef polygon (A, n = 33) with the subsections (West, n = 14 or East, n = 14) of the reef used in subsequent analyses. Deviations from a Poisson distribution were tested. Mean abundance and standard deviations, given in parentheses, are presented for each polygon. For labrids, only two species were included for analyses, the numerically dominant species *Thalassoma bifasciatum* and *Halichoeres bivittatus*

Taxa of Interest	Entire Polygon	Mean Abundance	Sub-section	Mean Abundance	SE	Pr. Chi-Square
lutjanids	A	1.77 (3.13)	E	0.71 (1.93)	0.3040	0.0029
	A	1.77 (3.13)	W	2.93 (4.34)	0.1830	0.0075
serranids	A	0.82 (0.98)	E	0.53 (0.72)	0.4300	0.2343
	A	0.82 (0.98)	W	0.71 (0.91)	0.3458	0.6561
haemulids	A	6.19 (25.86)	E	1.24 (2.66)	0.2241	0.0001
	A	6.19 (25.86)	W	16.00 (53.44)	0.0841	0.0001
scarids	A	19.05 (9.53)	E	22.29 (12.68)	0.0590	0.0001
	A	19.05 (9.53)	W	16.21 (7.44)	0.0725	0.1481
labrids	A	6.08 (5.67)	E	4.76 (6.21)	0.1225	0.0712
	A	6.08 (5.67)	W	8.50 (6.59)	0.1051	0.0008

Several factors may have affected our ability to detect relationships between landscape-scale measures of habitat diversity and reef fish assemblage structure parameters as defined in this study. The range in habitat diversity values, for example, may have been too restricted and not representative of the relationships across a broader range of values. In addition, fish censuses were conducted only within reef habitat. As a consequence, we only tested the influence of adjacent habitat diversity on a select assemblage of fishes, i.e. only those fishes directly associated with reef habitat during the day. It is possible that fine-scale measures of microhabitat heterogeneity (e.g., topographic complexity, benthic community composition such as the percent cover of specific algal and coral taxa, and reef morphology) within the reef habitat may be the more appropriate scale for describing and/or predicting measures such as total abundance and total species richness of benthic reef-associated fishes (see: Williams 1991). It is possible also, that our specific definition of landscape habitat diversity may not be the appropriate descriptor of the surrounding seascape, and may not capture elements such as the patchiness of discrete habitat patches, the types of different habitats or the spatial arrangement of those patches with respect to the focal reef. Finally, although a single index such as H' is appealing, it does not distinguish the functional benefits

of different habitat types (e.g., additional reef habitat versus sand which may be important foraging areas for goatfishes or grunts).

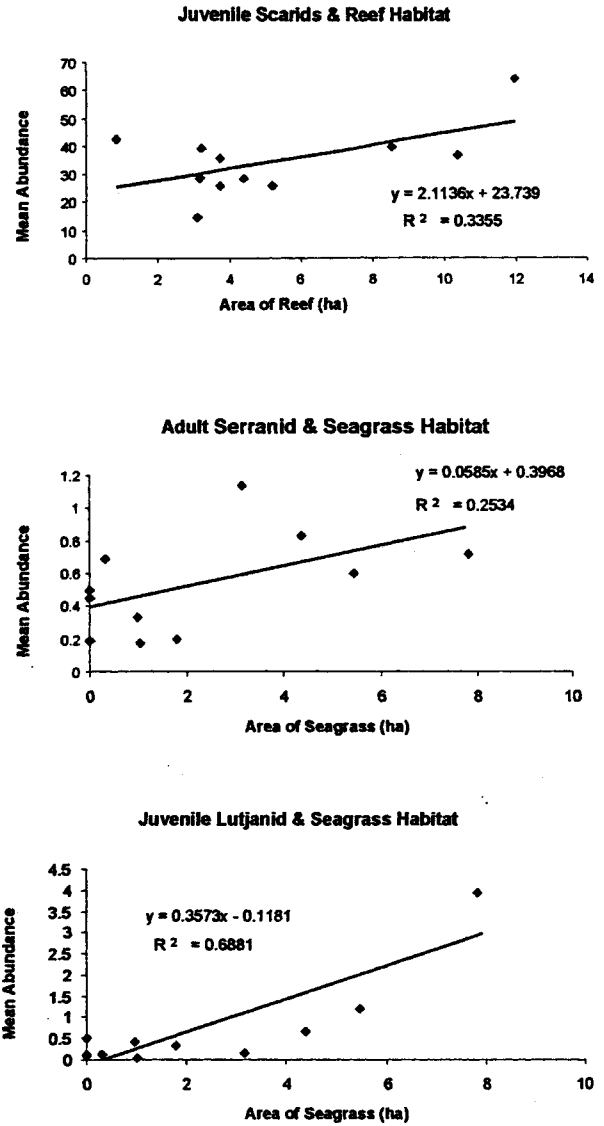


Figure 5. Linear regression results of reef fish parameters that that were statistically significant in stepwise multiple regression analysis with areal coverage of specific habitat types sampled on 11 reefs around St. John, United States Virgin Islands.

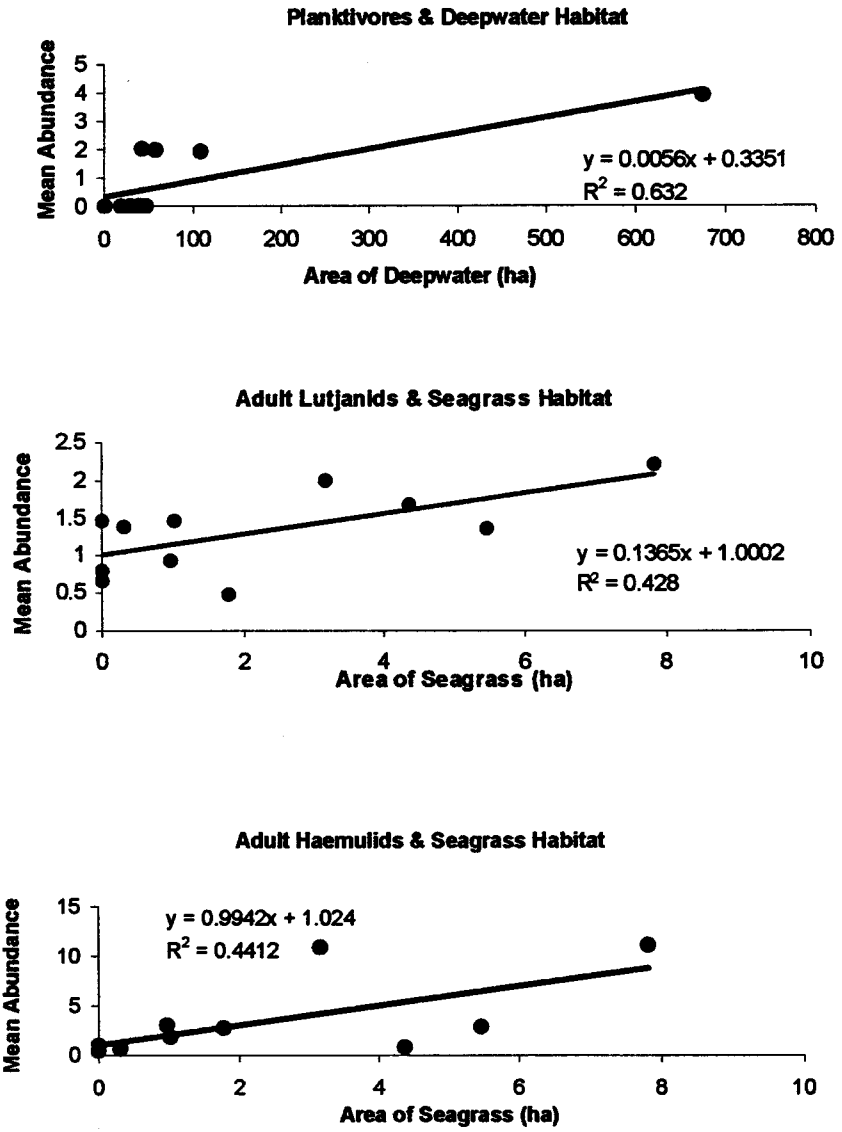


Figure 6. Linear regression results of reef fish parameters that that were statistically significant in stepwise multiple regression analysis with areal coverage of specific habitat types sampled on 11 reefs around St. John, United States Virgin Islands.

Table 5. Results from Coccoloba Reef to determine whether there was a statistically significant difference in the mean abundance of target taxa between the entire reef polygon (A; n=33) with the subsections (West; n=14 or East; n=14)of the reef used in subsequent analyses. Deviations from a Poisson distribution were tested. Mean abundance and standard deviations, given in parentheses, are presented for each polygon. For labrids, only two species were included in analyses, the numerically dominant species *Thalasssoma bifasciatum* and *Halichoeres bivittatus.*

Taxa of interest	Entire polygon	Mean Abundance	Sub-section	Mean Abundance	Standard Error	Pr Chi-Square
lutjanids	A	2.15 (3.51)	E	2.86 (4.04)	0.1977	0.1634
	A	2.15 (3.51)	W	2.21 (3.42)	0.2153	0.8716
serranids	A	0.55 (0.75)	E	0.50 (0.76)	0.4454	0.8451
	A	0.55 (0.75)	W	0.29 (0.47)	0.5528	0.2421
haemulids	A	5.36 (18.86)	E	11.79 (28.25)	0.1082	0.0001
	A	5.36 (18.86)	W	0.57 (0.76)	0.3615	0.0001
scarids	A	9.36 (5.04)	E	10.36 (4.73)	0.1007	0.2028
	A	9.36 (5.04)	W	8.5 (4.45)	0.1079	0.3045
labrids	A	28.21 (18.17)	E	23.86 (15.71)	0.0638	0.1499
	A	28.21 (18.17)	W	24.57 (8.17)	0.0631	0.5972

The negative relationship with H' for many taxa, however, suggests that single habitat types (e.g., essential habitats) may be better predictors of abundances of taxa associated with a particular habitat during some portion of their life histories. For instance, proximity of deep-water habitat may enhance the abundance of larvae recruiting to a reef. The amount of hard-bottom habitat adjacent to a particular reef may provide foraging habitat for schools of roving scarids, thereby allowing a reef to support higher abundances of these fishes. Bellwood and Wainwright (2002), for example, have suggested that non-reef areas are important for many fishes, both evolutionarily and ecologically. In this landscape-scale study, the amount and proximity of different non-reef habitat types (deep-water, seagrass communities, hard-bottom) to study reefs was frequently correlated with abundances of taxa associated with specific habitat types.

Adjacent Habitats

Historically, the context of a reef within the surrounding seascape has been largely ignored. Moreover, the relative importance and functional contribution of habitats adjacent to reef structures has been little studied (Sale 2002). Specific

habitat types (e.g., seagrass) are preferred by reef fishes for off-reef foraging or as settlement habitat. Moreover, these habitat preferences may change with ontogeny (Ogden 1998, Shulman and Ogden 1987). Though H' was not a consistent predictor of reef fish assemblage structure at these particular reefs, specific taxa were frequently correlated with those habitats for which an association was expected; particularly seagrass with adult haemulids, lutjanids and serranids. Tropical seagrass beds are important nursery and feeding grounds for coral reef fishes (Shulman and Ogden 1987, Ogden and Zieman 1977), critical habitats for larval settlement (Shulman and Ogden 1987, Ogden and Zieman 1977) and a source of food (e.g., benthic invertebrates) for some species of coral reef fishes (Randall 1963). The proximity of deep-water habitat was also positively associated with juvenile abundances of several taxa, which may suggest the importance of having a larval supply proximal to reef habitat. The total abundance of planktivores was also correlated with the areal coverage of deep-water habitat, perhaps due to the availability of plankton in the water column. Previous studies have demonstrated the relationship between planktivorous fishes and deep-water, although never before at this scale. Allen (1975) found that plankton feeding species of the damselfish genus *Chromis* were largely restricted to outer reef slopes, while Goldman and Talbot (1976) demonstrated that the proportion of plankton feeders was 2-4 times that of benthic invertivores on outer slopes of reef and suggested that this may be related to the greater availability of food due to strong currents. In our study, the areal coverage of hard-bottom and reef habitat was positively associated with sessile invertebrate feeders, such as pomacanthids, which forage on sessile invertebrates associated with hard-bottom habitat such as sponges and herbivores, which forage on algal species that colonize hard-bottom habitat. Our results are suggestive of the potential ecological importance of specific habitats at a landscape-scale. However, the relationships between individual habitat types and the abundances of taxa and life history stages suspected to be associated with these habitat types need to be more fully explored.

If critical habitats can be identified and quantified at a landscape-scale, then fisheries resource managers may use this information to help define characteristics of successful MPAs. Simberloff (1986) warned that the unwarranted focus on the supposed lessons of island biogeography theory detracted scientists away from the focal task of refuge planning, determining the critical habitats for the species of interest to resource managers and determining how to maintain them. Results from this research suggest the potential utility of landscape-scale measures of habitat to predict assemblage level parameters of interest to resource managers. Further experiments are needed to understand the functional linkages between specific habitats and their associated taxa. Understanding the effects of specific habitats and the arrangement of these habitats on abundance, movement, and growth of specific taxa is essential as we strive to manage these complex ecosystems.

Heterogeneity Study

Island biogeography theory assumes patches (or islands) are internally homogeneous and of equal size and quality, and that patches are either equally accessible to dispersing individuals or dispersal is restricted to adjacent patches (MacArthur and Wilson 1967). Analyses of the heterogeneity study reported herein confirm that reef polygons are not internally homogeneous; rather, there is within-patch heterogeneity, which is perceived by some taxa and not by others. For the purposes of this study, however, the 1994 reef fish dataset proved useful to explore the relationship of landscape metrics to reef fish assemblage structure. Future investigators that might employ a landscape approach are advised to representatively sample entire polygons to alleviate concerns or issues of within patch heterogeneity.

CONCLUSIONS

Habitat diversity, defined at a spatial scale on the order of 100's of meters, does not appear to be a positive predictor of entire assemblage level parameters of reef fishes in St. John, US Virgin Islands. The influence of specific and possibly essential habitat types on reef-associated fishes, however, may be detectable and quantifiable at a landscape-scale. The areal coverage of seagrass, hard-bottom, reef and deep-water habitats were positively correlated with the trophic guilds and taxa for which an association would be expected. The utility of landscape-scale habitat measures require further testing to determine whether they can predict abundances of trophic guilds and different life history stages of taxa, where prior ecological knowledge predicts an association with a particular habitat. The challenge will lie in testing the generalities of these initial findings with empirical datasets across systems..

The processes that structure reef fish communities occur across multiple spatial scales, and are influenced by both stochastic and density-dependent factors. Ecologists are increasingly looking at data from larger spatial and temporal scales to provide a framework for interpreting local patterns and small-scale experimental results (Bellwood and Wainwright 2002). This shift in scale is, in part, a response to the current degradation of coral reef communities, which calls for management-oriented research at spatial scales appropriate for resource managers (Sale 2002). The recent development of benthic habitat mapping technologies has provided an opportunity to study coral reef processes at large spatial scales. It is important, however, to determine whether state of the art mapping products are useful for decision making, specifically for designing and managing MPAs. If the benefits of essential fish habitats are both detectable and quantifiable at a landscape-scale, then benthic habitat mapping products may be used to delineate the boundaries of new MPAs or to better understand how an existing MPA functions. Our research contributes to the development of an emerging discipline, which will help understand both the benefits and the limitations of our state of the art mapping products and help resource managers apply this technology more appropriately.

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Biological Evidence of Diminished Nursery Capability in Discovery Bay, Jamaica

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ABSTRACT

The protected waters of mangrove lined estuaries are considered nursery grounds for many important fisheries species. In the US Virgin Islands settlement rates of *Panulirus argus* pueruli on Witham collectors are much higher in near shore estuarine habitats than those placed in off shore oceanic waters. In Discovery Bay, Jamaica, settlement of pueruli and recruitment of other organisms was higher on the exposed fore reef than in the estuarine waters. The lack of pueruli and the low recruitment of other organisms on collectors within the protected waters of the Discovery Bay estuary may be a function of habitat degradation. While much attention is given to over fishing around Discovery Bay, degradation of the near shore nursery habitat of Discovery Bay is seldom considered a major factor in the decline of local fisheries.

KEY WORDS: Nursery grounds, lobsters, recruitment, Discovery Bay, Jamaica

Evidencia Biológica de la Reducción en la Capacidad de Criadero en la Bajía Discovery en Jamaica

Las aguas protegidas y los estuarios delineadas con manglares son considerados como áreas de criadero de muchas especies importantes de peces. En las islas Vírgenes de los Estados Unidos la taza de sedimento de *Panulirus argus* pueruli en los colectores Witham son altas en los habitáculos estuarianos en aguas someras en comparación a los que son puestos en áreas mar afuera. Deposición de sedimentos en el área delantera y expuesta del arrecife en la Bajía Discovery era mas alta que en las aguas estuarinas de la Bajía Discovery. La ausencia de pueruli en los colectores dentro de las aguas protegidas del estuario en la Bajía Discovery pueden ser una función de la degradación de habitáculo. Mientras se le da mucha atención a la sobre pesca en los alrededores de la Bajía Discovery, a la degradación de los habitáculos en las áreas de criaderos en las aguas someras se le da poca consideración como un factor major en la reducción o decline en la pesca.

PALABRAS CLAVES: *Panulirus argus*, áreas de criadero, la Bajía Discovery, Jamaica

INTRODUCTION

The sea grass meadows, mangroves and protected waters of sheltered bays and lagoons are considered to be the nursery grounds for Caribbean fish (Ogden and Gladfelter 1982, Ogden and Quinn, 1984) and lobsters (Hunt et al 1990, Little 1997, Quinn and Kojis 1997, Quinn et al. 1998, Kojis et al. in press).

The western Atlantic lobster, *Panulirus argus* (Latreille 1804), is commonly caught by Discovery Bay, Jamaica fishermen in wire mesh traps (termed "pots") set on or adjacent to a coral reef. This study examined the abundance of lobster pueruli and other motile organisms recruiting to pueruli collectors placed in the fore reef of the Discovery Bay Barrier reef and on reefs within Discovery Bay. We hypothesized that there would be no difference in settlement at sites within Discovery Bay and at sites outside the bay.

METHODS

Site Description

Discovery Bay is located on the north coast of Jamaica. The middle of the bay is 55 m deep with shallow reefs on the western and along portions of the eastern side of the bay. In the northeast quadrant of the bay, there are sea grass meadows (Gayle and Woodley 1998). A shipping channel was dredged in 1964 to increase the entrance channel depth from 5 m to 12 m to allow for large bauxite bearing ships to leave Port Rhoades in Discovery Bay. Although there is no permanent river flowing into Discovery Bay, fresh groundwater does continuously enter the bay through deep cracks in the basement limestone. This reduces the salinity throughout the bay.

Sampling Design

Puerulus settlement of the western Atlantic spiny lobster, *Panulirus argus*, was sampled using modified Witham collectors identical to those used in Quinn and Kojis (1997) and Kojis et al (in press). Sites were chosen within the sheltered waters of Discovery Bay at Columbus Park (18°28.00'N.; 77°23.62' W.) and Blue Hole (18°28.04'N.; 77°23.64'W.) and outside the bay at Dairy Bull (18°28.07'N.; 77°23.63.00'W.) and M1 (18°28.12'N.; 77°25.00'W.) (Figure 1). The collection sites were inside a Marine Protected Area that existed from 1996 to 2000 (Woodley et al, in press). Collectors were set ~ 3 m above a sandy substrate in water 10 – 14 m deep near coral reefs. From April 2001 to November 2002, the collectors were sampled periodically. All motile animals were removed from the collector, identified and counted.

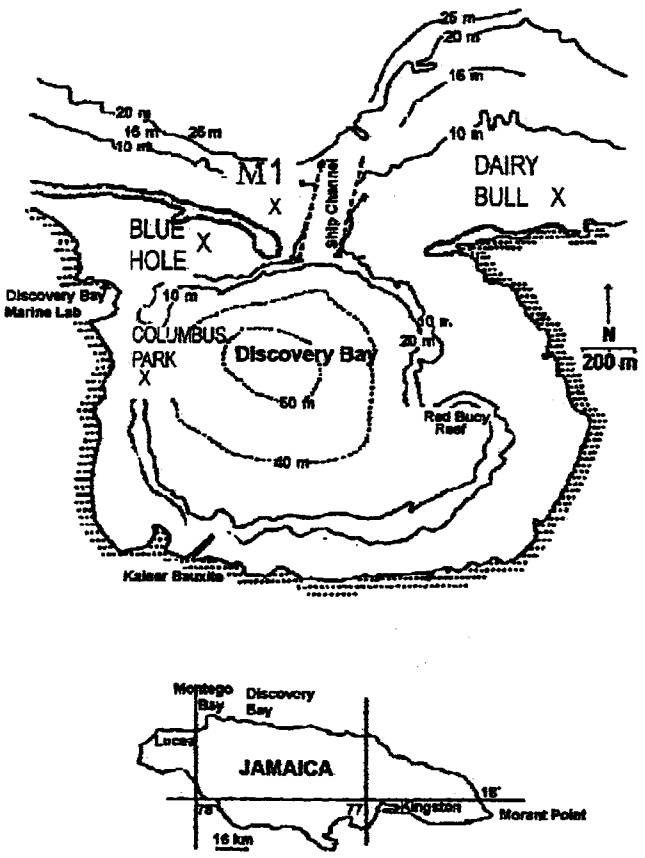

Figure 1. Map of Jamaica and sampling sites around Discovery Bay.

RESULTS

No pueruli were caught at the two sites inside the bay. Also, the abundance of other species recorded was low. The mean number of individuals of all species per sampling date (MID) (19.4 animals; n = 8; C.V. = 32 %) and total number of species caught (S) (11 species) was the lowest at the Columbus Park site inside Discovery Bay (Figure 2). The collector at this site was so laden with red muddy slit after a couple weeks that it could not be supported by the float. Visibility at this site was commonly < 4 m. Although the water is slightly clearer at the Blue Hole (~ 6 m visibility) and the muddy silt was not present, the number of animals was only slightly greater (45.3 animals; n = 10; C.V. = 24 %) and 24 species.

All pueruli were caught either at Dairy Bull (12 pueruli) or at M1 (17 pueruli), outside the bay. M1 also had the greatest species diversity with a MID of 61.4 animals (n = 12; C.V. = 41 %) and a total of 37 species (Figure 2). Dairy Bull had a MID of 52.1 individuals (n = 10; C.V. = 51 %) and 31 species.

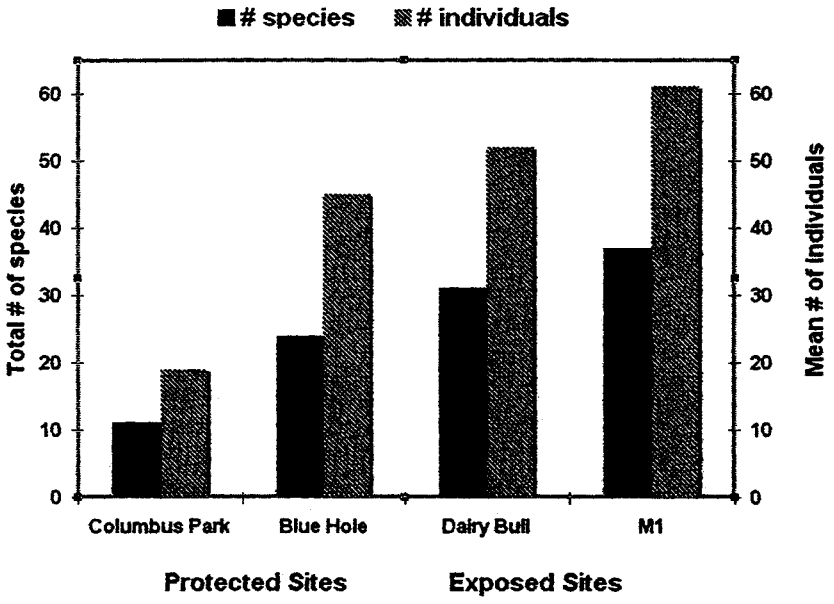

Figure 2. Comparison of mean number of individuals and total number of species settled in Discovery Bay sites.

DISCUSSION

The absence of pueruli within the bay was unexpected. In St. Thomas, US Virgin Islands 83% and 74% of the settled pueruli in 1993 and 1999, respectively, were caught in sheltered waters (Figure 3) (Quinn and Kojis, 1997; Kojis et al. in press). As pueruli have been shown to be more abundant in near shore Caribbean habitats (Olsen et al 1975, Heatwole et al. 1992, Little 1997) we suggest that the lack of pueruli settlement within Discovery Bay and the low abundance of other organisms on collectors is the result of increased sediment and nutrient loading resulting in degraded nursery habitat.

Birkeland (1997) observed that human activities have been affecting coral reefs and tropical coastal ecosystems much more than was generally recognized. Many studies have demonstrated that sediments and accompanying nutrients are one of the greatest threats to coral reefs (Johannes 1975, Hatcher et al. 1989, Rogers 1983,

1990, Hallock et al. 1993). In Queensland, the fluvial discharge rates from the coastal rivers is four times greater now than before humans began altering the drainage basins through deforestation and farming. Presently, approximately four times as much sediment, nitrogen, and phosphorus enter the Great Barrier Reef lagoon than before western agriculture began (Brodie 1995).

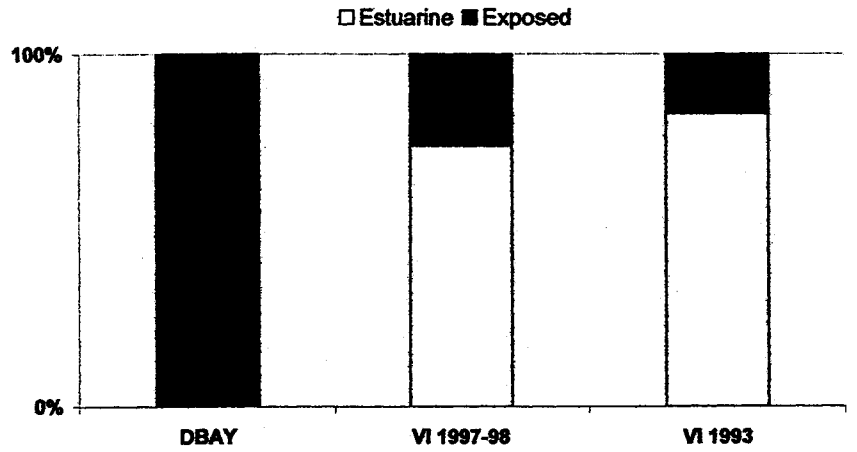

Figure 3. Comparison of percentage of pueruli caught in Discovery Bay with the US Virgin Islands (Quinn and Kojis 1997, Kojis et al. in press).

Many reefs near human population concentrations in the Caribbean (Rogers 1985), the Florida Keys (Jaap 1984), Bermuda (Dodge and Vaisnys 1977) and the U.S. Virgin Islands (Hubbard et al. 1987) have become degraded by sedimentation and nutrient input. No study makes that association with reefs near Discovery Bay. However, the ecological consequences of land based nutrient input to coral reefs communities in the Negril Marine Park have been studied (LaPointe and Thacher 2001). Negril and Ocho Rios have higher nitrogen and phosphorus concentrations than Discovery Bay (Greenaway pers. comm.)

The sea grass community (*Thallasia testudinum*) in the bay is not characteristic of a pristine oligotrophic bay and clearly shows signs of anthropogenic disturbance primarily through reduced light levels and increased nutrient levels (Bramwell 2000). Discovery Bay is impacted by sediment from the bauxite loading facility in the bay. During dry, windy periods bauxite is blown onto the bay waters and surrounding vegetation and ground. During heavy rains this is washed into the bay and impacts the sea grass community and coral reefs by direct contact and indirectly through reduced light levels.

Although Woodley et al (in press) reported that the reefs within Discovery Bay were in good condition until Hurricane Allen in 1980, Bonem (1975) reported in the early 1970s that the substrate at Red Buoy Reef was composed of carbonate sediment with varying amounts of skeletal debris – primarily *Halimeda* plates and

the reef was dominated by *Halicona* sponges. Hermatypic corals characteristic of shallow, clear Jamaican reefs such as *Dendrogyra cylindrus, Acropora plamata, Siderastrea radians* and *Diploria* spp. among others, were not present. The large amount of suspended sediment affected and limited coral diversity in the bay by reducing light penetration and by direct contact (Bonem 1975). Today a fine muddy substrate is characteristic of Bonem's Red Buoy reef site and the western shore of the bay by Columbus Park.

Wapnick et al. (2002) asserted that the branching stag horn coral, *Acropora cervicornis*, essentially dominated the Columbus Park reefs continuously prior to the 1980s similar to the present lagoonal reefs of Belize (MacIntyre et al. 2000). Wapnick et al. (2002) extracted cores from the Columbus Park reef, and are examining whether the transition from the acroporid coral to a macroalgal dominated community is unique on a centennial or millennial scale. They consider that it is likely that these reefs are currently exhibiting a community structure unique in the past several thousand years caused by extreme levels of both human and natural disturbance.

It has generally been accepted that the Jamaican north coast shallow coral reef fish stocks have been over-exploited (Roberts 1995, Woodley et al. in press). This recognition is largely due to the over three decades of research on the reefs of Discovery Bay and resulting numerous publications which have documented the fish stocks (Munro 1983, Aiken and Haughton 1987, Sary 2001, Sary et al. in press). The massive algal overgrowth of the coral reefs near Discovery Bay, which resulted in a severe loss of the biodiversity and disruption of the ecosystem, is considered "one of the worst cases known" (Munro 2001). This environmental change was initiated by the die off, thought to be caused by a virus, of the black long spined sea urchin (*Diadema antillarum*) in 1984 and exacerbated by the lack of herbivorous fish present to control the algal growth (Hughes 1994).

Watson and Munro (in press) found that the larval supply of commercially important fish species was far lower off the West Fore Reef of Discovery Bay than at any site in the British Virgin Islands. Together with the observations from the wire mesh traps set for juvenile fish, Watson and Munro (in press) observed that the larger high-valued species of snappers, grunts and jacks have almost disappeared from the Discovery Bay ecosystem.

Recruitment of juveniles is recognized as a major determinant of community structure in marine ecosystems (Doherty and Williams 1988, Harrison and Wallace 1990). We hypothesize that the low number of adults of many species is the result of low recruitment brought about by the degradation of nursery habitat on the north shore of Jamaica.

While much attention is given to over fishing around Discovery Bay, degradation of near shore nursery habitat may be an important contributing factor to the decline of fisheries (Rogers 1985, Nagelkerken 2000). We suggest monitoring water turbidity and sedimentation levels to document their contribution to habitat degradation and mitigating non-point source pollution are necessary steps to begin to improve the nursery habitat of Discovery Bay and increase spiny lobster

and fish populations.

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The Use of Fish Traps in Puerto Rico: Current Practice, Long-term Changes, and Fishers' Perceptions

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ABSTRACT

Traps are used extensively by artisanal fishers in the Caribbean for catching fishes and crustaceans in diverse habitats. An interdisciplinary study incorporating fisher knowledge and quantitative field surveys was employed to study current trap fishing practices in Puerto Rico in order to provide up to date information to managers and researchers. Here, we report on trap fishing methods today and fishers' perception of current trends and some problems affecting the resource of Puerto Rico. Forty-seven trap fishers representing 5 regions (North, South, East, West, and Islands) were interviewed on site about gear construction, effort, habitat preferences and fishers' perceptions of the main problems in the fishery and their possible solutions. Materials used in fish trap construction have been changing, over time; however, the main routine for setting traps remains generally the same with some localized variations. Despite its traditional dominance, more than half of fishers have reduced their number of traps; therefore individual effort seems to be declining. Coral reefs were not reported as a preferred fish trap location, but rather areas adjacent to reefs (sand, seagrass, hard-bottom, and algal habitats) are targeted. The main problems reported by fishers in Puerto Rico are trap loss and habitat degradation, problems that correspond to increasing coastal development. Additionally, conflicts among users have promoted the use of unbuoyed traps, which in turn may lead to an increase in ghost fishing impacts. Ghost traps are known to continue fishing long after they are lost and may be causing undetermined effects on fishing grounds. Suggestions to alleviate some problems include enforcement of environmental regulations and zoning schemes.

KEY WORDS: Fish traps, Artisanal fishery, Puerto Rico

La Pesca de Nasas en Puerto Rico: Situación Actual, Cambios a Largo Plazo y la Percepción de los Pescadores

Las nasas son utilizadas en la mayoría de las islas del Caribe para la captura de peces y crustáceos en diversos hábitats, por lo que tienen un impacto sobre la dinámica natural del hábitat y de las poblaciones pescadas. En un enfoque interdisciplinario describimos la metodología de la pesca de nasas actual en Puerto Rico y la percepción de los pescadores sobre los cambios y problemas en la pesquería. Cuarenta y siete pescadores de 5 regiones (norte, sur, este, oeste e islas) fueron entrevistados in situ. El propóstio de la encuesta era describir el método de construcción de las nasas, el tipo de esfuerzo, preferencias de hábitat y la percepción de los pescadores sobre los principales problemas de la pesquería y sus posibles soluciones. Los resultados indican que el material utilizado en las nasas ha cambiado aunque la manera en que se utilizan se ha mantenido igual con algunas variaciones por localidad. A pesar de ser el arte de pesca tradicional de Puerto Rico, más de la mitad de los dueños de nasas han reducido el número de trampas, y por ende, el esfuerzo. Los arrecifes de coral no son la localidad preferida para pescar con nasas, pero si las áreas adjacentes a éstos (rastreales, yerbazales, fondos de algas y gorgónios). Los mayores problemas que afectan a los pescadores de nasas en Puerto Rico son: el robo de artes de pesca, la pérdida de boyas y la degradación ambiental, entre otros. Estos problemas están correlacionados al aumento en el esfuerzo pesquero por parte de los buzos, el aumento en el número de embarcaciones recreativas en áreas pesqueras y el desarrollo costero. El aumento desregulado de embarcaciones en las areas de pesca ha causado el uso de nasas 'ahogadas' (sin boyas), lo que ha provocado un aumento en la pérdida del arte. Las nasas perdidas tienen un efecto en los hábitats y debe considerarse en las regulaciones de manejo de pesquerías. Algunas sugerencias para aliviar estos problemas incluyen vigilancia en el mar y zonificación de aguas costeras.

PALABRAS CLAVES: Las nasas, situación actual, percepción

INTRODUCTION

Throughout the twentieth century traps were the most important gear (Jarvis 1932, Abgrall 1975). Traps are reported as one of the most common fishing methods since the 19th century (Torres 1969), and are presently considered one of the dominant fishing methods in Puerto Rico, responsible for 22 % of the overall catch in 2001 (Matos-Caraballo pers. comm.). It is estimated that 15,481 traps were being used during 1995-1996, a 13 % increase from the 1988 report of the Puerto Rico Fishery Census (Matos-Caraballo 1997). Nonetheless, the number of traps used today seems to be declining and the average number of traps per fisher has decreased due to competition with trammel and gill nets, and the increasing number of divers (Griffith and Valdés-Pizzini 2002).

Given this historical pressure on reef-fish stocks, and the dynamics of habitats they depend on, it is necessary to understand the details of this fishing practice to be able to determine appropriate management actions. Interest in habitat effects by fishing gear has increased recently and the role of fish traps impacting essential fish habitats such as coral reefs needs to be understood. The purpose of this study was to investigate the current practices of artisanal trap fishers of Puerto Rico in order to better assess both the differences in fishing methods and analyze fishers' perspectives. By understanding the intricacies of this fishery within and between landing sites, the problems that fishers and managers confront are revealed. This information provides a basis for the development of an integrated management scheme in which the information provided by fishers may lead to their inclusion in future management decisions.

METHODOLOGY

Study Site

Research was conducted within the Puerto Rican archipelago, including the main island (18° N; 67° W) and two inhabited satellite islands, Vieques and Culebra located 19 and 40 km, respectively, to the east of Puerto Rico. Two interviewers visited 13 coastal sites in a stratified sampling scheme during spring of 2002. The study area was divided into five regions; North (Barceloneta, Vega Baja and Arecibo), South (Juana Diaz, Salinas and Guayama), East (Fajardo, Naguabo and Humacao), West (Lajas, North and South Cabo Rojo), and the islands (North and South Vieques and Culebra). Two municipalities, Cabo Rojo and Vieques were subdivided into North and South sites due to the great extent of the platform and the increased number of trap fishers in these regions. Lajas was grouped with the west region rather than south, due to its southwestern location.

Methods

Verbal interviews were conducted on site with at least three trap fishers (if available) per site, usually at the dock or residence (Table 1). The survey instrument was composed of twenty-four items inquiring about the following issues: target species, fishing grounds, habitat and depth, seasonal trap movement, number of traps per fisher, trends in number of traps per fisher, trap construction materials, layout of traps, use of floats, habitat preferences, soak time, retrieval mechanism, methods to find lost traps, similarity of other fishers methods, and fishers' perceptions of the main problems in the fishery and their possible solutions. All responses were incorporated as given by the fishers.

Table 1. Number of interviews per site in five regions of Puerto Rico.

Region	Site	# Fishers
North	Arecibo	3
	Barceloneta	4
	Vega Baja	2
South	Juana Diaz	4
	Guayama	3
	Salinas	3
East	Ceiba	4
	Naguabo	3
	Humacao	3
West	N. Cabo Rojo	3
	S. Cabo Rojo	3
	Lajas	3
Isles	N. Vieques	3
	S. Vieques	4
	Culebra	2
5	15	47

RESULTS

Target Species

Seventy-seven per cent of fishers targeted both reef fish and lobster, 13 % targeted finfish species alone and 10 % targeted only lobsters. The main target species include the Caribbean spiny lobster (*Panulirus argus*), groupers (*Epinephelus* spp.), shallow and deep-water snappers (*Lutjanus* spp.), trunk and box fish (*Lactophrys* spp.), grunts (*Haemulon* spp.), goatfishes (*Mulloidichthys* spp.), triggerfishes (*Balistes* spp.) and parrotfishes (*Sparisoma* spp. and *Scarus* spp.). Additionally spider crabs (*Mythrax spinossissimus*), octopus and conch (*Strombus gigas*) are occasionally captured in fish traps. Traps varied in size, shape and materials depending on the target species. Wooden pots ("cajones") are used mostly for lobster while wire mesh traps ("nasas") are used for fish and lobsters. Many fishers didn't identify a single target species due to the high species richness found in reef-fish communities.

Fishing Grounds

Fishing grounds are located 1 to 40 km off shore depending on the extent of insular platform available and the fisher's boat or motor size. Traditional knowledge coupled with landmarks was the most common method used to locate fishing sites.

Only one fisher reported the use of GPS (Global Positioning System). Not all of a fisher's traps are located together; groups of traps may be several km apart and are tended on alternate days.

Traps are set from 9 to 181 m depth, with an average between 40 – 62 m. Mean depths at which traps are set vary in response to the characteristics of the insular platform. North coast fishers distribute traps in the deepest range (72-130 m), while southern fishers ranged between 40 and 51 m, the rest exploit slightly shallower depths ranging from 29-49 m.

Half the fishers interviewed moved traps in relation to a given season of the year. The main reasons given for moving traps seasonally were related to sea conditions, including weather related swells, hurricanes, currents and winds. The second most important reason was related to fish or lobster movements either during migrations or aggregations of target species.

Habitat Utilization

Coral reefs were not reported as the preferred habitat for trap setting. However, fishers do target habitats associated with reefs (sand, seagrass, hard-bottom, and algal habitats). Overall, 38 % of fishers selected the "rastreal" as the preferred habitat. Rastreal is the local name given to a hard bottom of low to medium relief, which may be colonized by gorgonians, algae, sponges, and isolated coral colonies. Categories reported by the fishers include vegetation, sargassum, sand, rocks, and others depicted in Figure 1. At greater depths fishers are not able to determine a habitat and the category 'unknown' may be impacting habitats that are important for deeper water species.

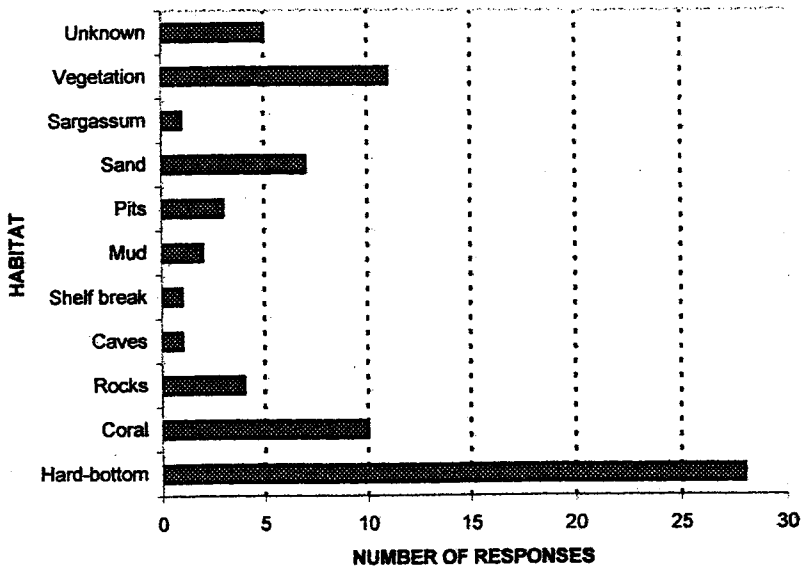

Figure 1. Preferred habitats for trap placement in Puerto Rico

Number of traps

The number of traps and pots per fisher ranged from 10 to 300 and averaged 67 units overall, although regional variation was observed. On average fishers on the southern coast own the greatest number of traps (106), followed by westerners (77), islanders (69), easterners (58), and the northern fishers (26). Island wide, 55 % of fishers interviewed have experienced a decline in the total number of traps they own, 13 % have increased the number of traps and 30 % have maintained a constant number.

Trap Characterization

Most fish traps in Puerto Rico are constructed by the fisher himself or a local trap builder. Trap framework is most commonly made with steel (60 %), followed by wood (34 %), and plastic (6 %), or combinations of these materials. Most traps are steel rebar (generally used for construction) that is cut and welded to the fishers' specifications. Traditionally red mangrove, *Rhizophora mangle,* wood was most common, although substitute woods are also used. Fishers must request a special permit to the Department of Natural and Environmental Resources to extract mangrove wood for fishing activities.

All shapes were reported (arrowhead, "Z", and square). Traps are usually covered by chicken wire or similar mesh ranging from 2.2 to 5 cm diameter, which may be bare wire (galvanized) or plastic covered wire ("engomado"). Many fishers reported the use of 5 cm hexagonal mesh. Federal regulations limit the minimum mesh size at 5 cm hexagonal or 3.75 cm square. Bare wire lasts approximately 1 year underwater and plastic covered wire lasts twice as long.

Trap dimensions range from 80 to 240 cm (mean=125 cm) length by 45 to 150 cm (mean = 103 cm) width and 32.5 to 60 cm (mean=43 cm) height. The most common iron rebar trap used in Puerto Rico measures 120 cm long by 90 cm wide and 45 cm high. Larger traps may reach 180 cm by 120 cm by 45 cm and are usually made of rebar. Smaller traps are often 90 cm by 90 cm by 40 cm and made of wood frames weighted with rocks. Plastic framed traps were reported on the East coast, and are made of food trays or sliced PVC pipes. Larger metal frame traps are used for deeper water while smaller wooden, metal, and plastic traps are used in shallower areas. Not all fishers bait their fish traps, although some reported leaving by-catch species inside the trap.

Lobster pots are usually smaller (60 x 60 x 120 cm) than fish traps and made of wooden slats of precut pine or spruce (imported from U.S.) placed in parallel and may contain wire mesh inside. Pots are weighted with cement or rocks to be kept upright while setting, and are generally baited with animal bones or hide. This gear is used by a few fishers of each region and is generally less abundant than fish traps.

Trap Setting

Single trap layouts were reported by 53 % of fishers, where each trap is set with a single line and a series of buoys or floats below and at the surface. A total of 22

fishers (47 %) use series (strings) of 2 to 3 traps per line (range from 2 to 6, mean = 3.2). Of those, 68 % reported using buoys at both ends of each string, while the remaining 32 % do not use buoys, a method locally known as "ahogado" or drowned traps. Usually, 36-m to 99-m (equal to or greater than water depth) polypropylene lines connects the traps in series underwater.

Regional patterns can be observed between the use of single and series of traps. There is a predominant use of single traps on the West (100 %) and North (78 %) coasts, while most fishers on the South (70 %) and East (80 %) coast use series of traps. In the islands both methods were used extensively: 44 % single and 56 % in series. Three fishers from the South, three from the East and one from the islands reported the use of drowned traps in series.

Soak time

Traps are tended at 2 to 9-day intervals (mean = 5). Soak time varies due to weather, target species (fish die quickly, lobster survive longer) or catch rate. It was reported that if the catch in that particular area or season were poor, they would extend soak time. The most common reason for extending the soak time beyond the average is the inability of the fisher to reach the trap due to unfavorable weather conditions.

Haul Mechanism

Sixty-eight per cent of trap fishers reported the use of a winch or other mechanized apparatus to haul traps; otherwise it is done by hand. More than half of the fishers (68 %) reported small-scale trap movement after hauling. Traps are lifted vertically from the sea floor as the boat is positioned up current for retrieval. In the case of series of traps, each trap is hauled vertically and not dragged along the bottom. Fishers mentioned that it is counterproductive to drag a trap along the seafloor as it can get caught, damaged or lost if it catches onto coral or rock.

Lost Gear

Twenty-four per cent of fishers admitted they abandon traps not found. The most common way of searching for those missing traps is with a grapple hook (34 %), followed by diving (32 %) or circling ropes around the area that the trap was set. If waters are clear, occasionally they can see the line or trap from the surface and attempt to hook it.

Fishers' Perceptions

The main problems reported by fishers in Puerto Rico are gear loss (due to theft or unintentional cutting of buoys), catch theft (surface or underwater), habitat degradation (habitat destruction, water pollution, sedimentation, eutrophication, etc.), overfishing and conflicts over space. The most common cause of the fisheries problems is attributed to trap loss, by intentional or unintentional means. Commercial and recreational divers remove the catch from the trap or cut the buoy line underwater. Another common problem is cutting of buoys by vessels (tugboats,

recreational, and commercial). Storms were reported as another cause of gear loss and strong currents may deflate or shrink buoys by submersion as these become fouled with epibiota. The economic costs of lost gear and the lack of government assistance were also mentioned as problems.

Environmental degradation of mangrove and seagrass habitats has reduced nursery habitats of inshore areas and this in turn has reduced catches in traps. Overfishing and illegal forms of fishing (undersized or gravid lobsters) were also mentioned as a problem. Other factors included the health issues affecting fishers, the lack of enforcement and overregulation applied to some local fishers. Additionally, the increased numbers of recreational vessels and trap loss or catch theft in fishing areas have promoted the use of unbuoyed traps.

Possible solutions to these problems were predominantly the improvement of management and enforcement actions. Some fishers suggested zoning schemes, such as designated fishing areas or marked vessel traffic lanes, to help alleviate these problems. A generalized increase in respect or awareness toward the fishers would help reduce trap loss, or perhaps government assistance would alleviate the economic hardship. Negative habitat effects of other activities (industrial, commercial, military, sewage, etc.) need to be addressed and fishers would like to see the enforcement of environmental laws and regulations.

DISCUSSION

Target Species

Overfishing may be influencing the catch composition in this fishery as many fishers are not targeting species rather than catching whatever is available. The catch of less "primera" (first class species such as groupers and snappers) and more "segunda" (second class fishes such as parrotfish, goatfish, triggerfish and grunts) is associated with changes in species composition in the Caribbean. More herbivorous fishes and other second-class species are being captured and marketed locally in response to these changes. Nassau grouper (*Epinephelus striatus*) were caught in all shallow habitats in fish traps 50 years ago, but are very rarely captured today (Oscar Lugo pers. comm.). A similar change in catch composition was observed in the USVI (Garrison et al. 1998).

Fishing Grounds

Historically, fishing grounds were located in shallow inshore areas close to land. Modernization and government support allowed many fishers to exploit fishing grounds further offshore with the acquisition of motorboats (distance) and mechanized hauling equipment (depth). More recently, fishers have moved further offshore due to diminishing stocks and habitat degradation (pollution, sedimentation, eutrophication, sewer outfalls, etc.) in shallower coastal areas.

Fishing grounds and trap positions were found to vary in relation to catch or species aggregations by Jean-Baptiste (1999). Valdés-Pizzini et al. (1997) described

seasonal movements dictated by weather (hurricane season), searching for productive fishing grounds, and conflict avoidance at the southwestern coast of La Parguera. Both studies conclude that there is territoriality at sea, in which each fisher is utilizing a specific area that is avoided by others. Small-scale (<25 m) movement of traps seems to be associated to physical conditions such as wind and currents during tending. Swells, storms, and strong windy seasons may cause fishers to move traps closer to shore due to the difficulty of reaching deeper areas in small (<10 m) boats.

Habitat Utilization

Fishers are exploiting coral reef associated habitats, although the reef itself is not targeted in most cases. Fishers seem to be targeting low relief hard bottom habitats where the trap will attract and not compete with the vertical relief of coral patches or rocks. Some fishers explained that traps set on coral are not very effective as the fish have other refuges available and will not enter the trap. They also do not want to risk entangling in rocky coral habitats where gear can be damaged or lost. Jean-Baptiste (1999) identified sandy algal plains as the most frequently exploited habitat in La Parguera, Puerto Rico. A study by Appeldoorn et al. (2000) demonstrated that most of the traps are on reef associated habitats, but not coral, and those considered in coral reef habitat were on sand 30 % of the time. Comparably, over half of the traps surveyed by SCUBA in St. John USVI were set in algal plain or gorgonian hard bottom habitats (Garrison et al. 1998). Scaling effects are very important in the determinations of habitat utilization by fish traps.

Number of Traps

A century ago a single fisher utilized 6-12 traps per boat (Wilcox, 1900) and that was enough for significant catches. In 1930, Jarvis (1932) estimated a total of 4,239 traps and more recent estimates lie above 11,000. Despite the historical increase in the number of traps per fisher, this survey indicates declining trends in which many fishers have reduced the number of traps owned or are retiring completely from the fishery. This result is supported by data from the Puerto Rico commercial fishery statistics program (Matos-Caraballo pers. comm.).

Trap loss seems to be the principal reason for the decline in number of traps, and those that reported an increase in the number of traps are trying to compensate for gear loss to maintain a constant number of traps. Increase in costs (between $100 and $150) of traps has also influenced the reduction in numbers of traps per fisher.

Trap Characterization

Caribbean arrowhead is the most common form used in Puerto Rico historically (Abgrall 1975). In the past most fish traps were constructed of mangrove (*Rhizophora mangle*) wood, with organic fibers (palm, cane, calabash) woven to construct mesh and ropes and bamboo used as floats (Wilcox 1900). Galvanized wire or plastic covered chicken (hexagonal) wire was in common use by the 1960s (Suarez-Caabro 1969). Modern traps are required by federal regulation to have a

biodegradable panel that releases catch of lost traps, but not all fishers comply with this regulation. They believe that larger fish, corrosion, and impact with rocks due to swells will open the trap and few fish will be killed. In the past this was less significant due to the organic nature of trap materials that decomposed quickly underwater. The use of synthetic materials may increase the ghost fishing effect of lost gear.

Metal traps are heavier and seem less susceptible to movement on the bottom than wooden or plastic traps. Lighter wood or plastic traps have a greater potential to cause benthic habitat damage (collision, abrasion) due to swells in shallow areas. Pots seem to be more vulnerable to sea swells than traps, perhaps due to the smaller size and lighter construction materials. These could potentially cause more habitat damage in shallower areas subject to swells and currents.

Trap Setting

Historically, series of traps were set in clear, shallow habitats where they could be located visually and retrieved with grapple hooks. The main reason for not using buoys on trap series today is due to theft. Deteriorating water quality in coastal regions of Puerto Rico makes finding unbuoyed traps more difficult. To locate unbuoyed series of traps, fishers drag a small grapple hook on the seafloor at slow speeds until it catches on the trap line that usually floats a bit from the surface. In order to do this, they prefer areas with little or no bottom relief where the grapple can become entangled.

Soak time

Soak times today (5 days) are generally longer than historical reports (1 day), although this varies depending on the target species. Presumably, the effects of overfishing have increased the soak time for traps as many fishers reported that if capture rates are low, they extend soak time. During mutton snapper (*Lutjanus analis*) aggregation season, they will check traps more frequently as these fish die quickly. Climatic events will extend soak time in some cases due to dangerous seas for the small (<10 m) open craft vessels trap fishers use in Puerto Rico.

Haul Mechanism

Presently, most fishers are assisted by a mechanized winch to haul traps to the surface. With this equipment fishers have been able to exploit deeper regions of the platform (Abgrall 1974) and a larger number of traps per fishing unit (boat, fisher and crew). Nonetheless a few still haul traps by hand and are prone to show associated health conditions such as hernia and back problems.

Lost gear

The use of grappling hooks for gear recovery potentially damages benthic habitat as this action may dislodge smaller colonies of coral, octocoral, sponge, vegetation etc., which are important components of essential fish habitat. Gorgonian and vegetation hard bottom habitats may be impacted although the scars produced

by this mechanism are shallower and thinner than boating scars, for example. The effects of grappling hooks pulled by fishers should be assessed in diverse habitats in order to quantify the relative damage by trying to recover lost traps.

Fishers' Perceptions

The perceptions reported in this study appear to be a constant concern of local fishers, as reported in other studies (Griffith and Valdés-Pizzini 2002). Habitat damage by industrial pollution, sewage discharge, and military practices are considered a threat to trap fishing. These activities are reportedly affecting coastal habitats and have contributed to the decline of fish stocks (Martínez and Valdés-Pizzini 1997). The stealing of other fisher's trap contents is not new to fishing in the Caribbean. Leaving gear unattended has been a cause for the conflict since colonial times (Torres 1969). More recently traps have buoy lines intentionally cut and may be tended underwater by divers with the aid of SCUBA. In some cases, fishers will retrieve empty traps with doors wide open. In some cases this has promoted the use of plastic ties on trap doors so that the fisher will know if their traps were tampered with. This may increase the 'ghost' fishing effect if the biodegradable panel is sealed shut. Ghost traps are known to continue fishing long after they are lost (Bullimore et al. 2001) and may be causing significant impacts that needs to be considered.

In relation to the main problem of trap and catch loss there is much enforcement required at sea. Local agencies are not equipped to provide this enforcement and co-management by fishers associations may be a solution to these problems. In some cases, fishers have taken the matter into their own hands, which has lead to violent and destructive actions.

Loss of gear caused by propellers cutting lines is very common in Puerto Rico. Increasing numbers of recreational and industrial vessels have been a problem since the 1970s (Abgrall 1974). In the past it was the southern and eastern coasts that were more affected by industrial development and increased maritime traffic (thermoelectric plants, oil refineries, military practices, etc.). Today trap fishers from all regions of the island are losing buoys due to increased commercial (ferries, freight, tugs) and recreational (charters, private, diving) maritime traffic. This conflict may also cause increased 'ghost' fishing in specific areas. Some suggestions to alleviate these problems include enforcement at sea and zoning schemes.

An increasingly common problem affecting natural resources island wide is the decreasing quality of the marine environment. The destruction of benthic habitats and water pollution are considered serious threats to the fishery. Mangroves are removed and wetlands filled to construct industrial, commercial and residential projects that respond to increasing populations of the islands. Damage to marine habitats includes dredging, sewage outfalls, chemical spills, military activities, and groundings among others. Many nursery and essential habitats critical for species in the marine ecosystem have been eliminated and fishers claim for environmental justice. Most fishers believe that large polluters should be regulated and enforced or fined in proportion to the damage they have caused to the environment. Several fishers recommended that results of water quality monitoring in estuarine and coastal

areas should be made available to the public on a timely basis in order for environmental justice to be achieved.

CONCLUSIONS

The main impact on habitats by this gear is related to the abundance and distribution of traps, although the frequency of hauling seems to be lower than in the past. Even though coral reefs are not preferred by fishers, isolated coral colonies and other benthic organisms may be impacted by traps in hard-bottom habitats, although these are usually dominated by gorgonians which absorb the greatest impact (pers. obs.). The ghost fishing effect will impact the populations of benthic organisms and higher consideration should be given to this impact in fishery management plans.

Current practices are affected by a number of anthropogenic factors that impact the natural resources that support the activity. This is supported by a panel of experts assessing human uses in coral reefs (Valdés-Pizzini 2002). Conflicting uses of coastal areas, environmental degradation, and diminishing resources may be causing a short-term decline in the trap fishery of Puerto Rico, after a steadily increasing historical trend.

The suggestion given by some fishers of zoning coastal areas may be useful in two manners:

i) Zoning at sea could reduce gear loss by avoiding vessel traffic in fishing areas and *vice versa*, and

ii) Establishing fishing or non-fishing zone concepts among users in Puerto Rico. The designation of management areas could incorporate marine protected areas in the zoning schemes that could benefit the fishery.

ACKNOWLEDGEMENTS

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The Role of Oil and Gas Platforms in Providing Habitat for Northern Gulf of Mexico Red Snapper, *Lutjanus campechanus*

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ABSTRACT

The northern Gulf of Mexico (GOM) off Louisiana and Texas currently produces significant portions of the commercial and recreational harvests of red snapper *Lutjanus campechanus*; however, this has not always been the case. Annual commercial landings in the five states bordering the GOM indicate a shift in the fishery from the eastern to the more western GOM since 1970 concomitant with the placement of several thousand oil and gas platforms into the area. Although the addition of considerable complex steel structure to the environment and the shift of the red snapper fishery to Louisiana and Texas may be coincidental, there is still a need to better understand the role of oil and gas platforms in red snapper life history.

Quantitative estimates of red snapper associated with platforms have been derived both from assessments of the effects of platform removal via explosives and from hydroacoustic surveys of selected platforms. Based both on these estimates and on the numbers of platforms sited at depth, we estimate from 1.2 to 7.2 million red snapper live around platforms placed at depths of 20 - 100 m. Many of these are relatively young individuals of ages 2 - 4 years. These numbers suggest a range of red snapper abundances reflecting the ubiquitous presence of red snapper at oil and gas platforms. We intend to continue this line of investigation to determine if platforms have become "essential' to the persistence of a large population of red snapper in the northern GOM.

KEY WORDS: Red snapper, *Lutjanus campechanus*, habitats, oil and gas platforms

El Papel de las Plataformas Petroleras y de Gas de Proever Habitat para el Pargo Rojo *Lutjanus campechanus* en el Golfo de México

El norte del Golfo de Mexico en la parte correspondiente a Luisiana y Texas actualmente produce una porcion significativa de las cosechas comerciales y recreativas de la pesca del huachinango (*Lutjanus campechanus*). Sin embargo, esto no siempre ha sido el caso. Las capturas comerciales de los cinco Estados que bordean el Golfo de Mexico indican una migracion en la pesqueria de la parte Este al Oeste a partir de 1970, concomitantemente con la instalacion de varios miles de plataformas de gas y petroleo en el area. Aunque la aparicion de estructuras

metalicas complejas en el ambiente y la migracion de la pesqueria de huachinango en Luisiana y Texas sea coincidente, existe todavia la necesidad de ampliar el conocimiento del papel que juegan estas estructuras en el ciclo de vida del huachinango.

Estimaciones cuantitativas de huachinangos asociados a las plataformas fueron derivadas a partir de evaluaciones de los efectos de la remocion de plataformas usando explosives y conteos hidroacusticos en sitios selectos. Basados en ambas estimaciones y en el numero de plataformas situadas en profundidad, nuestros resultados indican entre 1.2 a 7.2 millones de huachinangos utilizando estos habitats en profundidades de 20 a 100 m. La mayoria de estos individuos son de edades de 2 a 4 años. Estas densidades sugieren una abundancia que justifica el notable componente de huachinangos en la comunidad de peces que usan las plataformas de explotacion petrolera. Seguiremos esta linea de investigacion para determinar si la prescencia de plataformas se ha hecho "escencial" para mantener a la gran poblacion de huachinangos en el norte del Golfo de Mexico.

PALBABRAS CLAVES: Huachinango, *Lutjanus campechanus*, plataformas de gas y petroleo

INTRODUCTION

The management of the red snapper *Lutjanus campechanus* in the Gulf of Mexico (GOM) remains among the more problematic issues facing fishery managers of the region. Commercial landings increased from 1950 to 1965 and subsequently exhibited a constant decline until regulations were imposed in the 1990s. Both the commercial and recreational red snapper fisheries are now constrained by size limits, creel or trip limits, seasonal closures, and quotas as formulated by the Gulf of Mexico Fisheries Management Council in response to reports of overfishing (Schirripa and Legault 1999). Shrimp trawlers have also been required to install bycatch reduction devices in their nets to curtail mortality among juvenile red snapper.

Both qualitative and quantitative assessments of fish populations have shown that oil and gas platforms situated in the northern GOM can hold large and diverse populations of fish species. Among these the red snapper repeatedly has been identified as a major component of the platform-associated fauna. In visual surveys conducted by SCUBA divers at platforms off central Louisiana, the species was characterized as common by Sonnier et al. (1976) and as numerous by Bull and Kendall (1994); Putt (1982), using video cameras, found red snapper to constitute 2 - 4% of the total fishes inhabiting platforms off Texas. The recent fusion of hydroacoustic and visual (either with divers or with camera-equipped remotely operated vehicles) survey methods has produced estimates not only of total numbers of fishes around platforms, but also of species composition and their numerical or proportional representation within the total population (Stanley 1994, Stanley and Wilson 1996, 1997).

The benefit of oil and gas platforms to commercial and recreational fishing interests has been questioned as recently as the mid 1970s (Sonnier et al. 1976). Also, the question of whether platforms simply aggregate existing fish biomass or serve to increase limited habitat and thus produce additional fish biomass remains to be resolved. In either case, a significant portion of the recent and current red snapper commercial and recreational harvests has come from the north central GOM and at or near oil and gas platforms. Indeed, among 44,465 and 16,762 fishes caught at oil and gas platforms off Louisiana in 1987 and 1988, respectively, 35% and 41% were red snapper (Stanley and Wilson 1990). The addition of considerable complex steel structure to the environment in the western GOM off Louisiana and Texas undoubtedly has had a tremendous impact on fishes, especially reef-associated species such as the red snapper. However, there is still a need to better understand the role of oil and gas platforms in red snapper life history.

MATERIALS AND METHODS

A variety of data sources were accessed in the preparation of this contribution. Commercial (NMFS 2002a) and recreational (NMFS 2002b) landings of red snapper were located at websites operated by the United States National Marine Fisheries Service (NMFS). Numbers of operating oil and gas platforms in the northern GOM were obtained from the United States Minerals Management Service (MMS), Gulf of Mexico Region (MMS 2002). Fishery independent estimates of red snapper populations around oil and gas platforms come from two sources:

i) Counts of mortalities produced subsequent to explosive removal of obsolete oil and gas platforms (Gitschlag et al. 2002, Nieland and Wilson 2002), and

ii) *In situ* hydroacoustic and video assessments of fish populations inhabiting the areas around and beneath oil and gas platforms (Stanley 1994, Stanley and Wilson 1996, 1997, 1998, 2000, unpublished data).

RESULTS

The growth and subsequent decline of commercial red snapper landings (Figure 1) was concurrent with the development of the offshore oil and gas industry in the northern GOM. Commercial landings by state indicate that the fishery has shifted from the eastern to the western GOM since 1970. Florida, Alabama, and Mississippi all have experienced declines in landings since 1965, but Louisiana and Texas have realized increases since the 1970s; this shift is coincident with the rapid expansion of offshore oil and gas development and the placement of increasing numbers of platforms (Figure 2).

Quantitative estimates of the inhabitation of platforms by red snapper are provided by the National Marine Fisheries Service, which has conducted periodic assessment of the effects of explosive platform removal on resident fish populations. Gitschlag et al. (2001) collected fish mortalities subsequent to explosive detonations

at nine platforms off Louisiana and Texas (15 - 32 m water depth) and found that red snapper constituted an average of 15.4 % (range = 1.1 - 25.6%) of the total fish population per site (Figure 3). Fully 37% (n = 373) of the fish mortalities recovered subsequent to the explosive detonation and removal of the relatively small obsolete platform located in the Ship Shoal (SS) 209 lease block were red snapper (Nieland and Wilson 2001). Gitschlag et al. (2001), upon further analysis of the numbers of mortalities gathered from the SS 209 detonation, reported 24% (n = 418) of the fish population to be red snapper.

The hydroacoustic surveys of fish populations around oil and gas platforms of Stanley (1994) and Stanley and Wilson (1996, 1997) showed red snapper numbers to vary from 521 to 8,202 individuals at a platform off western Louisiana. Similarly, among estimated total fish populations of ~29,000 and ~13,000 individuals at two platforms off central Louisiana, 4.4% and 19.2%, respectively, were red snapper (Stanley and Wilson 2000). Red snapper numbers at ten additional platforms (22-110 m depth, 38 total hydroacoustic surveys) averaged 2,100 individuals or approximately 21% of the fish populations (Figure 3) at these sites (Stanley and Wilson unpublished data).

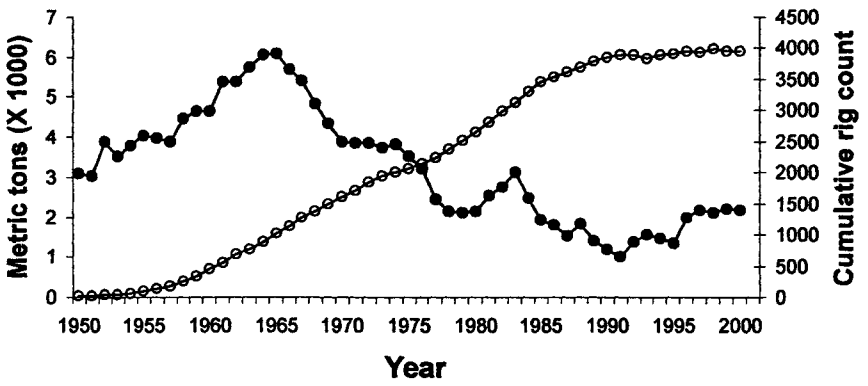

Figure 1. Commercial landings (closed circles) of red snapper *Lutjanus campechanus* from 1950 to 2000 (NMFS 2002a) and cumulative number of oil and gas platforms (open circles, MMS 2002) in the northern Gulf of Mexico.

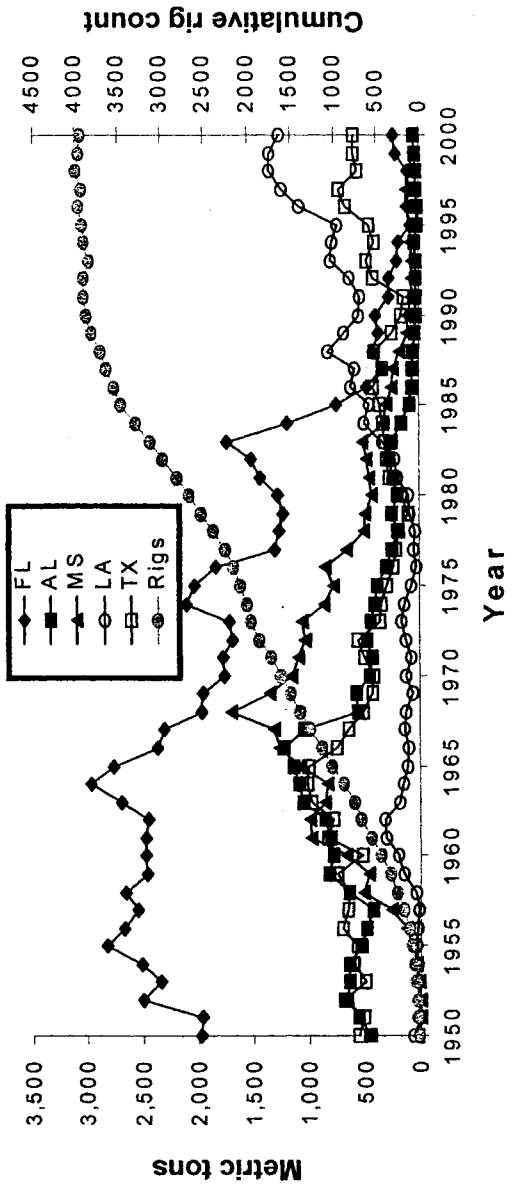

Figure 2. Commercial landings of red snapper *Lutjanus campechanus* by state from 1950 to 2000 (NMFS 2002a) and cumulative number of oil and gas platforms (MMS 2002) in the northern Gulf of Mexico.

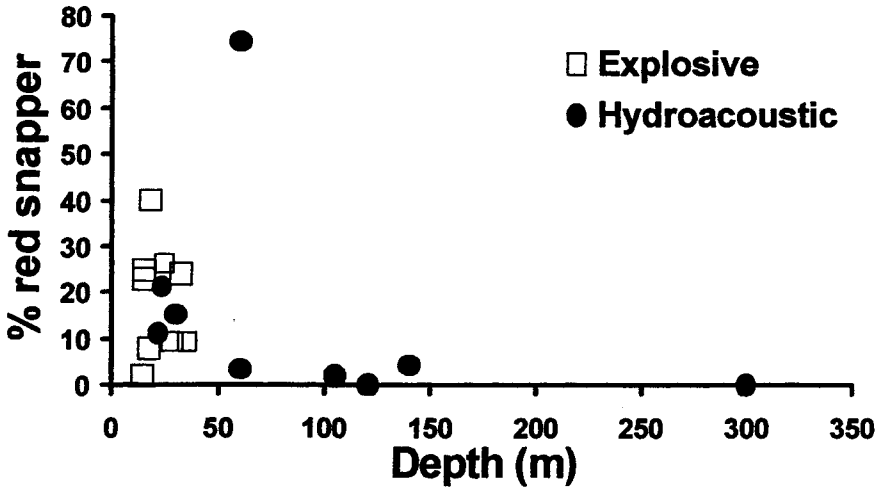

Figure 3. Percent of total fish populations represented by red snapper *Lutjanus campechanus* at oil and gas platforms at various depths in the northern Gulf of Mexico. Percentages estimated either from fish mortalities recovered following explosive platform removal (open squares) or from hydroacoustic surveys (closed circles).

DISCUSSION

Juvenile red snapper are known to inhabit hard bottom areas of low relief and shell rubble where they are vulnerable to capture in trawls (Workman and Foster 1994, Szedlmayer and Howe 1997, Szedlmayer and Conti 1999). This behavior is illustrated in fishery independent trawl data from the GOM, specifically the Fall Groundfish Survey and the Summer SEAMAP Survey, in which the great majority of red snapper captured are age 0 and 1 (Schirripa and Legault 1999). It has been hypothesized that the disappearance of age 1 red snapper from the trawl data represents migration to high relief structures such as natural reefs, wrecks, and platforms which presumably provide refuge from large predators (Render 1995). It might also be postulated that platforms, in the absence of other preferred habitats, are essential habitat for young red snapper.

Estimates of red snapper numbers around oil and gas platforms, regardless of their source, must be recognized for what they indeed are — chronological "snapshots" of the resident populations (Nieland and Wilson 2002). Previous research efforts have shown conclusively that red snapper numbers can vary significantly among seasons (Putt 1982, Stanley 1994, Stanley and Wilson 1997,

2000) and among platforms at different depths (Stanley and Wilson 1998, 2000). Red snapper are also known to stratify by size at different depths around platforms; further, larger individuals are less obligate in their association to platforms than are smaller individuals (Render 1995).

MMS reports that there are approximately 2500 platforms in the northern GOM at depths ranging from 20 m to 100 m. Based on the estimated numbers of red snapper given above, we may estimate that from 1.2 to 7.2 million red snapper live around platforms placed in this depth range. Many of these may be relatively young individuals as Nieland and Wilson (2001) reported that the red snapper around the SS 209 platform were predominantly 2 - 4 year olds. These estimates are based on a limited number of surveys, but they suggest a range of red snapper abundances that reflect the ubiquitous presence of red snapper at oil and gas platforms. We should continue this line of investigation to determine if platforms have become "essential' to the persistence of a large population of red snapper in the northern GOM.

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The Coral Reefs of Tobago: Status and Management

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ABSTRACT

The marine ecosystems of Tobago are extremely important to the island for both ecological and socio-economic reasons. Not only are they needed for coastal defense/breakwater/ protection of shoreline, nursery grounds, habitat for marine organisms, production of sand, reduction of pollution (mangroves); but also as a source of recreation, livelihood, and food. It is no great surprise, therefore, that Tobago's two premier industries (Tourism and Fisheries) depend on a very healthy marine environment for their own survival. The existence and continued formation of good quality reefs in Tobago is contingent on the growth of hermatypic corals.

Additionally, it must be noted that these tiny unicellular organisms are very sensitive to any changes in the delicate balance of their physical and chemical environment. Work conducted by both the CARICOMP project in Buccoo Reef Marine Park (BRMP), and by Lapointe et al. (2002) in both the dry and rainy seasons of 2001 has shown the susceptibility of the complex ecosystem to environmental changes in temperature and nutrients. This review showed some of the various environmental and anthropogenic impacts affecting the coral reefs. It also looked at the present status through the ongoing CARICOMP project and the work of Lapointe et al, where information on the status of the benthos of most of Tobago's reefs was revealed (cover of hard corals, octacorals, macro algae, turf algae, coralline algae and sponges). Information was also obtained on dissolved inorganic nitrogen, soluble reactive phosphorus and N^{15} to N^{14} ratios. Based on the above it was deduced that land-based discharges of nutrients from deforestation, sewage, construction and agricultural activities contribute a threat to Tobago's coral reefs.

The Department of Marine Resources and Fisheries (DMRF) through its management plans, its annual work programmes and very enthusiastic but small staff work conscientiously each year to manage the marine resources and fisheries of the island. The DMRF, however, is unable to realize the desired successes due to the many constraints it encounters. It is therefore necessary for the state to start financing the DMRF and its programmes; so that it can carry a more holistic ecosystems-based management programme, as is advised in the two marine areas management plans and the legal instruments at its disposal.

KEY WORDS: Coral reefs, Tobago, management

Los Arrecifes de Tobago: Condiciones y Manejo

Trinidad y Tobago es una isla del Caribe pequeña (300 km2) situó el noreste de aproximadamente 29 kilómetros de Trinidad entre las latitudes 111 8 = y 111 22 = y las longitudes 601 30 = y 601 51 =. el aproximadamente 70 % de las aguas costeras de Tobago's (a lo largo de sus líneas de la costa del este y del Caribe) son caracterizados por las formaciones del arrecife de las cuales el arrecife de Buccoo es el más grande y es el único parque marina protegido en la República de Trinidad y Tobago. Un plan de la gerencia ahora se está terminando para el segundo sitio más grande en Speyside, que se puede pronto considerar para el estado protegido similar del área como Buccoo bajo acto del realce y de la preservación de 1970. Los otros sitios principales del arrecife coralino alrededor de Trinidad y Tobago incluyen los arrecifes en la isla de la cabra, poca Trinidad y Tobago y la bahía de la Hombre-de-Guerra en el noreste; Bahía de Culloden y Arnos Vale en la costa del norte; y el arrecife del vuelo, el filón de la salsa de tomate, la tierra del grouper, el filón de Kariwak, el filón del Mt. Irvine y el asilo de la piedra ladran en la costa al sudoeste (Laydoo, 1991). Estos arrecife son importantes para las industrias de la pesca y del turismo de Tobago's. Se cree que sirven en parte como argumentos del cuarto de niños para algunas de Trinidad y Tobago de especies comerciales importantes de s. La industria de pesca local es pequeña pero es en segundo lugar solamente al turismo como Tobago's la mayoría del adquirente importante del rédito. La industria de pesca abarca unos 694 recipientes, la mayoría de los cuales es pirogues más unos 10 recipientes multipropósito. La blanco del fisherfolk de los island's un ciertas 19 especies de pescados y de crustáceos por once diversos métodos de la pesca. Seis impianto de los pescados procesan la porción principal del retén y el producto se empaqueta y se vende localmente, nacionalmente e internacionalmente. Los affinis de Hirundicthys (los pescados que vuelan cuatro-cons alas) y su pelagics grande asociado son las especies principales cogidas. Además, el turismo está vivo y bien con los barcos inferiores de cristal que funcionan su excedente de los viajes algunos de los arrecifes, anunciando snorkeling y la visión del filón. Tiene también sido un aumento sensible en el número de los zambullidores de la ESCAFANDRA AUTÓNOMA que visitan los arrecifes y el número de las tiendas de la zambullida (21) en la isla también ha aumentado. Se cree que algún 40 % del turismo de los island=s es turismo de la zambullida. Conch, la langosta y los pescados se creen para ser tomados regularmente de las aguas cerca de los arrecifes a los restaurantes locales de la ayuda y para la pesca de la subsistencia. El pote y una cierta pesca de la lanza se divulgan como campo común en algunas áreas. La joyería y los recuerdos también se hacen de corales y de otros organismos del arrecife para sostener negociar turístico. El anclar dentro de las bahías y por lo tanto sobre el filón es común. El departamento recientemente establecido de recursos y de industrias pesqueras marinas de la casa de Trinidad y Tobago de la asamblea ha asumido la responsabilidad de la gerencia de los recursos marinas y de las industrias pesqueras

de la isla. Ha emprendido un plan ambicioso de la gerencia de recurso natural participante, que incluyen las entradas de un número de tenedores de apuestas locales, nacionales y regionales, determinado para utilizar las mejores prácticas de gerencia de asegurar sustainability.

PALABRAS CLAVES: Arrecifes coralinos, Trinidad y Tobago, gerencia

INTRODUCTION

Tobago is a small island (300 km^2) situated approximately 29 km northeast of Trinidad between latitudes 11° 8' and 11° 22' and longitudes 60° 30' and 60° 51'. Approximately 70 % of Tobago's coastal waters (along its eastern and Caribbean coastlines) are characterized by reef formations, of which Buccoo Reef is the largest and is the only protected marine park in the Republic of Trinidad and Tobago. The other major coral reef sites around Tobago include reefs at Speyside, Goat Island, Little Tobago and Man-of-War Bay on the northeast; Culloden Bay and Arnos Vale on the north coast; and Flying Reef, Ketchup Reef, Grouper Ground, Kariwak Reef, Mt. Irvine Reef and Stone Haven Bay Reef on the Southwestern coast (Laydoo, 1991) (Figure 1).

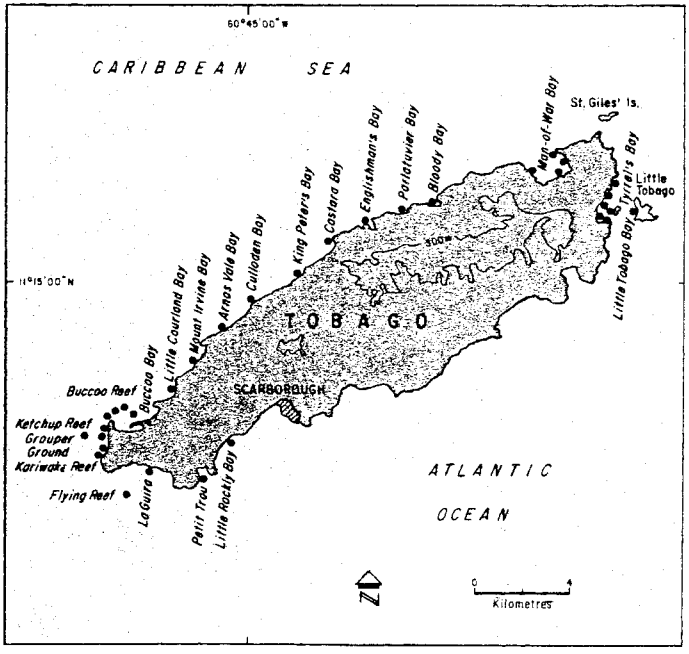

Figure 1. Map showing the Major Reefs around Tobago

These reefs are important to Tobago's Tourism Industry. Glass bottom boats operate their tours over some of the reefs advertising snorkeling and reef viewing. There has been a noticeable increase in the number of SCUBA divers visiting the reefs. The number of dive shops on the island has increased significantly (22) within resent years. Conch, lobster, and fish are believed to be regularly taken from waters near the reefs to support local restaurants and for subsistence fishing. Pot and spear fishing are common activities. Jewelry and souvenirs are also made from corals and other reef organisms to sustain tourist trading. Anchoring within the bays and therefore over the reef is common.

The reefs of Tobago are directly and indirectly impacted on by human, construction development and agriculture activities, which occur in the adjacent villages, towns and estates. Southwest Tobago, with reefs at Mt. Irvine, Buccoo and the general Crown Point area has seen massive building growth and development in the tourism and related services sector (hotels and guest houses), as well as, in residential village expansion. The unprecedented buildup has resulted in increased nutrient enrichment on the complex marine ecosystems (corals, sea-grass beds and mangroves) through pollution from hotel and household effluent and sewage. This nutrient loading has lead to over growth of marine macro-algae on the once sandy bottoms and in the coral areas.

Tropical coastal ecosystems, and coral reefs in particular, are suffering worldwide from the impacts of land-based nutrient pollution and eutrophication of coastal waters (NRC 2000). Pollution from land-based sources is considered the single most important threat to the marine environment of the Caribbean and an impediment to sustainable use of its resources (UNEP 1994). Sources of nutrient pollution known to impact Caribbean reefs include poorly treated sewage and gray-water, domestic and commercial (tourism) outfalls, fertilizers, deforestation, and topsoil loss (Lapointe et al. 1990, Lapointe and Thacker 2001, Likens, 2001). Throughout the Caribbean SIDS (Small Island Developing States) inappropriate or non-existent wastewater treatment represents a major source of land-based nutrient pollution to not only coral reefs, but also to adjacent sea grass and mangrove ecosystems as well (NRC 2000).

The island of Tobago offers an ideal site to study the effects of nutrient pollution on coral reefs. Approximately 70 % of Tobago's coastal waters (along its eastern and Caribbean coastlines) are characterized by reef formations, of which the Buccoo Reef Complex (BRC) is the largest and the premier Marine Protected Area (MPA) in the Republic of Trinidad and Tobago.

SOCIO - ECONOMIC IMPACT

The importance of the fishing industry to Tobago's economy and social development cannot be overemphasized. Indeed, in providing opportunities for employment, food security, and stability for rural communities it has a pivotal role to play in Tobago's development and is by far the main economic support for our

coastal communities. The fishing industry is second only to tourism as an income earner for this island. According to 1998 statistics, the fisheries sector contributed approximately 80 % to Tobago's agricultural gross domestic product (GDP). There are some 35 main landing beaches around the island, including 10 with fish landing centers. There are over 2,000 registered fishermen operating 1603 registered fishing vessels (including bumboats, pirogues, and ten multipurpose vessels). It has been calculated that these vessels represent a current capital investment of approximately 41 million TT dollars. Enormous investment has also been made by the private sector in establishing and developing Tobago's ten processing plants that process and market high quality fish locally, regionally and internationally and where more than three hundred persons are employed during the year. Over 180,000 kg of fish are caught annually and, in 1998 around five million dollars worth of fish was purchased by fish processors from Tobago fishermen. In addition, the diving industry is also a significant contributor to the economy of Tobago, contributing an estimated gross of 54 million TT dollars in 1998, from 22 dive shops.

INTERNATIONAL CONVENTIONS, GOVERNMENT POLICIES, LAWS, AND REGULATIONS

The management of reefs in Tobago are directly influenced by three (3) United Nations Conventions, twelve (12) pieces of national legislation and two (2) policy documents (details in APPENDIX) and indirectly by numerous other conventions, legislation and policies. The Tobago House of Assembly through its Department of Marine Resources and Fisheries has the direct responsibility for the management of Tobago's reefs. This network of conventions, legislation, and policy provide an intricate atmosphere for the management of coral reefs around the island. For example, the THA undertakes the day to day responsibilities for management while the Ministry of Agriculture, Land, and Marine Resources has the legal responsibility for the implementation of the Marine Areas (Preservation and Enhancement) Act of 1970 and the Environmental Management Authority will legislate activities within selected reefs through the Environmentally Sensitive Areas Rules 2001. Efforts are being made to harmonize these documents and effect much needed management initiatives through the signing of memoranda of understanding among the various entities but progress to date is dismal.

BIOLOGICAL/ PHYSICAL (IMPACTS/ EFFECTS)

Tobago is located along the runoff path of several major South American river systems that have a direct effect on the reefs that fringe the island. The runoff brings with it large quantities of sediments, minerals, and nutrients such as nitrogen and phosphates that encourage algal growth. This coupled with global problems such as sea level rise and global warming has exacerbated an already burgeoning problem on the reefs of Tobago. In 1998, there was a bleaching event that affected 100 % of

the observed reefs of Tobago (Guppy 2000). This was part of the worldwide trend in 1998, widely attributed to the rise in global sea temperatures in that year. Since then there have been unconfirmed bleaching events in 2000 (Guppy 2000), 2001 and 2002 (Lum Kong and Juman 2002). It is feared that with the change in the climate these bleaching events will become regular occurrences with the added threat of rising sea levels.

Man's activities negatively impact on the reefs, both directly and indirectly. Anchorage, breaking corals for the tourism trade, over-fishing of reef species and boat operators dumping garbage directly onto the reefs are problems common to all the reefs of Tobago. For over 20 years reef tour operators in Buccoo Reef encourage visitors to walk upon the corals in an attempt to snorkel. Yachts anchor around the reef at Man-of-War Bay in Charlotteville and have been known to empty their tanks directly onto the reef. Yacht owners are asked to dispose of their waste some five kilometres out at sea, but there is no enforcement of marine policies and regulations outside the boundaries of the Buccoo Reef Marine Park.

Construction development on the island is at an all time high, with numerous other developments being proposed for the future. In the Marine Park area alone, a resort has been earmarked for the adjoining lands in addition to the three major housing developments, which are already significantly impacting the reef. This is in addition to the numerous registered hotels and guesthouses, as well as the other unregistered bed and breakfast homes already existing in the area. This trend is being duplicated throughout the island, thus posing a severe threat to our reefs, especially in terms of nutrient loading from sewage and other sources such as agricultural run-off, industrial and domestic wastewater.

The Institute of Marine Affairs has the responsibility to monitor the Buccoo Reef Complex as part of the Caribbean Coastal Marine Productivity (CARICOMP) project. Data collected over the past few years showed that there was no significant decrease in the hard and soft coral cover and no increase in the algae from 1996 to 2000 (Lum Kong and Juman 2002). There was, however, a decrease in rugosity during that period. There are diseases such as dark spot disease, black band disease and white pox affecting the corals around the island but there is no proven correlation between the occurrence of diseases in corals and human activities.

MANAGEMENT

Of the 34 reefs identified, management plans were commissioned for the two most popular reef systems at Buccoo and Speyside. Recommendations of the Buccoo Reef Management Plan, formulated in 1995, are yet to be implemented. The approach seemed to rely heavily on beaurocracy to effect changes. The management plan for the Speyside Marine Park, completed in 2001, however, has sought to place an emphasis on collaborative (participatory) management. Present trends seem to indicate that the recommended approach to the management of reef systems around the island may be best addressed by the formulation and

implementation of a coastal zone management plan, which would incorporate concerns involved in the 'ridge to reef' management concept.

Environmental Education and Public Awareness

There have been several collaborative, public awareness and education programs initiated by government, government agencies and NGOs over the past few years. The Institute of Marine Affairs and The Tobago House of Assembly began a program in Speyside in September 2002 to meet the needs of the Speyside Reef area. Local NGO Buccoo Reef Trust, in conjunction with the Department of Marine Resources and Fisheries produced a video, which highlighted the problems facing Buccoo Reef Complex Ecosystem. There is yet to be a comprehensive education program implemented for other coastal communities around Tobago.

Research, and Monitoring

To date, some 36 research papers have been written about the Buccoo Reef Marine Park. In compariso,n there has been just a few papers written on Speyside and even less on other the reefs around the island. Traditionally, monitoring has been carried out by the Institute of Marine Affairs, but the Department of Marine Resources and Fisheries has recently began regular monitoring the coral cover and reef species as part of the Reef Check Program. There are plans to monitor the five main reefs around the island.

Conflict Management

With the growth of the tourism industry there has been increased competition for use of the marine resources. Tourism in Tobago, as in many other Caribbean islands, is concentrated along the coast. Traditional beach access is constantly threatened, and fishermen and other local users of the beaches are often at odds with hoteliers and developers. One prominent example was the recent conflict between the owners of Club Pigeon Point Beach Resort and the fishermen that traditionally use the area. This culminated with a fatal shooting in March 2000. The Department of Marine Resources and Fisheries played a most pivotal role in the resolution of this conflict through mediation between the two sides on many occasions.

Enforcement

Currently, the Department of Marine Resources and Fisheries is staffed with four (4) Reef Patrolmen that have responsibility for enforcing the regulation governing the use of the marine park at Buccoo. ,The reef patrol system lacks effectiveness as it is in dire need of appropriate tools and equipment, as well as, an adequate number of properly trained, motivated staff to implement a 24-hour workday, for seven days every week. In an effort to improve the system, the DMRF hosted Phase 1 of a Marine Ranger Training Workshop in July 2001 from which persons will be recruited to work with the Department. Plans are also underway to set up a volunteer marine ranger system, which will allow for the involvement of

community members in patrolling and monitoring of their local marine resources. The local Police and Coast Guard personnel have been trained in the legislation governing the marine areas earlier in 2002.

Work Programs

Each year, as part of the annual budget, the Department of Marine Resources and Fisheries requests funding for marine areas (e.g. reefs, sea-grasses and mangroves) management, protection, conservation, research and development. Some of these projects include reef regeneration, placing signs on the boundaries of the reefs, public awareness and education programs, placing permanent moorings for anchorage on the reefs, training reef tour operators in coral reef biology, and tour guide methodology.

Government officials have consistently denied requests for funding of reef related projects, as with many other environmental projects. Over the last six years, funding for reef management was allocated in 1997, 1998 and 2001, with total allocation representing less than 1 % of the total Tobago House of Assembly budget. This has allowed for ineffective management as there are insufficient funds to hire staff, purchase equipment, or establish a feasible infrastructure.

CONCLUSION AND RECOMMENDATION

Tobago's coral reefs along with its sea grass beds and mangroves are extremely important for both ecological and socio-economic reasons. They have been constantly impacted over recent decades by not only natural phenomena but also more so by the sea-based and land-based actions of man. Land-based and coastal engineering and developmental activities have had numerous devastating effects on coral reef health. It is therefore recommended that adequate funding be made available by the State and any donor agency to ensure the annual conduct of the Department's programmes, thus ensuring the much needed wise-use management of these important reefs and associated ecosystems.

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Appendix 1. The legal document governing the management of Reefs in Tobago

Document	Brief Description
The Three Chains Act (1865)-	This Act refers to land surrounding the coast that is three chains breadth from the high water mark that was reserved for the execution of forts and batteries. The Act grants the State the authority over those areas and the public access through the three chains. It essentially gives the control of the land beyond the high water mark around the coast to the landowners (not the State). This affects the governing of the land bordering the Bon Accord Lagoon where this land was mangrove in 1865.
State Lands Act (1918)	Section 3 of this Act states that "the domination of the nearshore between the high water and low water marks belong to the and is vested in the State." Coast begins where the shore ends at the high water mark.
Marine Areas (Preservation and Enhancement) Act (1970)	The Act which defines the Marine Areas, and allows 'the Minister' to designate any area in Trinidad or Tobago a restricted area. It also gives general directions on how to manage protected areas.
Marine Areas (Restricted Area) Order (1973)	Designated Buccoo Reef Complex as an area for preservation and protection. It determines that no person may go into the Buccoo Reef area except as provided for by the Regulations. This Order demarcates the boundaries of the proposed Buccoo Reef National Marine Park inaccurately.
Marine Areas ("Preservation and Enhancement) Regulations (1974)-	Under Section 6, 'the Minister' has the discretion to make regulations generally for purposes of giving effect to the Act.
CARTAGENA Convention	This is the Convention for the Protection of Development of the Marine Environment of the

	Wider Caribbean Region. It was entered into force in Trinidad and Tobago on October 11th 1986.
SPAW Protocol	This is the Convention concerning Specially Protected Areas and Wildlife to the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region which was entered into force in Trinidad and Tobago on January 18th 1990
The United Nations Convention on Biological Diversity	Entered into force on August 01st 1996. Instrumented by the development of the National Biodiversity Strategy and Action Plan, which provides a contextual framework for development and management of the natural living resources of the country.
Environmental Management Act (1995)	Provides for management of the environment within Trinidad and Tobago through the establishment and operation of an Environmental Management Authority (EMA), an Environmental Trust Fund, and an Environmental Commission, to define the powers and duties thereof, and for related matters. The THA signed a Memorandum of Understanding (MOU) with the EMA in 2001.
Tobago House of Assembly Act (1980)	Section 21 gave the THA the responsibility for implementing, in Tobago, Government policy relating to the 'conservation and improvement of the environment'.
Amendment to the Constitution Act # 39 (1996)	Made necessary changes in the constitution to effect THA Act 40 of 1996.
Tobago House of Assembly Act # 40 (1996)	Replaces the Tobago House of Assembly Act (1980).
National Environmental Policy	Approved by Cabinet and laid in Parliament on September 2nd 1998. This provides a "national, practical and comprehensive framework for environmental management.
Environmental Management Act # 3 (2000)	Replaces Environmental Management Act 1995.
*Environmental Sensitive Area Rules (2001)_*	One of the criteria for designation is the "conservation of natural resources and protection of the environment and the targeting of areas for effective management.
*Environmental Sensitive Species Rules (2001)_*	Seeks to protect species for the conservation of biological diversity and protection of the environment.
Technical Agenda for Agriculture, Marine Affairs and the Environment (2001)	3.4.4 states an objective "to conserve and restore coral reefs of Tobago and their associated fauna".

Identification of Small-scale Coral Reef Habitats from High Resolution Side Scan Sonar Imagery

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ABSTRACT

A detailed characterization of habitat is important to understand how organisms react and use their immediate environment and to study many ecological processes occurring at these scales. However, detailed habitat knowledge needs to be extended over broad areas to determine the spatial distribution of benthic habitats and their connectivity. This large scale habitat assessment is crucial to determine the effects of disturbance, heterogeneity and dispersal between habitat patches on marine populations. Unfortunately, detailed habitat identification over large areas is unknown for the majority of reef areas. In this work, a total of 60 km^2 off La Parguera, Puerto Rico were surveyed using a Side Scan Sonar (SSS). The acquired imagery has high spatial resolution (0.15 m) and allowed the identification of 21 different habitat types. The most structured habitats (6) were dominated by corals and gorgonians, which covered 28% of the area. Vegetated habitats (8) represented 13% of the area, while unconsolidated habitats (7) occupied 59% of the area. Abundant coral patches on a sandy matrix, small coral patches surrounded by a seagrass halo, dominance of coral limestone patches aligned parallel to the prevalent waves, deep sand channels, and extensive gorgonian plains are all examples of previously uncharted habitats. Mangrove habitat could not be mapped with SSS. Habitats recognized were related to biologically relevant measures –structure, rugosity, benthic community composition and abundance- that are known to be the factors affecting fish community structure. Therefore, SSS is a particular valuable technique for quantitative assessments of habitat distributions important for fish management, e.g., habitat abundance and connectivity for essential fish habitat or MPA design.

KEY WORDS: habitat characterization, side scan sonar, small scale habitats, coral habitats

Identificación de Habitats de Arrecife de Coral a Pequeña Escala desde Imágenes de Sonar Lateral de Alta Resolución

Una caracterización detallada de hábitats es importante para entender como los organismos reaccionan y usan su ambiente, y para estudiar muchos procesos

ecológicos que ocurren a pequeña escala. Sin embargo, un conocimiento detallado necesita ser extendido sobre grandes áreas para determinar la distribución espacial de hábitats y su conectividad. Este asesoramiento de hábitats a mayor escala es crucial para determinar los efectos de disturbios, hetereogeneidad y dispersión entre parches de hábitats sobre las poblaciones marinas. Desafortunadamente, la identificación detallada de hábitats sobre grandes áreas es desconocida para la mayoría de las áreas de coral. En este trabajo, un total de 60 km^2 afuera de La Parguera, Puerto Rico, fue inspeccionada usando un sonar lateral (SSS). Las imágenes adquiridas fueron de alta resolución (0.15 m) y permitieron la identificación de 21 habitats diferentes. Los hábitas más estructurados (6) estuvieron dominados por corales y gorgonios, los cuales representaron un 28% del área. Los hábitas con vegetación (8) representaron un 13%, mientras que los hábitas de sedimentos no-consolidados ocuparon un 59% del área. Abundantes parches de coral en una matriz de arena, pequeños parches arrecifales rodeados por un halo de pasto marino, dominancia de parches de coral alineados paralelos al flujo de las olas, canales de arena profundos y extensas planos de gorgonios fueron todos ejemplos de hábitats previamente no mapeados. Los manglares no pudieron ser mapeados con un SSS. Los hábitats reconocidos se relacionaron con mediciones biológicas relevantes – estructura, rugosidad, composición de comunidades bénticas y abundancia- que son conocidos factores que afectan la estructura de la comunidad de peces. Por lo tanto, SSS fue una técnica particularmente valiosa para asesoramientos cuantitativos de la distribución de hábitats importante para el manejo pesquero, e.g., abundancia de hábitat y conectividad para EFH ó AMP.

PALABRAS CLAVES: Caracterización de hábitats, sonar lateral, hábitats a escala detallada, hábitats de coral

INTRODUCTION

Coral reef habitats exist as complex systems, spatially distributed as multiple patches interacting with their surroundings at different scales and serving as refugea, feeding areas and migratory pathways for many marine organisms, particularly for reef fishes. Detailed habitat information is essential to understand many ecological processes such as prey selection, predator detection, shelter choice, and choice of settlement location. However, this detailed knowledge of habitats needs to extend over a broad area in order to understand processes occurring at larger spatial and temporal scales, such us the effects of disturbance, heterogeneity and dispersal between habitat patches on marine populations. Detailed habitat properties, such as the spatial distribution of coral reef habitats, degree of habitat fragmentation, and habitat structure (rugosity) over large sections of the shelf are crucial to understand the relationship between reef habitats and reef fishes, and thus to determine what is Essential Fish Habitat (EFH).

Habitat characterizations combining high resolution with broad extent will require the use of active remote sensors, such as Side Scan Sonar (SSS) and

Geographic Information System (GIS) tools to be able to collect and analyze information over the full range of habitats, usually unknown for majority of reefs. The objective of this work was to identify coral reef habitats present on 60 km^2 of the insular shelf of Puerto Rico based on high resolution (0.15 m) SSS imagery necessary for further GIS manipulation.

METHODS

Study Area

The study area was located off La Parguera (17° 58' N, 67°02' W) in southwestern Puerto Rico, representing one of the widest and coral rich sections of the insular shelf (Figure 1). All benthic habitats contained within the area were surveyed, covering the entire shelf, from the shoreline the shelf edge (11.11 – 12.96 km offshore) in a 5.55 km swath, for a total of 63.4 km^2. The area was divided into 18 squares of 3.5 km^2 each, and one 0.64 km^2.

Data Acquisition and Processing

A 300 KHz transducer from Marine Sonic Technology, Inc was selected as the SSS system. Predefined transect lines, spaced 75 m apart, were navigated and SSS imagery was collected on 50 m of either side of each transect line. The resolution of the SSS imagery was 0.15 m. Data were acquired from 9 September 1998 to 28 November 1999, although only 21 days were run in 1998, and 27 days in 1999. Raw imagery was processed to eliminate electromagnetic interferences, and to produce bottom mosaics from which reef habitats were identified (Prada *et al.*, in preparation a).

Ground Truthing

To relate SSS imagery patterns to coral reef habitats, a total of 166 sites were visited to gather qualitative and quantitative information, resulting in 5-6 replicates per habitat type. However, the various grass, algae, sand and mud dominated habitats were each combined into single habitat types resulting in a total of 11 habitats for quantitative ground truthing. At each replicate site, we estimated percent cover of sand, rubble, live coral, dead coral, gorgonians, sponges, macroalgae, grass and Cyanophyta within four quadrats of 1 m^2. Merged habitats were described based only on qualitative ground truthing, which consisted of diver observations or of videotaping an average of 3 minutes per location. An additional 12 measurements of rugosity were determined at each sampled site using a 3-m chain (2 cm links). The surface rugosity index was proportionally calculated by dividing the difference between the extended chain length and the chain length over the reef contour by the extended chain length.

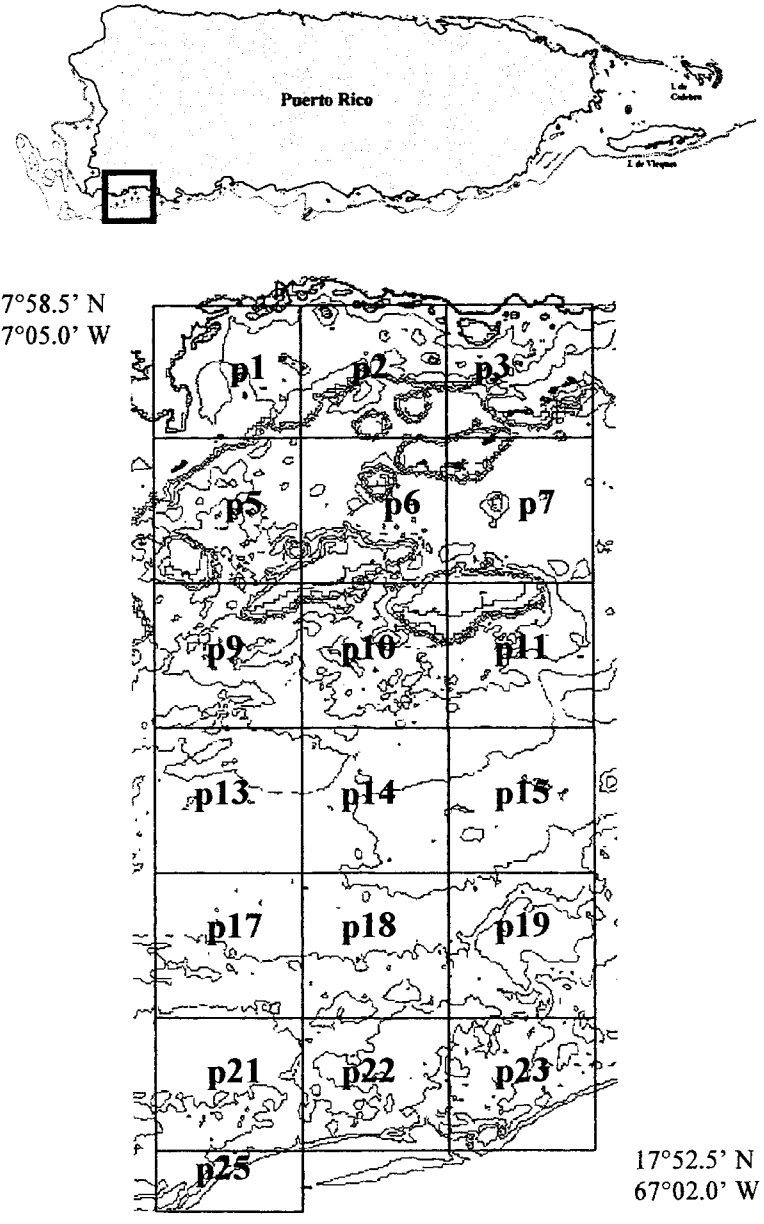


Figure 1. Bathymetric map of study area of 19 samples areas. Squares represent one square nautical mile exept for p25, which is only ½ square nautical mile.

RESULTS

The complexity of coral reef ecosystems within the study area was evidenced by a high number of habitat types (21) discriminated from the SSS imagery (Figures 2 – 6). Ground truthing helped to gather biological information and to define the identified habitat types, as presented in Table 1. Within the habitats having higher rugosity values (i.e., those of consolidated substrata), six habitat types were recognized, four being dominated by hard corals, and two by gorgonians. The moderately structured habitats included all vegetated habitats, of which nine habitat types were recognized, including five dominated by seagrasses and four by macro-algae. Flat and unconsolidated habitats having accounted for an additional seven habitat types, four being dominated by sand and three dominated by mud.

The unconsolidated habitat types occupied 59 % of the area, while the consolidated habitats cover 28 % of the area. The remaining vegetated habitats represented 13 % of the area. Interesting findings were the abundance of coral patches on a sandy matrix, small coral patches surrounded by a *Halophila decipiens* halo, the dominance of coral limestone patches aligned parallel to the prevalent waves, deep sand channels, and extensive gorgonian plains, all examples of previously uncharted habitats. However, mangrove habitat, an important nursery habitat, could not be discriminated from SSS imagery, and its abundance and spatial distribution would require the use of different sensors (passive sensors).

Besides the advantage of detecting and mapping several uncharted habitats, the true value of the SSS technology is that the imagery detects small changes in habitat rugosity and biological cover. Because of the importance of these factors in determining habitat structure, the identified habitats represented biologically distinct and ecologically relevant habitats. Such habitat information is expected to be essential in studying factors affecting the reef-fish community structure (Kimmel, 1985; Appelddoorn et al. in press, Prada et al. in preparation b).

Table 1. Quantification of habitat types found at La Parguera shelf using a MSTL SSS system.

Habitat type	Area (ha)	Characteristics
Continuous Corals	563.9	SSS return was characterized by strong reflection and comprised of distinct round structures representing the coral colonies.
	9.26 %	Coral reefs extending more than 200 m in any linear dimension having high rugosity. Include inshore reef platforms along the emergent reefs with a slope, or deep outer shelf platforms with no clear slope. Habitat having wide range of depths, from the surface down to 25 m.
Coral Patch	179.3	SSS return only differ from previous type in the smaller size observed from the patches.
	2.94 %	Coral patches smaller than 200 m in any linear dimension, separated from surrounding sandy by a sharp boundary. Patches vary in size, shape, health condition and relief, usually with higher percent cover of dead coral and soft algae than continuous corals habitats. Maximum coral patch density was found at the mid shelf, but they can be found also inshore and offshore in depths of 12-24 m.
Coral Limestone	277.6	SSS return clearly identified the elevated patches having a strong reflection similar to previous corals habitats but having less roughness.
	4.56 %	Corals with distinct boundaries, growing on westerly aligned coral ridges of 1-3 m in height. Hard corals having less relief in relation with previous coral habitat types. Habitat dominant in outer shelf, occurring at 13 - 21 m. Areas of this habitat were separated from each other by sand channels to form an overall system that has been commonly named in the literature as the spur and groove habitat.
Gorgonian Patch	11.2	SSS identified them as bright patches with smooth texture.
	0.18 %	Distinct patches of mixed species, where gorgonians dominated benthic coverage. Habitat found within the first 6 km of the shelf from shore, with depths ranging from 4.5 to 12 m.
Gorgonian Plains	614.9	SSS imagery was characterized as bright and grainy returns.
	10.01 %	Flat and extensive areas where live cover is dominated by gorgonian colonies mixed with isolated corals low relief. Found 12-18 m deep on the outer and mid shelf.

Table 1 continued:

Habitat type	Area (ha)	Characteristics
Elevated Gorgonians	59.9	SSS was similar to previous but in addition present an abrupt boundary with the adjacent deeper habitats.
	0.98 %	Flat surfaces covered by gorgonians, as above, but sharing abrupt boundaries with the adjacent deeper sand habitats, implying the presence of a distinct raised margin.
Dense Grass	268.7	SSS return was characterized by an area of continuous rough texture with isolated bright areas.
	4.41 %	Dense cover of seagrass (80-100% cover). The seagrass *Thalassia testudinum* was the most common species, growing monospecifically, or mixed with *Syringodium filiforme.* This habitat occurred inshore and shallow (0.5 – 3 m).
Sparse Grass	59.2	SSS was similar to previous but bright areas were more abundant.
	0.97 %	Seagrass with variable coverage, between 40-75%. Fine and/or coarse sand accounted for around 30 % cover mostly by calcareous algae.
Grass and Invertebrates	85.5	SSS return was similar to other grass habitats but mixed with strong reflections from isolated corals and gorgonians.
	1.40 %	Sparse grass habitat mixed with larger invertebrates, including isolated coral colonies, sponges, and gorgonians. Invertebrates reach larger sizes and can be identified from the SSS. Habitat found mostly on the protected sides of the emergent reefs and in smaller areas on the exposed side of inshore reefs
Grass Halo and Coral Patch	15.6	SSS identified them as a dark halo surrounding small coral patches.
	0.26 %	Grass Halo and Coral Patch was defined as the combination of deep (mean of 23.5 m depth) and relatively small coral patch reefs, 3-8 m in diameter, surrounded by a halo of *Halophila decipiens.* Habitat located in proximity to Continuous Corals.
Dense Algae on Sand	31.2	SSS was characterized as patches of dark return.
	0.51 %	Dense algae patches embedded on a sandy matrix. Habitat observed at middle and outer shelf at 17 – 20 m deep. Algae were mostly Rhodophyta mixed with Chlorophyta.

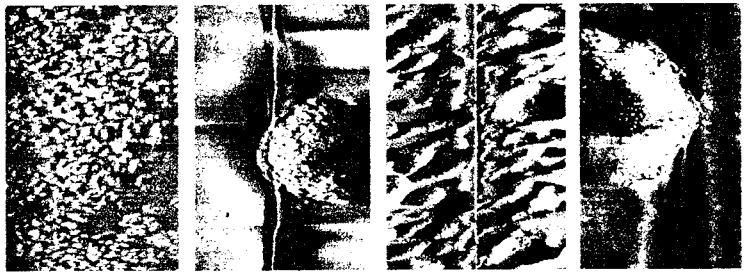
Table 1 continued:

Habitat type	Area (ha)	Characteristics
Sparse Algae on Sand	45.5	SSS was characterized by alternating dark and bright areas corresponding to algae and sand respectively.
	0.75 %	Broad areas of sparse algae growing on sandy plains, with no abrupt boundaries. Found in relativly deep water, between 15-20 m and predominantly on the middle shelf.
Deep Algae on Mud	272.3	SSS imagery was characterized as low returns with smooth texture.
	4.47 %	Dense or sparse algae growing on a silty-sand matrix. Green calcareous algae dominated, mixed with several other species of fleshy algae. Habitat present inshore as shallow as 3 – 6 m, and as deep as 12-15 m.
Shallow Algae on Mud	26.0	SSS pattern was similar to previous but presented more texture.
	0.43 %	Algal cover growing on silty-sands with no distinct boundaries. Greater abundance of green and red fleshy algae. Habitat occurred only inshore and shallow (< 3 m).
Sand with Invertebrates	453.2	The SSS return was a bright reflection presenting isolated structures.
	7.44 %	Biogenic coarse sand covered with sparse coral and gorgonians. It was assumed the sand constituted a veneer over underlying hard bottom since corals or gorgonians do not recruit on unconsolidated sediments.
Sand- No Ripple	1530.0	SSS return was characterized as a continuum bright reflection.
	25.12 %	Biogenic coarse sand with greater than 85 % cover, but not having distinct sand ripples or waves. It was found around emergent reefs or over extensive plain areas 12-18 m deep on the mid and outer shelf, mostly between the coral limestone habitat.
Sand-Ripple	853.4	SSS was similar to previous but having clear ripple marks.
	14.01 %	Similar as previous, but having characteristic sand ripple or waves oriented at the right angles to the prevailing surface swell. Habitat found mostly at the outer shelf, especially in large areas over the southeast section.

Table 1 continued:

Habitat type	Area (ha)	Characteristics
Sand Fine	194.6	SSS was similar to sand no ripple but with lower brightness.
	3.19 %	Similar to sand- no ripple habitat, but having sands with smaller grain sizes. Habitat present mostly on the mid shelf (5-9 km from shore) and responsible for a turbid layer found in waters close to the bottom.
Mud Bare	172.6	SSS appeared as a uniform dark and soft return.
	2.83 %	Unconsolidated sediments, mostly grayish/brownish silt, silty-sand and fine sands (> 90% cover) with very little biological cover. Occurred on the inner shelf, 8 - 21 m depth.
Mud and Invertebrates	361.8	SSS return recognized the biological coverage as an increasing texture in relation with previous habitat.
	5.94 %	Similar habitat as previous, but having more biological coverage such as small sponges and fleshy algae. Occurring only on the inner shelf.
Mud Reef	0.3	SSS return similar to previous but clearly identified its elevation.
	0.004 %	Accumulated and cemented mud forming an elevated feature with minimal biological cover. uncommon habitat, located inshore of an emergent reef.

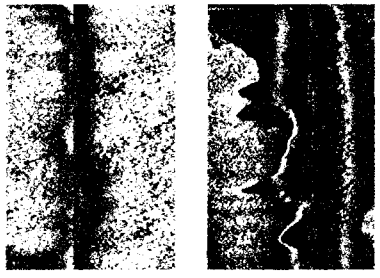
Coral Dominated Habitats



	Continuous Corals	Coral Patch	Coral Limestone	Gorgonian Patch
Number of Taxa :	88	73	85	92
Rugosity:	0.31	0.27	0.22	0.24
% Live hard coral	30	27	20	8
% Dead hard coral	36	31	31	17
% Gorgonian	12	9	9	39
% Sponges	3	1	3	5
% Algae	9	27	26	5
% Rubble	1	0.6	9	3
% Unconsolidated	10	4	5	16

Figure 2. Side Scan Sonar (SSS) imagery of coral dominated habitats off La Parguera, Puerto Rico

Gorgonian Dominated Habitats



	Gorgonian Plain	Elevated Gorgonians
Number Taxa :	91	
Rugosity:	0.09	
% Live hard coral	10	
% Dead hard coral	16	
% Gorgonian	24	
% Sponges	2	
% Algae	15	
% Rubble	3	
% Unconsolidated	28	

Figure 3. Side Scan Sonar (SSS) imagery of gorgonian dominated habitats off La Parguera, Puerto Rico

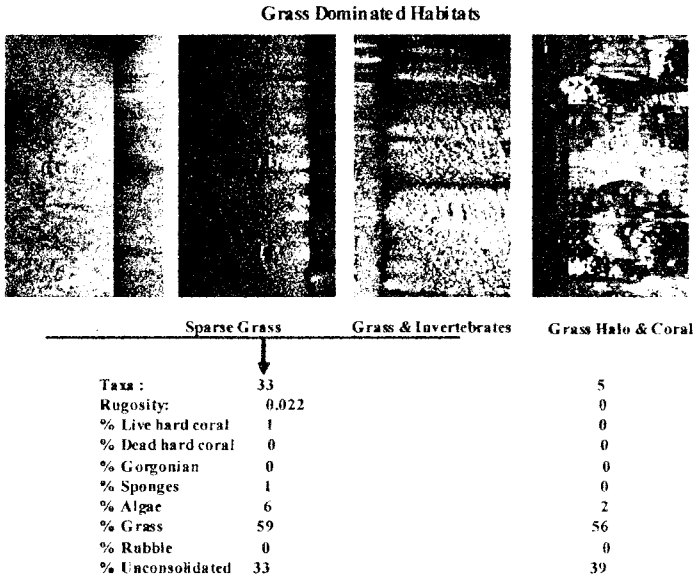


Figure 4. Side Scan Sonar (SSS) imagery of grass dominated habitats off La Parguera, Puerto Rico

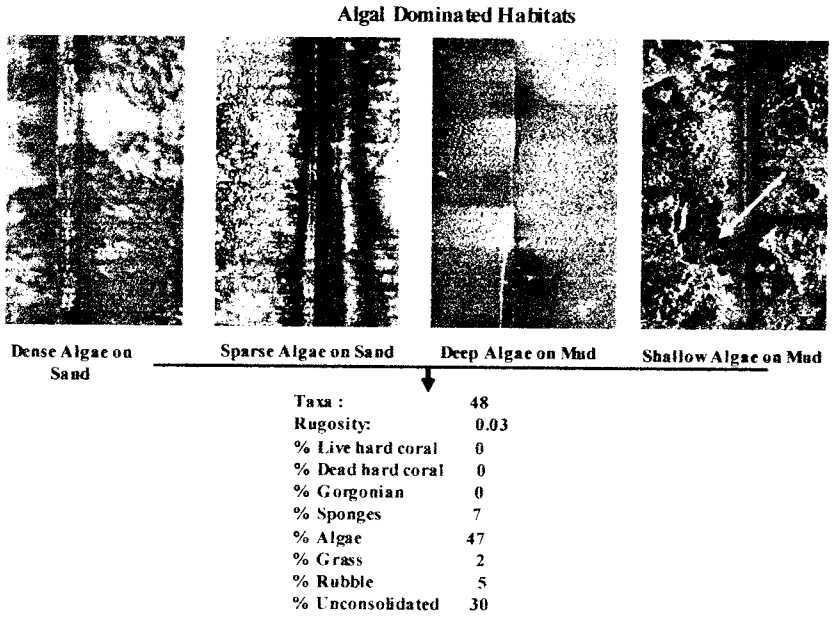


Figure 5. Side Scan Sonar (SSS) imagery of algal dominated habitats off La Parguera, Puerto Rico

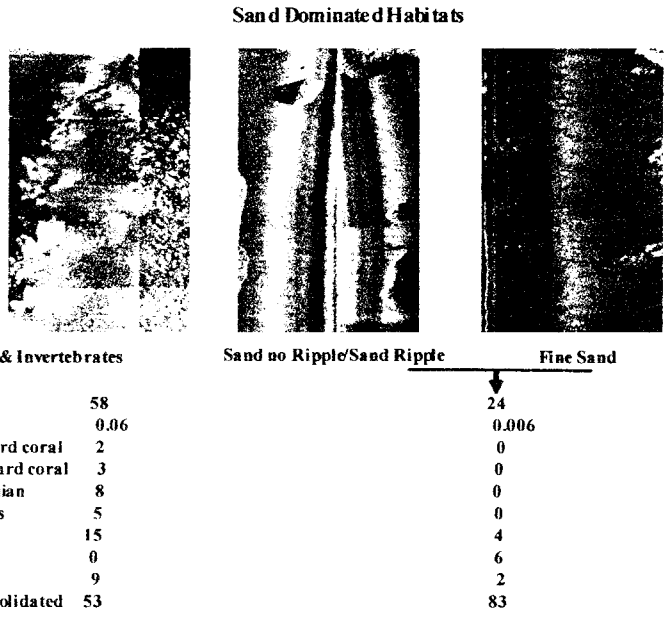


Figure 6. Side Scan Sonar (SSS) imagery of sand dominated habitats off La Parguera, Puerto Rico

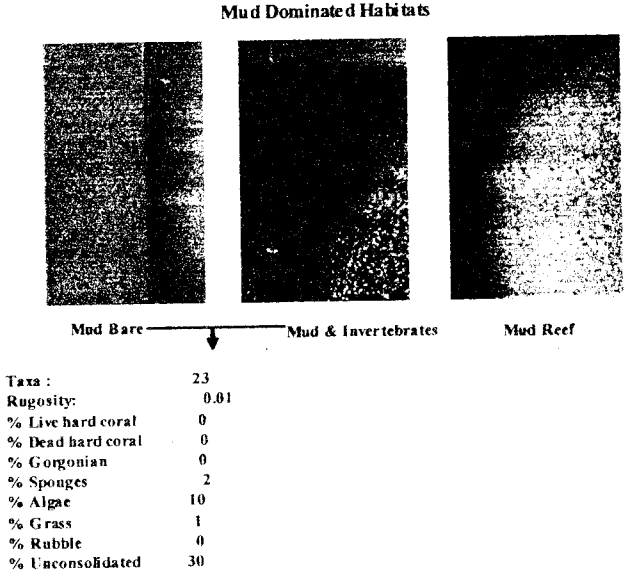


Figure 7. Side Scan Sonar (SSS) imagery of mud dominated habitats off La Parguera, Puerto Rico

DISCUSSION

Spatially explicit knowledge of the habitat components and their respective spatial distributions, detected by the high SSS imagery, allows for the quantification of habitat abundance and patchiness using GIS manipulations and subsequently to determine habitat connectivity. Such information is necessary for fisheries management and for developing criteria for siting MPAs. For instance, small coral patches have been found to support higher densities of reef fishes (Randall 1963, Ault and Johnson 1998, Chittaro 2000, Prada et al. in preparation b). These patches play an important role in connecting settlement areas with adult habitats in ontogenetically migrating fishes (*sensu* Appeldoorn et al. in press). Thus, the possibility of mapping small coral patches is of great value for fishery biologists.

While coral reefs themselves are particularly valuable habitats for commercially important fisheries and the maintenance of system biodiversity, total production and diversity are likely to depend on a variety of habitat related factors including, abundance, location, degree of connectivity, and the surrounding matrix of other habitats (*e.g.*, Appeldoorn et al. in press). Ontogeny of many reef fishes is usually characterized by shifts in diets/habits (Wissinger 1994) resulting in juvenile fishes having special and different habitats separate from adults (Lirman 1994, Green 1996, Appeldoorn et al. 1997, Beukers and Jones 1997, Dahlgreen and Egleston 2000, and Eagle et al. 2001). Knowledge of these requirements coupled with high resolution habitat information can be used to determine where ecological connectivity exists and to what extent it may occur.

Qualitative differences in rugosity detected in SSS imagery and quantified by field measurements allowed distinction of benthic habitats in coral reef systems. Rugosity has been known to be a good predictor of fish abundance (Gladfelter and Gladfelter 1978, Luckhurst and Luckhurst 1978, Alveizon et al. 1985, Choat and Bellwood 1991, Green 1996, Appeldoorn et al. 1997, Coreless et al. 1997, Roberts 1997, Friedlander and Parrish 1998, Syms and Jones 2000, Eagle at al. 2001). As such, any improvement in resolving habitat structure should result in even greater information and utility of SSS habitat information. This would be possible, for example, if SSS imagery were merged with multi-beam bathymetry (*e.g.*, de Moustier and Matusmoto 1993), obtaining greater definition of topographic complexity, especially at sites with pronounced slope.

ACKNOWLEDGEMENTS

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Preliminary Results: Fate of Regulatory Discards from the Red Snapper, *Lutjanus campechanus*, Commercial Fishery in the Northern Gulf of Mexico

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ABSTRACT

The red snapper, *Lutjanus campechanus*, is one of the most important and most controversial fish species in the northern Gulf of Mexico. For stock assessment models to be as accurate as possible, mortality estimates, including those associated with regulatory discards, should be known or at least estimated within a reasonable margin of error. In this study, we used observers onboard red snapper commercial fishing vessels to determine the number and condition of regulatory (undersize) discards during normal fishing operations. A total of 2,075 discards from 108 separate fishing locations during eight fishing trips were observed and characterized for release condition. All were caught with "bandit" multi-hook fishing gear at water depths of 17 to 85 m (mean = 44 m); the mean size and age of a random sampling (n = 202) of discards were 13 inches mm TL and 2 years, respectively. Of the discards, 363 (17 %) swam down vigorously, 396 (19 %) stayed at the surface momentarily before orienting toward the bottom, 794 (38 %) were released alive but never swam down, and 532 (26 %) were discarded dead. Based on qualitative characteristics of the discard release condition, 64 % of specimens returned to the water were dead or near death as evidenced by their failure to re-submerge. Discard mortality observed in this study was almost twice the current estimate (33 %) used in red snapper stock assessment models.

KEY WORDS: Discard, Mortality, Red Snapper

El destino de Regulativo Tira de la Pesquería Comercial de Huachinango (*Lutjanus campechanus*) en el Golfo Septentrional de México

El huachinango, *Lutjanus campechanus*, es uno de la mayoría importante y la mayoría de la especies polémicas de pez en el Golfo septentrional de México. Para modelos de evaluación de acciones para ser tan exacto como sea posible, las estimaciones de la mortalidad, inclusive esos asociado con regulativo tiran, deben ser sabidas o por lo menos estimado dentro de un margen razonable del error. En este estudio, nosotros usamos onboard de observadores naves huachinango pesca de propaganda para determinar el número y la condición de regulativo (más pequeño que legal) tira durante operaciones pesqueras normales. Un suma de 2,075 tira de 108 ubicaciones pesqueras separadas durante ocho viajes pesqueros fueron

observados y fueron caracterizado para la condición de la liberación. Todo se agarró con "bandido" multi gancho pescando engranaje en profundidades de agua de 17 a 85 M (medio = 44 M); el tamaño y la edad medio de un azar que prueba (N = 202) de tira eran 13 inches TL y 2 años, respectivamente. Del tira, 363 (17 %) nadó hacia abajo vigorosamente, 396 (19 %) permanecido en la superficie momentáneamente antes orientar hacia el fondo, 794 (38 %) fueron liberados vivo pero nunca nadaron hacia abajo, y 532 y (26 %) fueron tirados muerto. Basado en características cualitativas del tira la condición de la liberación, 64 % de muestras vuelta al agua era muerte muerta o cercano como evidenciada por su fracaso a re-sumerge. Tire la mortalidad observada en este estudio era casi dos veces la corriente estima (33 %) usado en modelos huachinango de evaluación de acciones.

PALBABRAS CLAVES: Huachinango, mortalidad, tira

INTRODUCTION

The red snapper *Lutjanus campechanus* is one of the most economically important fish species in the northern Gulf of Mexico (GOM). Red snapper commercial fishermen are currently allowed a Gulf-wide quota of 2,114 metric tons (4.65 million lb) that is divided into a winter and autumn season. Both seasons are currently open to red snapper harvest only for the first 10 days of each successive month until the quota is achieved. A trip limit of 0.91 metric ton (2000 lb) for holders of federally issued reef fish permits and the modest number of available fishing days has resulted in a "derby" fishery which necessitates maximum catch in a minimum of time. To compete in this derby fishery, many commercial fishermen maximize their fishing time during each 10-day period by concentrating on nearshore fishing locations. Thus, the majority of red snapper in the commercial fishery are harvested as close to port as is possible (perhaps in relatively shallow water) and as soon as they achieve legal size as three to four year olds, or shortly thereafter. There is little financial incentive to fishermen to venture farther offshore to deeper waters where the larger, older red snapper are presumed to live.

An unfortunate consequence of this derby style fishery is an increase in the number of regulatory (undersize) discards. Current research has shown that the vast majority of red snapper harvested in the commercial fishery are at or just slightly above minimum legal size (Wilson and Nieland 2000). The number and condition of regulatory discards is poorly understood, but the most recent red snapper stock assessment (1999) assumes 33 % mortality for the commercial fishery. Two studies simulating techniques used in the red snapper recreational fishery have estimated discard mortality to range between 1 % and 44 % depending on depth of capture (Gitschlag and Renaud 1994, Render and Wilson 1994). The National Marine Fisheries Service initiated an observer program in 1995, and included some trips aboard commercial handline vessels. Discard mortality was reported to be only 1.6 %, but most of the discards had either inflated gas bladders and/or protruding eyes and probably suffered delayed mortality (Shirripa and Legault 1999). A recent,

more qualitative study of red snapper discard release condition, based on the Texas red snapper recreational headboat fishery, indicated that as many as 39 % of discards were released dead or near death (Dorf 2002). Despite these research efforts, little information is available concerning the number and condition of regulatory discards of the commercial handline fishery.

For stock assessment models to be as accurate as possible, mortality estimates, including those associated with regulatory discards, should be known or at least estimated within a reasonable margin of error. Should it be shown that discard mortality is a significant factor in the red snapper commercial fishery, perhaps a re-evaluation of minimum sizes as part of an overall management strategy would be in order. The goal of this study was to determine the number and condition of regulatory (undersize) discards of the red snapper commercial handline fishery. Our specific objectives were to determine the catch-and-release mortality and the age and length composition of red snapper regulatory discards.

METHODS

Louisiana State University personnel accompanied fishermen onboard red snapper commercial handline fishing vessels during eight trips from November 2001 through April 2002. Trips were approximately 2 - 5 days in length, with each trip usually resulting in a catch of up to 0.91 metric tons. Based on criteria set forth by Patterson (1999), regulatory discards were categorized as:

i) Alive and swam down vigorously,
ii) Swam down slowly and/or erratically,
iii) Alive, but floated and remained at the surface, or
iv) Unresponsive or dead.

Water depth, capture depth, date of capture, capture location, and type of fishing gear were also recorded. In addition, approximately 25 discards from each trip were sampled for age and length analysis. Fork length (FL) and total length (TL) in inches (because the U. S. fishery is based on a 15 inch minimum size) and whole body weights (BW) in g were recorded for each fish. Both sagittal otoliths were removed and weighed to the nearest 0.1 mg. Sex of each specimen was recorded when possible. Otolith preparations and ageing protocols followed standard procedures previously described elsewhere (Wilson and Nieland 2001).

RESULTS AND DISCUSSION

A total of 2,075 red snapper discards from 108 separate fishing locations during eight fishing trips were observed and characterized for release condition. All discards were caught with "bandit" multi-hook fishing gear at water depths of 17 to 85 m (mean = 44 m). Of the discards, 363 (17 %) swam down vigorously, 396 (19 %) stayed at the surface momentarily before orienting toward the bottom, 794 (38 %) were released alive but never swam down, and 532 (26 %) were discarded dead (Figure 1). Based on qualitative characteristics of the discard release condition, 64

% of specimens returned to the water were dead or near death as evidenced by their failure to re-submerge.

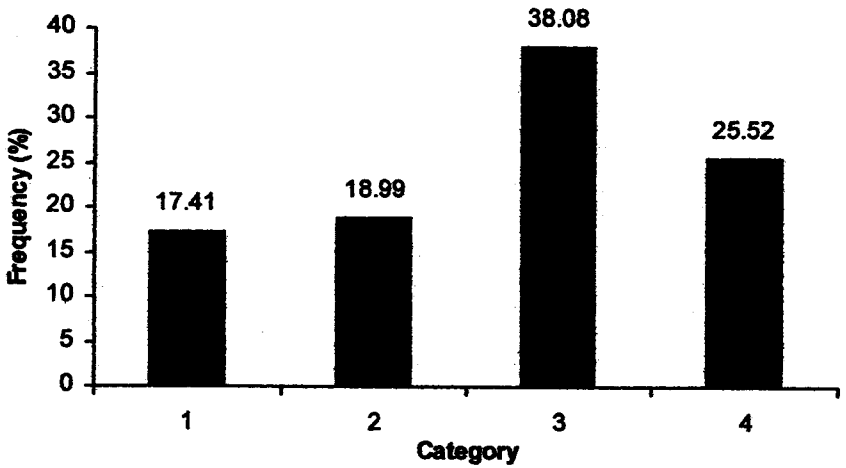

Figure 1. Fate of 2,075 regulatory (undersize) discards from the red snapper commercial fishery. Discards were categorized as 1) alive and swam down vigorously, 2) swam down slowly and/or erratically, 3) alive, but floated and remained at the surface, or 4) unresponsive or dead.

The mortality rate observed in this study is considerably higher than the current estimate (33 %) used in red snapper stock assessment models and rates reported by previous studies (Shirripa and Legault 1999). Two studies simulating fishing techniques used in the red snapper recreational fishery have estimated discard mortality to range between 1 % and 44 % depending on depth of capture (Gitschlag and Renaud 1994; Render and Wilson 1994). Render and Wilson (1994) speculated that some of the snappers released alive suffered delayed mortality due to physiological stress and/or predation. A 1995 study which employed National Marine Fisheries Service (NMFS) observers onboard several red snapper commercial fishing trips offshore of Louisiana and east Texas reported a low incidence of discard mortality (1.6 %), but emphasized that most of the discards had either inflated gas bladders and/or protruding eyes and probably suffered delayed mortality (Shirripa and Legault 1999). Dorf (2002) also reported a low incidence of actual discard mortality (1.4 %) in the Texas headboat recreational fishery; but again, they too speculated that as many as 39 % of discards released "alive" probably died after release.

Fishing techniques used in the red snapper recreational and commercial fisheries are considerably different and could result in the large discrepancy in discard mortality rates between our study and previous ones. Recreational fishermen typically use rod and reel gear with one or two hooks per line and exhibit more care

and attention to the handling of individual fish. In contrast, the commercial fishery commonly employs the use of large diameter "bandit" reels with multi-hook (~ 20) gear which are capable of bringing fish to the surface much more rapidly than the standard recreational gear described. In addition, commercial fisherman are often handling an order of magnitude more fish per site than recreational fishermen, limiting their capacity to provide undivided attention to individual fish. With the exception of the 1995 NMFS observer survey, all previous discard studies were based on recreational fishing practices conducted by recreational fishermen and/or researchers.

The size and age estimates of a random sampling (n = 202) of regulatory discards indicate an overwhelming majority of two year old snappers (95 % age 2, 4.5 % age 3, and 0.5 % age 4) with a modal TL of 13 inches (Figure 2). This was not at all surprising considering:

i) The 15 inch minimum size limit for the commercial fishery and
ii) The abundance of three and four year olds (~70 %) harvested in the commercial fishery (Wilson and Nieland 2000).

Over the last decade or so, young red snapper have become increasingly prevalent in the commercial catch and old red snapper (up to at least 55 years) have essentially disappeared from the harvest.

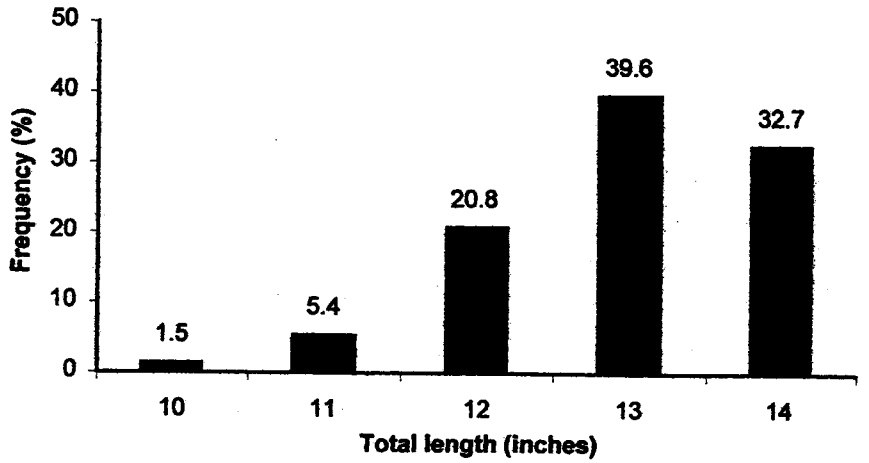

Figure 2. Total length frequency of a random sample of 202 regulatory (undersize) discards sampled from the red snapper commercial fishery.

Our study suggests that as many as 64 % of discards suffered mortality during the course of normal commercial fishing operations, nearly twice the estimate (33 %) used in the current stock assessment (Schirrippa and Legault 1999). The majority of these discards were within two inches of the minimum size limit. The total weight of discards accounted for roughly 14 % of the total catch weight of red

snappers (8 trips). There is little incentive, financial or otherwise, to fishermen to venture farther offshore to deeper waters where the larger, older red snapper are presumed to live. Research has shown that the heavy harvest sustained by the younger age-classes appears to have little effect on the red snapper population (Wilson and Nieland 2000). We suggest that perhaps it is time to re-evaluate the minimum size limit for the red snapper fishery, or in the least, raise the discard mortality rate used in the next stock assessment to a more appropriate level.

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Primeros Resultados sobre la Reproducción del Pargo del Golfo *Lutjanus campechanus* (P. 1860), de la Plataforma Continental de la Península de Yucatán, México

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RESUMEN

La proporción de sexos, la talla de primera madurez sexual y el ciclo sexual del pargo del Golfo han sido investigados entre marzo de 1999 y febrero de 2002, mediante el análisis de 1,280 organismos (Longitud total LT = 23.8-85.9 cm). Los especimenes de *L. Campechanus* fueron capturados por las flotas pesqueras de las costas norte (Progreso) y oeste (Campeche) de la Península de Yucatán. Las gónadas de los pargos del Golfo colectados fueron pesadas (cálculo del Índice gonadosomático) y examinadas microscópicamente (clasificación por estadio de maduración). No se observó diferencia significativa ($p > 0.05$) entre la proporción de sexos global observada (1:1.05; macho:hembra) y la de una proporción de sexos equilibrada (1:1). La talla mínima de primera madurez sexual fue de 24.7 cm LT para hembras y 23.8 cm LT para machos. Importante proporción de hembras y machos (n > 30 % cada mes) fueron encontrados sexualmente activos todo el año. La temporada de desove de la especie ocurrió entre marzo y noviembre, con picos de emisión de gametos en mayo y de agosto a octubre. Se observó que las áreas de desove de *L. Campechanus* en el sureste del Golfo de México, se ubican en la parte norte y noroeste del Banco de Campeche, entre 48 y 117 m de profundidad.

PALABRAS CLAVES: *Lutjanus campechanus*, reproducción, Golfo de México, Banco de Campeche

Reproductive Aspects of the Red Snapper, *Lutjanus campechanus* (P. 1860), from the Continental Shelf of the Yucatan Peninsula, Mexico

Sex ratio, length at first maturity, and the sexual cycle of red snapper were investigated between March 1999 and February 2002, through the analysis of 1,280 organisms (Total length Tl = 23.8-85.9 cm). *L. campechanus* specimens were caught by the fishery fleet from the northern (Progreso) and western (Campeche) coasts of Yucatan Peninsula. Collected red snapper gonads were weighed (for gonadosomatic index calculation) and microscopically examined (for stage of maturation classification). Global sex ratio (1:1.05; female:male) did not differ

significantly from a 1:1 sex ratio ($p > 0.05$). Minimum size at first maturity was 24.7 cm Tl for females and 23.8 cm Tl for males. High frequency of females and males ($n > 30$ % each month) were found sexually active all the year round. Spawning period of the species occurred between March and November, with gamete release peaks in May and from August to October. Spawning areas for red snapper from the southern Gulf of Mexico were observed in the northern and northwestern parts of the Campeche Bank, between 48 and 117 m depth.

KEY WORDS: *Lutjanus campechanus*, reproduction, Golfo of Mexico, Campeche Bank

INTRODUCCIÓN

El pargo del Golfo *Lutjanus campechanus* (P. 1860) conocido en México como huachinango del Golfo o huachinango de castilla, se distribuye a lo largo de la costa este de Norte América, desde Massachusetts en Estados Unidos hasta la extremidad oriental de la costa norte de la Península de Yucatán en México (Allen 1985). Los adultos viven sobre fondos rocosos entre 10 y 190 m de profundidad y los juveniles sobre fondos de arena o lodo, en aguas someras. Esta especie representa uno de los lutjanidos más importantes explotados por la pesca en el Golfo de México, tanto en términos de peso desembarcado como de valor comercial (Allen 1985).

En México, el estado de Yucatán representa el principal productor pesquero de *L. campechanus* para la región del Golfo de México (DOF 2000, SAGARPA 2001). En el periodo 1994 - 1997, su elevado precio unitario (2.94 US$/kg) lo ubicó económicamente en el cuarto lugar con respecto al valor de la captura total del Estado (Castro-Suaste et al. 2000). Actualmente, la pesquería de lutjanidos de la plataforma continental de la Península de Yucatán (Banco de Campeche) es considerada aprovechada al máximo sustentable (DOF 2000). Sin embargo, la tendencia histórica en la producción de pargo del Golfo en Yucatán, se caracteriza por un incremento de las capturas hasta alcanzar un máximo en 1989 (2,213 toneladas) seguido por un descenso progresivo hasta 2000 (832 toneladas). Así, entre 1989 y 2000, las capturas de *L. campechanus* del Banco de Campeche se redujeron a un 62 % aproximadamente (SEMARNAP 1999, SAGARPA 2001). Con el fin de disminuir los potenciales riesgos de sobreexplotación del recurso es necesario proponer esquemas adecuados de ordenamiento y manejo de la pesquería, los cuales están basados en la evaluación del stock y en el conocimiento de la biología de la especie explotada.

En relación con la biología de la reproducción del pargo del Golfo, estudios previos fueron realizados por Moseley (1966), Bradley y Bryan (1975) y Futch and Bruger (1976) para la población del noreste del Golfo de México. Más recientemente, Collins et al. (1996, 2001) presentaron resultados sobre el periodo de reproducción, las áreas de desove y la fecundidad de la especie para la región noreste y noroeste del Golfo de México. Los datos publicados sobre la reproducción de este lutjanido para la población de la región sur del Golfo de

México son más escasos. Estos fueron proporcionados a través de estudios preliminares realizados por Camber (1955) en el Banco de Campeche y por González de la Rosa y Ré-Regis (1996) a lo largo de la costa norte del estado de Campeche.

El propósito de esta investigación fue completar y actualizar la información disponible sobre la reproducción de *L. campechanus* en el sur del Golfo de México haciendo énfasis en las épocas y áreas de desove de la especie en el Banco de Campeche.

MATERIAL Y MÉTODOS

La mayor parte de los ejemplares de *L. Campechanus* (24.2 - 85.9 cm de longitud total; n = 1,069) analizados en este estudio fueron obtenidos mensualmente de las capturas comerciales realizadas por barcos pesqueros del puerto de Progreso, entre marzo de 1999 y abril 2000. Los organismos fueron capturados con líneas de mano maniobradas a través de un equipo llamado "bicicleta" (carrete y manivela), sobre fondos duros, entre 44 y 104 m de profundidad, en la región norte (Arrecife Alacranes-Bajos del Norte) y noroeste (Cayo Arenas-Banco Ingleses-Bajo Nuevo) del Banco de Campeche (Figura 1). Otros organismos (23.8 - 39.4 cm de longitud total; n = 211), procedentes de la pesca ribereña de la costa del estado de Campeche fueron obtenidos en febrero 2002 con el propósito de analizar ejemplares juveniles.

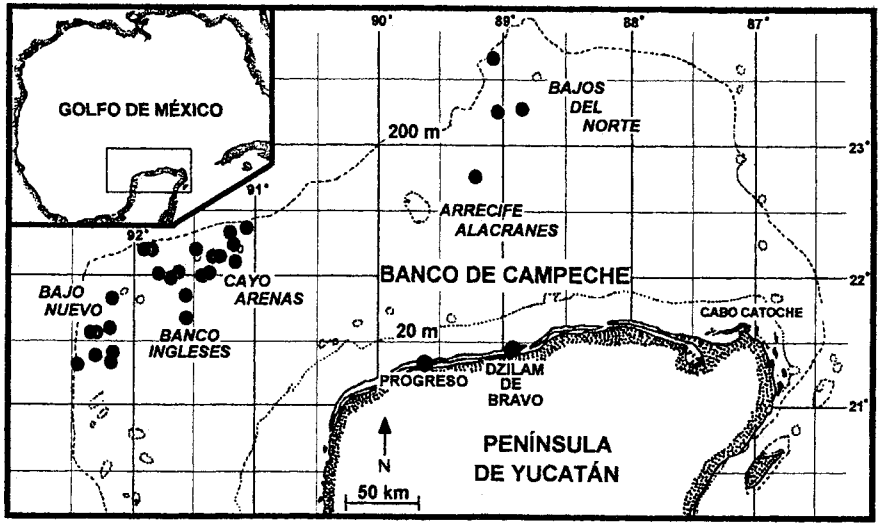

Figura 1. La costa norte de la Península de Yucatán y el Banco de Campeche. Los sitios de pesca representados de negro (·) indican los lugares donde fueron capturadas las hembras de *L. Campechanus* en fase de desove (presencia de ovocitos VI hialinos y/o de folículos postovulatorios en los ovarios), entre marzo de 1999 y abril de 2000.

Para cada espécimen colectado, se registraron las longitudes total y furcal (LT y LF, cm); los pesos total y del pez eviscerado (PT y PEV, g), y el peso de las gónadas (PG, g). Además, se fijó en solución de Bouin un fragmento de la parte media de una de sus gónadas. Se realizó el análisis histológico de todas las muestras de glándulas sexuales recolectadas, las cuales fueron incluidas en parafina, cortadas a un grosor de 6 μm, y tenida con el tricromo de Masson (Gabe 1969).

El sexo de los organismos fue determinado a través del examen microscópico de las gónadas, y se calculó la proporción de sexos global (Machos:Hembras, M:H) y por clase de tallas de 5 cm de intervalo.

El grado de desarrollo sexual de las hembras y machos fue analizado tomando en cuenta los estadios de desarrollo celular de la ovogenésis y espermatogénesis caracterizados por Moe (1969) y Brulé et al. (1999) para el mero rojo *Epinephelus morio*. Según su estadio microscópico de desarrollo gonadal, cada hembra y macho fueron clasificados en una de las cinco clases de madurez sexual presentadas en la Tabla 1.

Se consideró como talla mínima de primera madurez sexual en hembra y macho, la longitud total del más pequeño organismo de cada sexo, observado en los muestreos, y cuyo estado gonadal correspondía a una de las clases sexuales siguientes: "2 - En reposo" , "3 - En maduración", "4 - En desove/emisión" o "5 - En postdesove/postemisión)

El ciclo sexual fue analizado a través del seguimiento de la evolución mensual de los valores individual y promedio del índice gonadosomático (IGS = 100*PG/PEV) y de los porcentajes de cada clase sexual definida, tanto para hembra como para macho y sin considerar a los organismos inmaduros.

Los sitios de pesca en los cuales se capturaron hembras clasificadas como "4 - En desove" fueron considerados como áreas de probable desove de la especie.

RESULTADOS

Proporción de Sexos

Los valores de proporción de sexos por clase de tallas no fueron estadísticamente diferentes a los de una proporción de sexos equilibrada (1:1), excepto para la clase 22.6 - 27.5 cm LT, en la cual predominaron las hembras procedentes de la costa de Campeche (Tabla 2). La proporción de sexos global fue sesgada a favor de las hembras para el muestreo de la costa de Campeche (1:1.37): Sin embargo, no presento diferencia significativa de una proporción de sexos equilibrada el muestreo realizado en el Banco de Campeche (1:0.99) y el muestreo total (1:1.05).

Tabla 1. Clases sexuales y aspectos microscópicos de los ovarios y testículos en hembra y macho del *L. campechanus* del sur del Golfo de México.

Clase sexual	Hembra	Macho
1 - Inmadura(o)	* Ovogonias	*Cistes a espermatogonias
2 - En reposo	* Ovogonias * Ovocitos previtelógenos I y II * Cuerpos amarillos * Masas musculares	* Numerosos cistes a espermatogonias * Escasos espermatozoides residuales en lumen central
3 - En maduración	* Ovogonias, * Ovocitos previtelógenos I y II, * Ovocitos vitelógenos III-V	* Escasos cistes a espermatogonias * Numerosos cistes a espermatocitos y espermatidas * Escasos cistes a espermatozoides
4 - En desove/emisión	* Ovogonias * Ovocitos previtelógenos I y II * Ovocitos vitelogenos III-VI (hialino) * Folículos postovulatorios (fpo)	* Escasos cistes a espermatogonias, espermatocitos y espermatidas * Numerosos cistes a espermatozoides y/o numerosos espermatozoides libres en lumen central
5 - En postdesove/postemisión	* Ovogonias * Ovocitos previtelógenos I y II * Ovocitos vitelógenos III-V en atresia á y â	* Cistes a spermatogonias * Espermatozoides libres residuales en lumen central

Tabla 2. Números de hembras y machos y proporción de sexos de *L. campechanus* en la costa de Campeche y en el Banco de Campeche (marzo de 1999-febrero 2002).

Longitud	Hembras (N)[a]			Machos (N)			Proporción de sexos (M:H)[b]		
total (cm)	CC[c]	BC[d]	Total	CC	BC	Total	CC	BC	CC+BC
22.6-27.5	58	1	59	36	2	38	1:1.61*	1:0.50	1:1.55*
27.6-32.5	54	8	62	47	4	51	1:1.15	1:2.00	1:1.22
32.6-37.5	8	45	53	6	38	44	1:1.33	1:1.18	1:1.21
37.6-42.5	2	83	85	0	88	88	—	1:0.97	1:0.97
42.6-47.5	0	141	141	0	125	125	—	1:1.13	1:1.13
47.6-52.5	0	108	108	0	98	98	—	1:1.10	1:1.10
52.6-57.5	0	67	67	0	77	77	—	1:0.87	1:0.87
57.6-62.5	0	41	41	0	54	54	—	1:0.76	1:0.76
62.6-67.5	0	20	20	0	26	26	—	1:0.77	1:0.77
67.6-72.5	0	8	8	0	16	16	—	1:0.50	1:0.50
72.6-77.5	0	5	5	0	6	6	—	1:0.83	1:0.83
77.6-82.5	0	4	4	0	2	2	—	1:2.00	1:2.00
82.6-87.5	0	1	1	0	1	1	—	1:1.00	1:1.00
Total	122	532	654	89	537	626	1:1.37*	1:0.99	1:1.05

[a] N: Número de individuos; [b] M:H: Macho:Hembra; [c] Costa de Campeche; [d] BC: Banco de Campeche
* Estadísticamente diferente de 1:1 ($?^{2\ 0.05\ (1)}$)

Talla Mínima de Primera Madurez Sexual

Las tallas mínimas de primera madurez sexual observadas fueron respectivamente de 24.5 cm LT y 23.8 cm LT para una hembra y un macho capturados en la costa de Campeche, en febrero de 2002. Desde la más pequeña clase de tallas analizada en el presente estudio (22.6 - 27.5 cm TL), más del 68 % de las hembras y de los machos observados presentaban gónadas en fase de maduración (clase sexual 3). A partir de 52.6 cm TL para las hembras y de 62.6 cm TL para los machos, todos los organismos analizados eran adultos (Tabla 3).

Periodo de Reproducción

El incremento en los valores del IGS promedio ocurrió a partir de marzo-abril para las hembras y de junio para los machos (Figura 2). Los picos de IGS promedio fueron observados en mayo (0.86 %), julio (1.02 %) y septiembre (0.82%) para las hembras y en septiembre (0.24 %) para los machos. El decremento del IGS promedio en hembras y machos ocurrió entre octubre y diciembre. Los valores máximo de IGS individual fueron observados entre mayo y septiembre (2.20 - 3.52 %) para las hembras y entre Junio y octubre (0.99 - 2.40 %) para los machos.

Importante proporción de hembras y machos (> 30 % por mes) fueron encontrados sexualmente activos (clases sexuales 3 - 5) todo el año (Figura 3). Sin embargo, tomando en cuenta a las hembras que presentaron ovocitos VI (hialino) y/o fpo en sus ovarios (clase sexual 4), se observó que la temporada de desove de la especie ocurrió entre marzo y noviembre, con picos de emisión de gametos en mayo y de agosto a octubre. Las hembras en fase de postdesove (clase sexual 5) fueron capturadas entre agosto y noviembre.

Áreas de Desove

La ubicación geográfica de los sitios de pesca en los cuales se capturaron hembras en fase de desove con ovocitos VI hialinos y/o fpo en sus ovarios (clase sexual 4) se presenta en la Figura 1. Estos sitios se sitúan en la parte norte (22°45'-23°50'N y 88°50'-89°19'O) y noroeste (21°25'-22°20'N y 91°01'-92°30'O) del Banco de Campeche, entre 48 y 117 m de profundidad.

DISCUSIÓN

El pargo del Golfo, por ser una especie gonocórica (Grimes 1987), presenta generalmente una proporción de sexos equilibrada (1:1). Los valores de la proporción de sexos obtenidos en este estudio fueron equilibrados, salvo en el caso del muestreo procedente de la costa de Campeche donde se observó un sesgo a favor de las hembras en la clase de tallas 22.6 - 27.5 cm LT. La proporción de sexos global calculada a partir del muestreo total (1:1.05) fue muy similar a las proporciones de sexos de *L. Campechanus* observadas por Bradley y Bryan (1975) y Futch y Bruger (1976) en el noroeste y noreste del Golfo de México (1:1.02 y 1:1.28), por Camber (1955) en el Banco de Campeche (1:1.13) y por González de la Rosa y Ré-Regis (1996) para la costa de Campeche (1:1.06) (Tabla 4).

Tabla 3. Números de hembras y machos inmaduros y maduros y porcentajes de hembras y machos maduros de *L. campechanus* en el sur del Golfo de México (marzo de 1999-febrero de 2002). Los individuos de la costa de Campeche y del Banco de Campeche fueron agrupados.

Longitud total (cm)	Hembras				Machos			
	N [a]			%	N			%
	Inmaduras	Maduras	Total	Maduras	Inmaduros	Maduros	Total	Maduros
22.6-27.5	6	53	59	90	2	36	38	95
27.6-32.5	15	47	62	76	7	44	51	86
32.6-37.5	17	36	53	68	11	33	44	75
37.6-42.5	13	72	85	85	4	84	88	96
42.6-47.5	6	135	141	96	2	123	125	98
47.6-52.5	3	105	108	97	1	97	98	99
52.6-57.5	0	67	67	100	1	76	77	99
57.6-62.5	0	41	41	100	1	53	54	98
62.6-67.5	0	20	20	100	0	26	26	100
67.6-72.5	0	8	8	100	0	16	16	100
72.6-77.5	0	5	5	100	0	6	6	100
77.6-82.5	0	4	4	100	0	2	2	100
82.6-87.5	0	1	1	100	0	1	1	100
Total	60	594	654	91	29	597	626	95

[a] N: Número de individuos

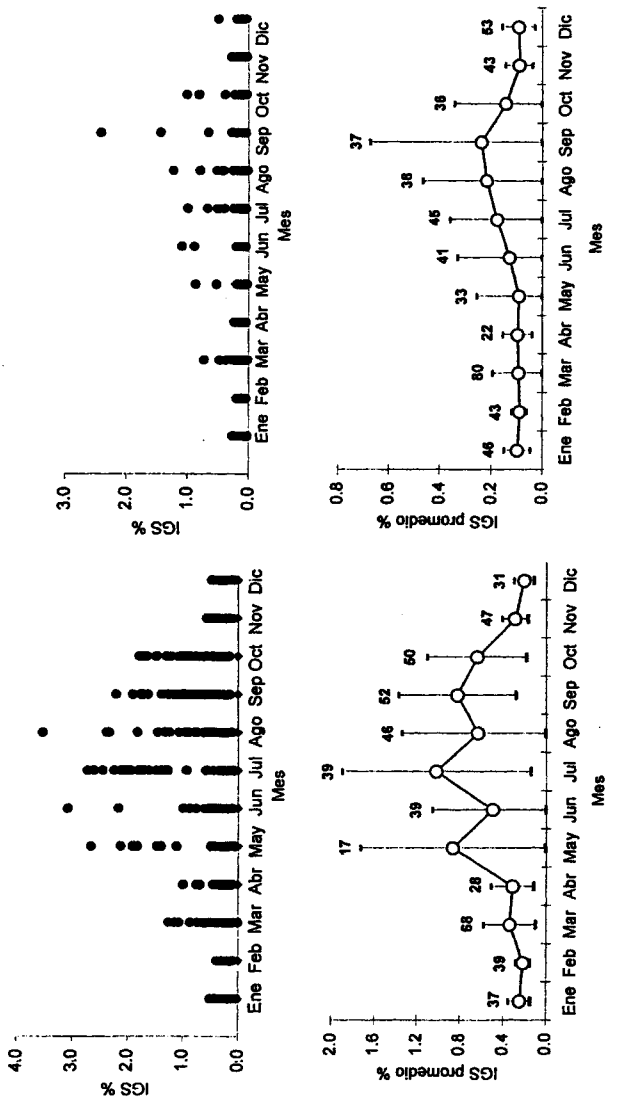

Figura 2. Evolución mensual de los índices gonadosomáticos (IGS) individual y promedio para las hembras y machos de *L. Campechanus* del Banco de Campeche. Todos los organismos obtenidos entre marzo de 1999 y abril de 2000, fueron agrupados por mes de captura y analizados durante un ciclo anual teórico. El número de organismos analizados por mes esta indicado arriba de cada valor del IGS promedio.

Tabla 4. Proporción de sexos, tallas mínima de primera madurez sexual, periodo de reproducción, picos de desove y áreas de desove *de L. campechanus* para diferentes zonas de estudio del Golfo de México.

Autores	Zona de estudio [a]	Fecha de estudio	Métodos de estudio [b]	Proporción de sexos (M:H)	Tallas mínima de primera madurez sexual [c]	Periodo de reproducción	Picos de desove	Áreas de desove
Moseley (1966)	NO	1964-1965	?	[56% ♂]	—	Jun-Sep	Ago	—
Bradley y Bryan (1975)	NO	1970-1974	Macro	1:1.02	♀ 25.5 LE ♂ 23.0 LE	May-Ene	Jun-Jul	—
Futch y Bruger (1976)	FL	1972-1975	Micro	1:1.28	—	Jul-Oct	Ago-Sep	—
Collins et al. (1996)	FL	1991-1993	IGS Micro	[50-41% ♂]	—	May-Oct	Jun-Ago	—
Collins et al. (2001)	NO y NE	1998-1999	IGS Micro	[48% ♂]	—	Abr-Oct	—	23.8-122 m 26.5-29°C
Camber (1955)	BC	1937-1951	Macro	1:1.13	♀/♂ 30-32 FL	Jul-Sep	Jul-Ago	—
González y Ré (1996)	CC	1993-1994	Macro Micro	1:1.06	♀ 18.9 LF ♂ 18.5 LF	Mar-Dic	Abr-Oct Nov-Feb	—
Presente estudio	BC y CC	1999-2002	IGS Micro	1:1.05	♀ 24.5 LT ♂ 23.8 LT	Mar-Nov	May Ago-Oct	48-117 m

[a] BC: Banco de Campeche; CC: Costa Campeche; NE: Noreste del Golfo de México; NO: Noroeste del Golfo de México

[b] Análisis de las gónadas - Macro: Macroscópico; Micro: Microscópico (histología); IGS: Indice gonadosomático

[c] LE: Longitud Estándar; LF: Longitud Furcal; LT: Longitud Total

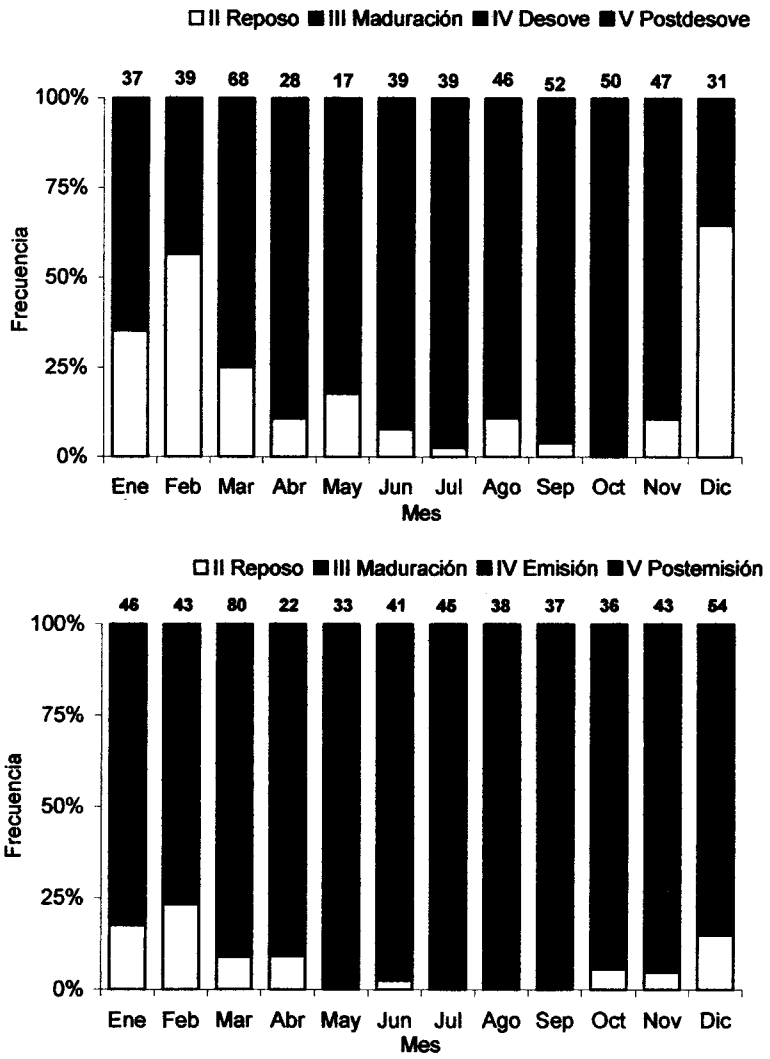

Figura 3. Evolución mensual del porcentaje de las clases sexuales para las hembras y machos de *L. Campechanus* del Banco de Campeche. Todos los organismos obtenidos entre marzo de 1999 y abril de 2000, fueron agrupados por mes de captura y analizados durante un ciclo anual teórico. El número de organismos analizados por mes esta indicado arriba de cada barra de frecuencias de clases de madurez sexual.

Las tallas mínima de primera madurez sexual para hembras y machos observadas en este estudio (♀: 24.5 cm LT; ♂: 23.8 cm LT) fueron inferiores a las obtenidas por Bradley y Bryan (1975) para la población del noroeste del Golfo de México (♀: 25.5 cm LE; ♂: 23.0 cm LE) y por Camber (1955) para los organismos capturados cerca de Cayos Arcas y Arrecife Alacranes, en el Banco de Campeche (♀/♂: 30-32 FL)(Tabla 4). Tomando en cuenta los datos presentados por González de la Rosa y Ré-Regis (1996), parece que la población del sur del Golfo de México debe alcanzar su primera madurez sexual a una talla aún más inferior: 18.9 cm LF para las hembras y 18.5 cm LF para los machos.

El periodo de reproducción del pargo del Golfo de las costas de la Península de Yucatán presentó características semejantes al de las poblaciones de la parte Norte del Golfo de México: duración máxima de 9 meses, iniciando en primavera (marzo-abril) y finalizando en otoño (noviembre-diciembre)(Tabla 4). Sin embargo, la población del sur del Golfo de México presentó dos picos de desove (mayo; agosto-septiembre) al lugar de uno (junio-septiembre) para las poblaciones del noroeste y noreste del Golfo de México (Moseley 1966, Bradley y Bryan 1975, Futch y Bruger 1976, Collins et al. 1996, 2001). Por otro lado, los resultados obtenidos en el presente estudio ponen en evidencia que el periodo de reproducción de *L. Campechanus* del Banco de Campeche es más extendido que lo descrito previamente por Camber (1955) (julio-septiembre) y que los picos de desove de la especie ocurren de manera más puntual en el tiempo que lo observado por González de la Rosa y Ré-Regis (1996) (abril-octubre y noviembre-febrero).

Los datos disponibles sobre las áreas de reproducción de *L. Campechanus* en el Golfo de México son escasos. Moe (in Bradley y Bryan 1975) observó áreas de reproducción de la especie a lo largo de la costa noroeste de Florida, entre 18.3 y 36.6 m de profundidad. Collins et al. (2002) ubicaron y caracterizaron varias zonas de reproducción de este lutjanido a lo largo de las costas de Texas, Louisiana, Alabama y Florida. Estas estaban situadas entre 23.8 y 122 m de profundidad y la temperatura del agua próxima al fondo fluctuaba entre 26.5° y 29°C. En el Banco de Campeche, el pargo del Golfo desova a profundidades muy similares a las observadas por Collins et al. (2002). Las zonas de desove observadas a través del análisis de las capturas comerciales se ubican en la región norte y noreste de la plataforma continental de la Península de Yucatán, entre Arrecife Alacranes y los Bajos del Norte, para una parte, y entre Cayos Arenas, Banco Ingleses y Bajo Nuevo, para la otra parte.

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Genetic Studies of Red Snapper (*Lutjanus campechanus*) in the Northern Gulf of Mexico

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ABSTRACT

The Gulf red snapper, *Lutjanus campechanus,* is a highly exploited marine fish in the Gulf of Mexico. Currently, management of Gulf red snapper in U.S. waters is based on a single-stock hypothesis. Herein we report results of a genetic survey of adults (1995 year class) and juveniles (1999 year class) sampled offshore from three geographic localities in the northern Gulf: Port Aransas, Texas; Port Fourchon, Louisiana; and Dauphin Island, Alabama. The study employed 19 microsatellites loci and was designed to test the single-stock hypothesis and estimate effective population size in the Gulf. We also assessed a possible genetic impact of shrimp-trawling on red snapper populations by comparing genetic variability and relatedness between juveniles sampled randomly and juveniles sampled in single tows of a shrimp trawler.

Significant genetic heterogeneity was observed among localities in the 1995 cohort, with the major differences occurring between red snapper sampled offshore of Port Aransas, Texas, and the other two localities. On another hand, no significant genetic heterogeneity was observed among samples from the 1999 cohort. These findings, along with the overall very low F_{ST} value (0.001), suggest considerable genetic mixing within the northern Gulf, consistent with the single-stock hypothesis. A maximum-likelihood estimate of effective population size (N_e) of red snapper in the northern Gulf based on the temporal method was 7,075 (95 % CI: 2,933 - >50,000). This estimate of N_e is at least two orders of magnitude lower than current estimates of census size (N).

Levels of genetic variability (gene diversity and allelic richness) between reference (control) and bycatch juveniles were equivalent. Estimates of the variance in genetic relatedness in both reference and bycatch samples were non-significant; however, this variance estimate was positive (0.001) for one of the bycatch samples and close to significance (P = 0.1) which might suggest the presence of related individuals in this sample. Further studies employing larger sample size and additional loci are necessary to assess possible genetic impacts of shrimp trawling on red snapper.

KEY WORDS: *Lutjanus campechanus*, genetic stock assessment, shrimp trawl bycatch.

Estudios Genéticos de la Estructura de la Poblaćion del Pargo Rojo (*Lutjanus campechanus*) en la Zona Norte del Golfo de México

Lutjanus campechanus es una especie marina importante para la pesca en el golfo de Mexico. El presente manejo se basa en la hipótesis que hay un solo stock, o poblacion (single-stock). Reportamos aqui resultados de un inventario genético de adultos (cohorte 1995) y juveniles (cohorte 1999) muestreado en tres localidades en la región norte del golfo de Mexico: Port Aransas Texas, Port Fourchon Louisiana, y Duaphin Island, Alabama. Diseñamos el estudio para testear el hipótesis single-stock y estimamos el tamaño de la población a través de análises de 19 loci genéticos de microsatelites-ADN. Adicionalmente evaluamos un posible impacto genético de pesca a la rastra para camarones en la población de *L. campechanus* comparando la variabilidad genética y la relación genética entre juveniles muestreados al azar con variabilidad en juveniles muestreado en un rastreo de un barco camaronero. Observamos heterogeniedad significativa entre localidades para el cohorte 1995, con las diferencias mayores encontrados entre *L. campechanus* muestreados fuera de la costa de Port Aransas, Texas y las otras localidades. En la otra mano, no hubo heterogeniedad significativa entre muestras del cohorte 1999. Estos resultados, tomando en cuenta el FST muy bajo (0.001), indican considerable mezcla genética, consistente con el hipótesis single-stock. Una estimación de tamaño poblacional efectiva (Ne) de la especie en el golfo norte basado en el metodo temporal fue 7,075 (95 % CI: 2,933 - >50,000). Este Ne es por lo menos dos ordenes de magnitud más bajo que estimaciones actuales del tamaño de censo (N). Niveles de variabilidad genética entre juveniles referencia y juveniles capturado durante el rastreo fueron equivalentes. Estimaciones de la varianza en relación genética en juveniles referencia y juveniles capturado durante el rastreo no fueron significativamente diferente. Pero, la estimación fue positiva (0.001) y casi significativa (P = 0.10) para uno de la muestras de rastreo, un resultado que sugiere la presencia de individuos relacionados en este muestreo. Futuros estudios empleando mayores tamaños de muestreo y más loci son necesarios para evaluar los posibles impactos genéticos de pesca a la rastra para camarones en *L. campechanus*.

PALABRAS CLAVES: Pargo rojo, *Lutjanus campechanus*, genéticos

INTRODUCTION

The Gulf red snapper, *Lutjanus campechanus*, is a highly exploited marine fish distributed along the continental shelf of the Gulf of Mexico (Hoese and Moore 1977). Red snapper abundance in the northern Gulf of Mexico (hereafter, Gulf) has decreased by almost 90 % in the past two decades (Goodyear and Phares 1990) due to overexploitation by commercial and recreational fisheries, high juvenile mortality due to the shrimp trawl fishery, and habitat change (Christman 1997, Gallaway et al.

1999). Important goals for management of red snapper resources include knowledge of stock structure for stock assessment and limitation of impacts of shrimp trawling activities.

Currently, red snapper resources in U.S. waters are managed under a single-stock hypothesis (GMFMC 1989, 1991). This hypothesis is supported by a number of prior genetic studies that employed allozymes (Johnson 1987), mitochondrial (mt)DNA (Gold et al. 1997), and microsatellites (Gold et al. 2001). However, all these studies either involved individuals of mixed cohorts (year classes) or were based on relatively small sample sizes. In this study, we document variation at 19 nuclear-encoded microsatellites within two cohorts sampled at three different geographic areas along the northern Gulf. Both adults (1995 cohort) and juveniles (1999 cohort) were assayed. We also assessed variation in allele frequencies between the two cohorts in order to estimate effective population size or N_e by the temporal method (Waples 1989).

A second issue involving red snapper in the Gulf regards impacts of shrimp trawling on red snapper juveniles. To date, studies on this topic have documented the volume of the bycatch (Gallaway et al. 1998, Gallaway and Cole 1999). In this study, we address the question of whether juvenile red snappers taken as bycatch represent a random sample of the genetic pool of the local population from which they were drawn. Briefly, non-random mortality of genotypes could have the effect of canceling the contribution of the corresponding families, thus reducing the effective number of breeding adults. This in turn could lower the (genetic) effective size of red snapper stock(s). To address this question, we documented variation at 11 nuclear-encoded microsatellites and at mitochondrial (mt)DNA among three samples of red snapper juveniles taken offshore of Galveston, Texas. Two of the samples were obtained from single tows of a shrimp trawler, and one (the reference or 'control' sample) was obtained by sampling randomly in the same geographic area during a groundfish survey.

MATERIALS AND METHODS

Adult red snapper belonging to the 1995 cohort were sampled in 1999 and 2000 by angling 25-30 miles offshore of Port Aransas (Texas), Port Fourchon (Louisiana), and Dauphin Island (Alabama) (Figure 1). Individual fish were aged by otolith-increment analysis following Wilson and Nieland (2001). Sample sizes for this cohort were 203 (Texas), 286 (Louisiana) and 376 (Alabama). Juveniles (age 0 fish) belonging to the 1999 cohort were sampled by trawling during the summer of 1999 in conjunction with a groundfish survey of the National Marine Fisheries Service (NMFS). Fish were sampled a few at a time (average of 11 fish per trawl) during multiple trawls that differed both spatially and temporally. Sampling localities were offshore of Brownsville, Texas (n = 50), Port Aransas, Texas (n = 47), Galveston, Texas (n = 76), Port Fourchon, Louisiana (n = 77), and Dauphin Island, Alabama (n = 63). Samples from Brownsville and Port Aransas were pooled and are referred hereafter as the Texas sample (n = 97). The sample offshore of Galveston (n = 76)

was used as the '*Reference*' in the analysis of possible genetic impacts of shrimp trawling. For the latter, samples of juvenile red snapper were obtained from two separate shrimp-trawl tows offshore of Galveston, Texas: one (*Bycatch A*) contained 123 juveniles, while the other (*Bycatch B*) contained 40 juveniles.

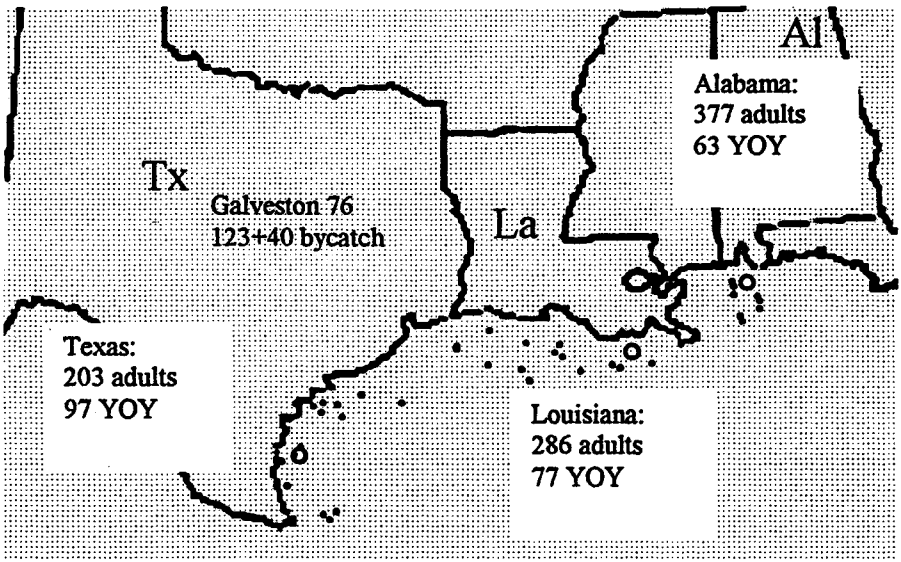

Figure 1. Sampling localities for the analysis of stock structure of red snapper and the effect of bycatch on juveniles. ○Adult sampling point, ● juvenile sampling point.

Tissue samples (heart and muscle) were removed from individual fish and stored as described in Gold et al. (2001). For stock structure analysis and estimates of effective population size, adults and juveniles of the 1995 and 1999 cohorts, respectively, were assayed for genotypes at 19 microsatellites, using PCR primers and methods described in Gold et al. (2001). For analysis of possible genetic impacts of shrimp trawling, samples obtained from shrimp trawls and the samples of juveniles obtained offshore of Galveston were assayed for genotypes at 11 microsatellites and for sequence variation in two fragments of mitochondrial (mt)DNA. The mtDNA assay employed single strand conformational polymorphism (SSCP) analysis of a 163 base pair (bp) fragment of the ND-4 gene and a 122 bp fragment of the ND-6 gene. Amplification, electrophoresis, and scoring of SSCP phenotypes followed methods developed in our laboratory (Burridge and Gold unpublished).

Summary statistics, including number of alleles, allelic richness (a measure of number of alleles independent of sample size), and unbiased gene (microsatellites) and nucleon (mtDNA) diversity were computed for each locus in each sample, using F-STAT, version 2.9.3 (Goudet 1995). Homogeneity of allelic richness and gene

diversity between pairs of samples was tested via Wilcoxon signed-rank tests. Departure of genotypic proportions from Hardy-Weinberg equilibrium expectations was measured within samples as Weir and Cockerham's (1984) small *f*; probability of significance (P_{HW}) was assessed using a Markov-chain method (Guo and Thompson 1992), as implemented in GENEPOP (Raymond and Rousset 1995) and using 5,000 dememorizations, 500 batches, and 5,000 iterations per batch. Genotypic disequilibrium between pairs of microsatellites within samples was tested by exact tests, as implemented in GENEPOP and employing the same Markov chain parameters. Homogeneity of allele and genotype distributions both among regions and between cohorts within regions (stock structure analysis), and among bycatch and reference samples (bycatch impact analysis), was examined via exact tests; significance of probability values was assessed by a Markov-chain method, as implemented in GENEPOP (Raymond and Rousset 1995) and using the same Markov-chain parameters as above. Homogeneity of mtDNA haplotype frequencies among the bycatch and reference samples was tested using the Monte Carlo simulation approach of Roff and Bentzen (1989), as implemented in REAP (Mc Elroy et al. 1992); significance of probability values was assessed through 1000 bootstrap replicates.

Pseudo-maximum-likelihood estimates of effective population size (N_e), based on the temporal method (Waples 1989), were generated following Wang (2001); 95 % confidence intervals were obtained as the range of support associated with a drop of two logarithm units of the likelihood function as inferred from the likelihood distribution (Wang 2001). Estimates of N_e were generated for individual geographic samples and for the northern Gulf; the latter was generated by pooling data by year class (cohort) across sample localities. Life-history data (age structure and weights of males and females belonging to the individual age class) were provided by D. Nieland and C. Wilson of Louisiana State University and used to compute correction factors for temporal-method estimates of N_e (following Jorde and Ryman 1995; 1996) in order to account for effects of overlapping generations. The correction coefficients C and G were estimated as described in Turner et al. (2002) except for the following modifications: Survivorship (S) was estimated to be 0.5 based on the age-structure data examined. The relative birth rate of each age class was estimated by the mean weights of males and females of the corresponding class. Values of C and G obtained were subsequently used to correct N_e by:

$$N_{ec} = N_e \times [C/G]$$

where N_e is the pseudo-maximum-likelihood estimate of variance effective size obtained following Wang (2001).

Microsatellite genotypes were used to estimate relatedness (genetic relationship) between pairs of individuals within bycatch and reference samples. Relatedness (pairwise relationship coefficients) was computed by using the moments estimator of Ritland (1996) and the regression estimator of Lynch and Ritland (1999). A bootstrap distribution (1,000 resamplings, where comparisons between individuals

with identical genotypes were excluded) of estimates of the variance of pair-wise relatedness in each sample was used to test whether the observed variance differed significantly from zero.

RESULTS

Population Structure and Variance Effective Population Size

Summary statistics (number of alleles, allelic richness, gene diversity; and results of tests of HW equilibrium) for each samples are given in Appendix 1. Number of alleles among samples ranged from 4-7 at *Prs*260 to 18-23 at *Prs*240, the corresponding Allelic richness range being 2.9-5.3 and 14.3-20.4. Significant departures from HW expectations, following Bonferroni corrections (Rice 1989), were found in three of 114 tests: *Prs*275 in Texas 1995, *Prs*137 in Alabama 1995, and *Prs*248 in Louisiana 1999. Significant, non-random association of genotypes was found in two of 1,026 pairwise comparisons following Bonferroni correction: *Lca*64 and *Prs*248 ($p < 0.001$) and *Prs*328 and *Lca*22 ($p < 0.001$) in the sample form Texas (1995).

Significant differences ($p < 0.001$) in allele and genotype distributions were found among localities in the 1995 year-class. The corresponding F_{ST} value was 0.001. Pairwise comparisons indicated that the sample from Texas differed significantly ($p < 0.002$) from the samples from Louisiana and Alabama. No significant differences ($p > 0.05$) in allele or genotype distributions were found among samples from the 1999 year-class. Both allele ($p = 0.011$) and genotype ($p = 0.017$) distributions differed between the two year classes sampled offshore from Texas; no differences ($p > 0.05$) between year classes at the other two localities were found.

The pseudo-maximum-likelihood estimate (and 95 % confidence intervals) of variance effective population size (N_e) for the three localities were 2,658 (1,035 - >50,000), 8,286 (1,418 - >50,000), and 3,210 (1,038 - >50,000) for Texas Louisiana, and Alabama, respectively. The (overall) estimate for the northern Gulf was 7,075 (2,933 - >50,000).

Genetic Variation and Relatedness in Bycatch Samples

Summary statistics for microsatellites (number of alleles, allelic richness, gene diversity; and results of tests of HW equilibrium) for the *Reference* and two bycatch samples (*Bycatch* A and *Bycatch* B) and analogous data for mtDNA are available from the authors upon request. Number of microsatellite alleles among samples ranged from 4 - 7 at *Prs*260 to 18 - 23 at *Prs*240; allelic richness ranged from 2.87 - 2.94 (*Prs*260) to 12.0 - 13.7 (*Prs*240). For mtDNA, number of haplotypes ranged from 9 – 20, and haplotypic richness ranged from 9.0 - 14.26. Gene (microsatellite) diversities ranged from 0.179 (*Lca*20 in *Bycatch* A) to 0.907 (*Prs* 240 in *Bycatch* B); nucleon diversity (mtDNA) ranged from 0.766 - 0.767. No significant differences in allele/haplotype richness ($0.32 < p < 0.92$) or gene/nucleon diversity

($0.18 < p < 0.93$) were found in pair-wise comparisons of samples. Tests of conformance to HW equilibrium and of genotypic disequilibrium (microsatellites) were non-significant following Bonferroni correction. Tests of homogeneity of allele and genotype distributions (microsatellites) and haplotype distributions (mtDNA) also were non-significant following Bonferroni corrections: ($0.07 < p < 0.63$ for microsatellites; $p = 0.18$ for mtDNA).

Estimates of small f (F_{IS}) over all microsatellites were 0.021, 0.022, and 0.063 for *Reference*, *Bycatch* A, and *Bycatch* B, respectively. None of these estimates differed significantly from zero following Bonferroni correction. Estimates of the variance (*Var R*) in both relatedness coefficients was 0 for all three samples except for the regression-based coefficient (Lynch and Ritland 1999) in *Bycatch B*. The variance in this sample was positive (*Var R* = 0.001) and its probability of differing significantly from zero (1,000 bootstrap resamplings) was 0.10.

DISCUSSION

Population Structure and Variance Effective Population Size

Analysis of genetic structure based on 19 independent microsatellite loci revealed a weak ($F_{ST} = 0.001$) but significant difference among localities in the 1995 year-class. However, no genetic difference among localities was found in the 1999 year class. Pair-wise homogeneity tests within the 1995 cohort indicated that the sample from Texas differed from the samples from Louisiana and Alabama. The analysis of temporal homogeneity revealed that this sample also differed from the sample obtained in Texas in 1999. Thus the significant heterogeneity in allele and genotype distributions observed here mostly concern one sample (Texas, 1995 year-class) that differs from the other samples and warrants further investigation. We are currently analyzing additional year classes at all three localities. Overall, these results are in accordance with most prior genetic studies of red snapper (Gold et al., 1997, 2001) and suggest that considerable gene flow occurs among red snapper in the northern Gulf. Such a pattern would be consistent with the single-stock model for red snapper in the northern Gulf.

The overall estimate of variance effective population size (N_e) for the northern Gulf was 7,075. This estimate is at least three orders of magnitudes less than current estimates of adult census size (N) (7 - 20 million, J. Cowan, Louisiana State University, personal communication.). Such a low ratio of effective size to census size is thought to be uncommon, as this ratio is expected to be in the range 0.25 - 0.75 in general (Nunney 1996). However, N_e/N ratios on the order of those observed here have been reported for other marine fishes (Turner et al. 2002, Hauser et al. 2002). Potential factors that may lead to very low N_e/N ratios are fluctuation in population size (N), variance in individual reproductive success (within and/or between sexes), and/or variation in productivity of nursery areas (Turner et al. 2002). The estimates of N_e also differed slightly among the sampled localities, although 95 % confidence intervals of estimates at each locality overlapped the

estimates at the other localities. The analysis of additional cohorts will allow to increase accuracy of N_e estimates. Differences in N_e among localities, if confirmed, might suggest the existence of different demographic units (stocks) that would require separate management even if genetic structure is very weak or non-significant. Regardless, our finding of such a low N_e/N ratio for red snapper suggests that red snapper genetic resources are much more limited than what one would expect based on estimates of census size.

Genetic Variation and Relatedness in Bycatch Samples

No significant differences in allele diversity (allelic/haplotypic richness, in this case), gene/nucleon diversity, and allele/haplotype and genotype distributions were found between the *Reference* samples and either of the two samples taken from single tows of a shrimp trawler. These results indicate that red snapper taken in the bycatch do not have reduced genetic variation relative to the local population (represented by *Reference* sample), nor do they appear to represent a non-random sample from the local population in terms of allele and genotype frequencies.

We also asked whether red snapper taken as bycatch were more closely related genetically to one another than were individuals drawn at random from the local population. Estimates of the variance (*Var R*) of two different relatedness coefficients did not differ significantly from zero for one of the bycatch samples and for the *Reference* sample. However, the variance of the regression-based coefficient of Lynch and Ritland (1999) was positive and close to significance ($p = 0.010$) for the *Bycatch* B sample. A significantly positive variance would indicate that the sample included individuals that were closely related genetically.

The interpretation of these results is limited by our sample size significant bias when estimating genetic relatedness may be introduced from errors in gene frequency estimation when samples sizes are less than 100 (Lynch and Ritland 1999). Other parameters such as number of loci and pattern(s) of allele distributions at each locus also impact the regression-based coefficient of Lynch and Ritland (1999). Further studies examining larger samples of red snapper from shrimp trawling and examining a larger number of loci are warranted.

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Nuevos Datos sobre el Patrón de Fecundidad del Mero Colorado, *Epinephelus guttatus* (Linnaeus, 1758)

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RESUMEN

El mero colorado, *Epinephelus guttatus,* es una de las especies comerciales más importantes en el Banco de Campeche, contribuyendo con el 33 a 35% de las capturas realizadas en Yucatán. A pesar de lo anterior es poca la información disponible acerca de la biología de la reproducción de este serranido. El presente estudio analiza el patrón de fecundidad de *E. guttatus,* utilizando organismos obtenidos a partir de capturas comerciales realizadas en dos probables áreas de agregación de reproducción (Arrecife Alacranes y Bajos del Norte), en diciembre de 1999 y febrero de 2000 y 2001. A bordo de los barcos pesqueros se realizó una preselección de 72 hembras a analizar con base al aspecto macroscópico de las gónadas (ovocitos visibles a simple vista). Se fijaron las muestras de ovario en Bouin para el control histológico del estado de madurez sexual así como para realizar mediciones de ovocitos y en Gilson para el conteo de los ovocitos. La totalidad de las hembras preseleccionadas se encontraban sexualmente activas, con ovocitos en fin de vitelogénesis secundaria en sus ovarios pero sin la presencia de ovocitos hialinos ni de folículos post-ovulatorios. Unos histogramas de frecuencia de distribución de diámetro de los ovocitos fueron establecidos a partir de los cortes histológicos y de los ovocitos enteros conservados en Gilson de ovarios de 12 hembras (31.5 a 43.0 cm de longitud total). El análisis de los gráficos permitió identificar en los ovarios la presencia de dos lotes de ovocitos separados por un hiato ubicado, en promedio, entre los 142 y 234 µm de diámetro. El diámetro mínimo promedio calculado para los ovocitos vitelógenos fue de 96 µm. Estos resultados, obtenidos tanto a través del examen histológico como del análisis de los ovocitos enteros, confirmaron las hipótesis anteriores presentadas sobre el probable patrón de fecundidad determinada de la especie.

PALABRAS CLAVES: Banco de Campeche, fecundidad, Mero Colorado

New Data on the Pattern of Fecundity of the Red Hind, *Epinephelus guttatus* (Linnaeus, 1758)

The red hind, *Epinephelus guttatus*, is one of the more important commercial species in the Campeche Bank, contributing 33 to 35% of the captures made in Yucatan. In spite of its importance in the landings, little information is available about the reproductive biology of this serranid. The present study analyzes patterns of fecundity of *E. guttatus*, using organisms obtained from commercial captures

made in two probable areas of reproductive aggregations (Arrecife Alacranes y Bajos del Norte), in December of 1999 and February of 2000 and 2001. On board of fishing boats a preselection of 72 females was made to analyze with base to the macrocospic aspect of the gonads ones (visible oocytes at first). The ovary samples were histologically prepared according to Gilson and Bouin for the control of their state of sexual maturity as well as to make the measurement and count of the oocytes. The totality of the preselected females was sexually active, with oocytes in late secondary vitellogenesis in their ovaries but without the presence of hyaline oocytes or post-ovulatorios follicles. Histograms of frequency of distribution of diameter of the ovocitos were established from these samples and of the conserved whole oocytes in Gilson of ovaries of 12 females (31,5 to 43 cm in total length). The analysis of the graphs allowed to identify in the ovaries the presence of two lots of separated oocytes by a hiatus located, in average, between the 142 and 234 μm of diameter. The minimum average diameter calculated for the vitellogenic oocytes was 96 μm. These results, obtained so much through the histologic examination as of the analysis of the whole oocytes, confirmed the previous hypothesis on the pattern of fecundity determined of the species.

KEY WORDS: Campeche Bank, fecundity, Red hind

INTRODUCCIÓN

La capacidad de una especie dada para producir gametos puede estar impuesta por las características reproductivas de esa especie. En particular, los modos de desarrollo y maduración de los gametos pueden determinar la cantidad que individualmente la especie puede producir, además de la frecuencia con la que pueden estar disponibles (Pankhurst 1998).

Los términos de fecundidad determinada e indeterminada son comúnmente utilizados para describir dos diferentes tipos de estrategia reproductiva. La fecundidad es determinada cuando el número de ovocitos que entran en vitelogénesis está fijado antes del inicio de la puesta anual (Hunter et al. 1992). En peces con fecundidad determinada, no hay reclutamiento de ovocitos vitelógenos a partir del lote de reserva de los ovocitos previtelógenos, durante el período de reproducción. La fecundidad es indeterminada cuando el número de ovocitos vitelógenos no esta fijado antes del inicio de la puesta. Los ovocitos continúan madurando a partir del lote de ovocitos previtelógenos y durante la temporada de reproducción de la especie (Greer Walker et al. 1994).

Los estudios de reproducción de peces se han orientado en la mayor parte de los casos hacia las especies de aguas continentales, estuarinas, de zonas templadas y de aquellas de tallas pequeñas en ambientes tropicales. Existen pocos trabajos que sintetizan algunos de los aspectos de las estrategias reproductivas y de sus relaciones con las condiciones ambientales en los peces tropicales de gran tamaño (Sadovy 1996).

El mero colorado, *Epinephelus guttatus* (Linnaeus 1758) es un mero de interés particular porque su biología reproductiva parece encontrarse entre los extremos exhibidos por sus congéneres. Por ejemplo, son protoginos, forman agregaciones de desove de corto tiempo y desova en pareja o en agregaciones de un solo macho con varias hembras. Los individuos pueden vivir 18 años o más y, durante la temporada no reproductiva viven en zonas comunes. Sin embargo, información detallada sobre la actividad reproductiva durante la temporada de reproducción, relación por sexo en los adultos y sistema de maduración del mero colorado, es escasa (Sadovy et al. 1994). Por lo anterior el objetivo de este estudio se enfoca en analizar el tipo de fecundidad que presenta *Epinephelus guttatus* en el Banco de Campeche, permitiendo incrementar los conocimientos básicos sobre la biología reproductiva de la especie.

MATERIAL Y MÉTODOS

Capturas

Los organismos fueron obtenidos de las capturas comerciales realizadas por barcos pesqueros. Los peces fueron colectados en dos áreas de pesca ubicadas en el Banco de Campeche: el Parque Marino Nacional Arrecife Alacranes y en los Bajos del Norte (Figura 1). En Arrecife Alacranes las capturas fueron realizadas de noviembre de 1999 a febrero de 2000, y durante febrero de 2001 en los Bajos del Norte. Las capturas fueron realizadas con arpón, sobre fondos coralinos y rocosos a profundidades que oscilaron entre los 7 y 37 m en ambos sitios.

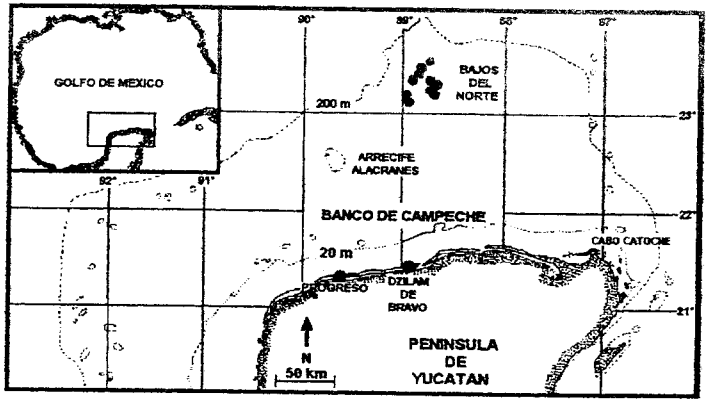

Figura 1. Ubicación geográfica de las zonas de colecta (Arrecife alacranes y Bajos del Norte) en la plataforma continental de la Península de Yucatán (Banco de Campeche).

Análisis de las Hembras a Bordo

Todos los especimenes fueron medidos (longitud total: Lt), pesados (peso total: Pt y peso de pez eviscerado: Ppev), y sus gónadas fueron extraídas y pesadas (Pg). Las hembras maduras se seleccionaron con base al aspecto macroscópico de las gónadas (presencia de ovocitos opacos visibles a simple vista en los ovarios). Se tomaron dos muestras de la parte media de una de las gónadas: el primero de 1 cm^3 aproximadamente, se colocó en solución de Bouin, para el análisis histológico (Bell 1978) y el segundo, de entre 20 y 30 g de peso, se conservo en líquido de Gilson (Bagenal y Braum 1978).

Análisis de las Hembras en el Laboratorio

El patrón de fecundidad de *E. guttatus,* fue analizado por medio de observaciones de corte histológicos de los ovarios y de conteos y medición de ovocitos enteros. Para el estudio histológico de las gónadas se utilizó la técnica clásica sugerida por Gabe (1968) que consiste en la deshidratación de las muestras, inclusión en parafina, corte de 5 a 6 µm, tinción de tricromo en un tiempo. El examen de los cortes histológicos fue realizado tomando en cuenta los criterios utilizados por Brulé et al. (1999) para la caracterización de los diferentes estadíos histológicos de la ovogénesis. Los cortes fueron analizados para:

i) Determinar el grado de desarrollo gonadal de los organismos,
ii) Observar la presencia de folículos post ovulatorios,
iii) Medir los diámetros de los ovocitos de cada estadío histológico, y
iv) Determinar el diámetro mínimo de los ovocitos vitelógenos, el cual fue realizado utilizando la técnica propuesta por Eltink y Vingerhoed (1989).

Para el conteo y medición de los ovocitos enteros se utilizo el método volumétrico propuesto por Bagenal (Kartas y Quignard 1984). Las observaciones, conteos y mediciones fueron realizados a través del uso de un microscopio óptico y uno estereoscopio, ambos equipados con cámara de video, una pantalla de televisión y el sistema de análisis de imágenes "Micromed". Con los valores obtenidos por ambos métodos se generaron histogramas de frecuencia de distribución del diámetro de los ovocitos con el fin de observar la presencia o no de un hiato entre los lotes de ovocitos vitelógenos y previtelógenos.

RESULTADOS

Durante diciembre 99, febrero 2000 y febrero 2001 se colectaron un total de 72 hembras en las zonas de pesca. Con relación a su tamaño, los organismos se distribuyeron en los intervalos de tallas (Lt) siguientes: 36 - 44 cm para Arrecife Alacranes (n = 36) y 32 - 44 cm para Bajos del Norte (n = 36). La mayoría se distribuyeron en la clase de talla de 38 cm (Figura 2). El estudio histológico de las gónadas permitió observar que la totalidad de los especimenes se encontraban sexualmente activas, con ovocitos en fin de vitelogénesis secundaria (estadío V) en sus ovarios, pero sin la presencia de ovocitos hialinos ni de folículos postovulatorios.

El diámetro mínimo de los ovocitos vitelógenos, considerando como el diámetro al cual el 50 % de los ovocitos analizados presentaban vesículas de vitelo en el citoplasma (estadío III) (Figura 3). Este diámetro mínimo fue de 96 µm para *E. guttatus* del Banco de Campeche.

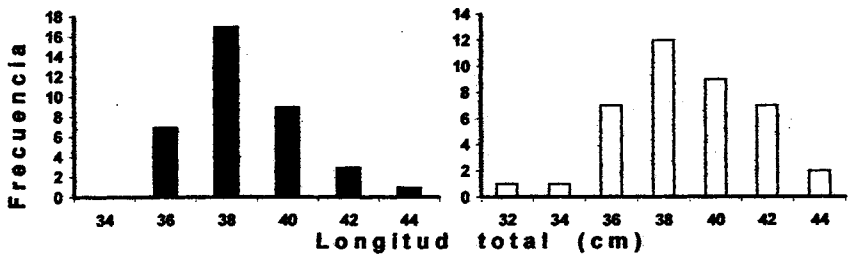

Figura 2. Distribución de frecuencia de tallas de las hembras capturadas en Arrecife Alacranes (Negro) en diciembre 1999 - febrero 2000 y Bajos del Norte (Blanco), y en febrero 2001.

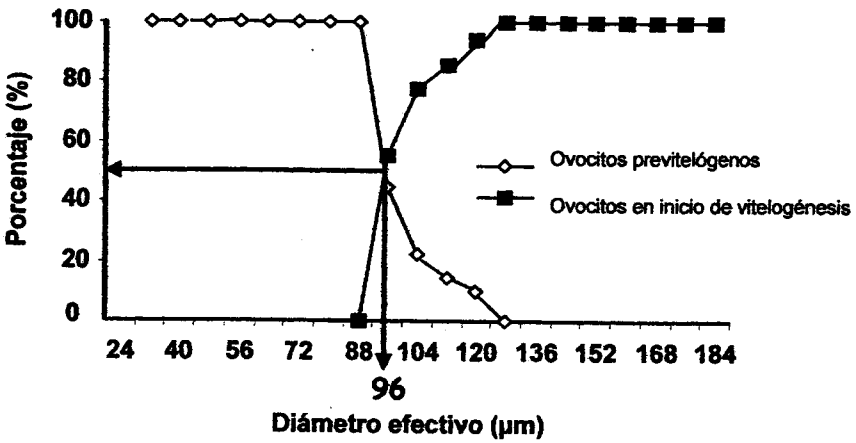

Figura 3. Distribución de frecuencia del diámetro de los ovocitos previtelógenos (estadíos I y II) y en inicio de vitelogénesis (estadío III) para hembras del mero colorado, *E. guttatus*.

Para analizar el patrón de fecundidad de *E. guttatus* se seleccionó seis hembras de diferentes clases de talla para cada sitio de estudio. Para Arrecife Alacranes (Figura 4A) a partir del estudio histológico se observó, una distribución bimodal con

dos lotes de ovocitos, el primero con diámetros de 30 - 150 µm que corresponde a los ovocitos previtelógenos (estadíos I y II) y el segundo de 240 - 390 µm que corresponde a los ovocitos vitelógenos (estadíos IV y V); además de la formación de un hiato ubicado entre los dos lotes. A partir de los datos generados con la técnica volumétrica (Figura 4B) se observó una distribución unimodal de ovocitos con diámetros efectivos de 360 - 500 µm, los cuales corresponden a ovocitos vitelógenos de estadíos IV y V (240 – 390 µm) observados en los cortes histológicos.

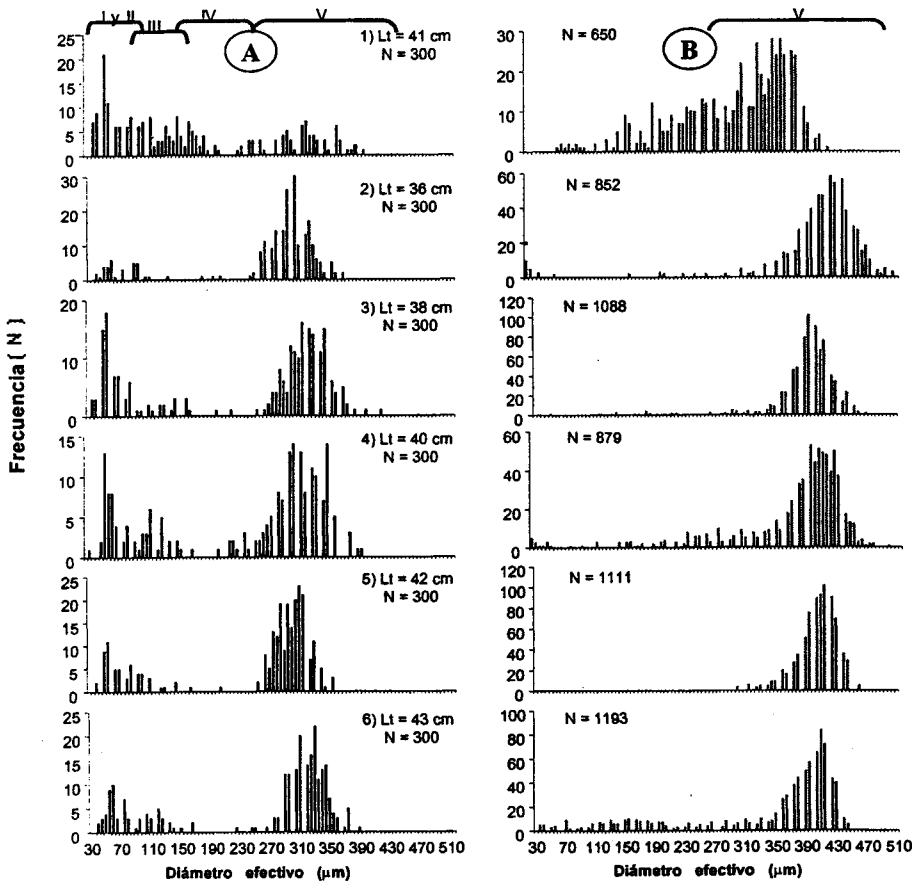

Figura 4. Histogramas de distribución de frecuencia del diámetro de los ovocitos medidos sobre cortes histológicos (A) y a través del método volumétrico (B) para Arrecife Alacranes. I y II: ovocitos previtelógenos; III: ovocitos en inicio de vitelogénesis; IV: ovocitos en inicio de vitelogénesis secundaria y V: ovocitos en fin de vitelogénesis secundaria.

Para Bajos del Norte (Figura 5A) a partir del estudio histológico se observó, una distribución bimodal con dos lotes de ovocitos, el primero con diámetros de 30 – 150 µm que corresponde a los ovocitos previtelógenos (estadíos I y II) y el segundo de 210 - 370 µm que corresponde a los ovocitos vitelógenos (estadíos IV y V); además de la formación de un hiato ubicado entre los dos lotes. A partir de los datos generados con la técnica volumétrica (Figura 5B) se observó una distribución unimodal de ovocitos con diámetros efectivos de 360 - 480 µm, los cuales corresponden a ovocitos vitelógenos de estadíos IV y V (210 – 370 µm) observados en los cortes histológicos. En los datos generados con los ovocitos enteros no se observa el lote de ovocitos previtelógenos debido a que estos se encontraban unidos en grupos y era imposible separarlos sin romperlos.

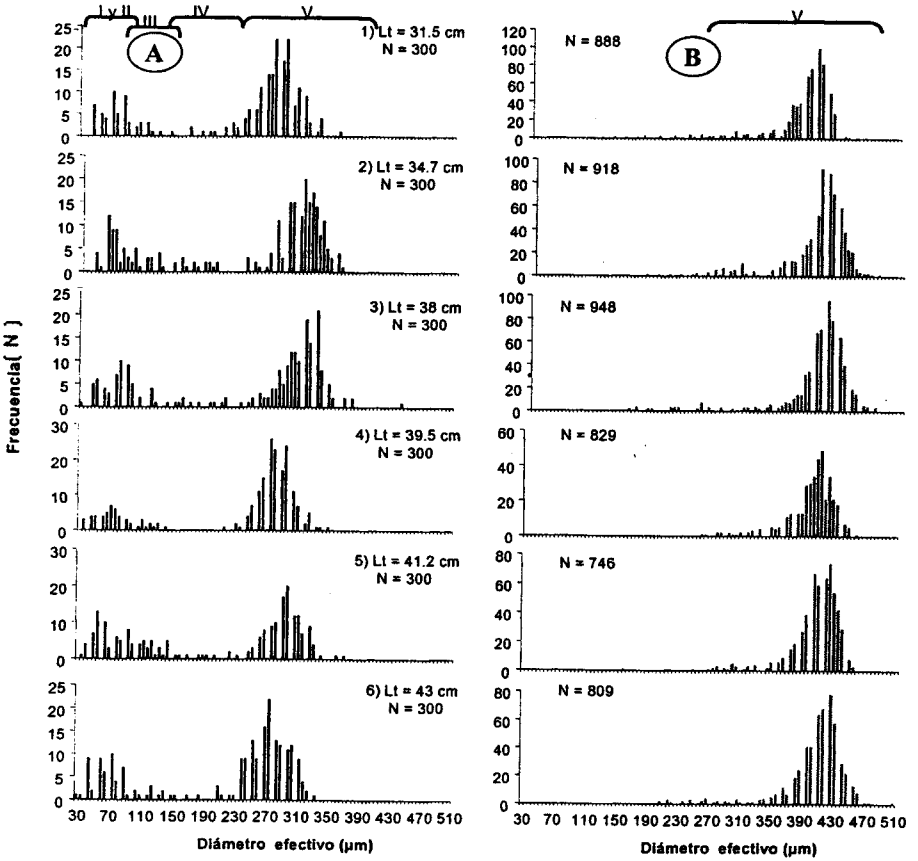

Figura 5. Histogramas de distribución de frecuencia del diámetro de los ovocitos medidos sobre cortes histológicos (A) y a través del método volumétrico (B) para Bajos del Norte. I y II: ovocitos previtelógenos; III: ovocitos en inicio de vitelogénesis; IV: ovocitos en inicio de vitelogénesis secundaria y V: ovocitos en fin de vitelogénesis secundaria.

DISCUSIÓN

El método tradicional de medición y conteo de los ovocitos permite observar el carácter modal de la distribución de frecuencia del diámetro de los ovocitos y determinar así el patrón de fecundidad de la especie (Tresierra y Culquichicón 1993). Sin embargo, es necesario realizar, un análisis histológico de las hembras maduras a fin de precisar el estadío de madurez sexual de *E. guttatus* y determinar el diámetro mínimo a partir del cual los ovocitos entran en vitelogénesis (estadío III). El análisis histológico de los ovarios, permitió determinar que el 100% de las hembras seleccionadas para este estudio se encontraban sexualmente activas, con ovocitos en fin de vitelogénesis secundaria (estadío V), sin ovocitos hialinos, ni folículos post ovulatorios. Para esta especie en el Banco de Campeche, los ovocitos comienzan a entrar en vitelogénesis cuando tienen un diámetro de 73 µm, Sadovy et al. (1994) reportan valores similares a los encontrados en este estudio, ya que los ovocitos entran en vitelogénesis cuando tienen un diámetro de 100 µm. Dicho diámetro servirá para cuantificar la fecundidad de las hembras y de esta manera no subestimar o sobrestimar la fecundidad del mero colorado.

En los histogramas de distribución de frecuencias del diámetro de los ovocitos se observo que los ovarios estuvieron comprendidos por dos lotes de ovocitos (previtelógenos y vitelógenos), exhibiendo un solo lote de ovocitos destinados a la puesta. Con relación a lo anterior existe poca información referente al patrón de fecundidad de *E. guttatus*, Sadovy et al. (1994) realizaron un estudio con esta especie, determinando macroscópicamente el estado de maduración de las gónadas, solo midieron el diámetro de los ovocitos más desarrollados (vitelógenos); con los datos obtenidos realizaron histogramas de frecuencia de los diámetros de los ovocitos y, finalmente sugirieron que las hembras presentaban fecundidad determinada y que desovaban más de una vez durante el curso de las agregaciones.

Con respecto a las tallas de los organismos se pudo observar que el patrón de fecundidad es independiente del peso y de la talla; lo mismo sucede con los sitios de colecta.

Con base a estos resultados preliminares, y en las observaciones realizadas por Sadovy et al. (1994) para *E. guttatus* de Puerto Rico, es probable que el mero colorado presente una fecundidad determinada. Sin embargo, información sobre el ciclo sexual de la especie y sobre la evolución de los estadíos histológicos de los ovocitos durante el período de reproducción de este mero (fase de vitelogénesis, fase de desove y fase de postdesove) son todavía imprescindibles para caracterizar de manera definitiva el patrón de fecundidad de la especie.

La temporada durante la cual se realizó el presente estudio corresponde generalmente a los meses de reproducción de *E. guttatus* (Bullock y Smith 1991, Colin et al. 1987, Sadovy 1996). De hecho, basados en conocimientos empíricos, los pescadores explotan los meros en los Bajos del Norte exclusivamente de febrero hasta mayo, por ser el período más productivo del año para la pesca de estos peces en esta región. Tuz – Sulub et al. (en prensa), mencionan que este comportamiento gregario puede estar relacionado con la actividad reproductiva de este mero, indicando que esta zona presenta indicios de agregación. Por lo cual una explotación

incontrolada de esta especie en sus áreas de agregación podría a futuro provocar su desaparición e inducir una sobreexplotación del reclutamiento del recurso (Colás-Marrufo 2000, Tuz-Sulub, com. pers.).

AGRADECIMIENTOS

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A Preliminary Investigation of the Age and Growth of Gray Snapper, *Lutjanus griseus*, in Louisiana Waters

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ABSTRACT

The gray snapper, *Lutjanus griseus*, is a temperate – tropical reef fish that is found along the Gulf of Mexico And Atlantic coasts of the southeastern United States. The fishery for gray snapper is rapidly developing in south Louisiana with the advent of seasonal restrictions on the established red snapper, *L. campechanus*, fishery. We examined the age and growth of gray snapper in Louisiana with the use of cross-sectioned sagittal otoliths. A total of 374 specimens, (202 males, 156 females, 14 juveniles, 2 unknown sex) were opportunistically sampled from the recreational fishery from July 2001 to August 2002. Males ranged in size from 308 to 732 mm TL and from 0.28 kg to 5.6 kg TW while females ranged from 298 to 756 mm TL and from 0.34 kg to 5.6 kg TW. A combined TL-TW regression for males and females was fit on log transformed data as $TW = 1.15 \times 10^{-8} (TL)^{2.96}$ ($r^2 = 0.97$). Edge analysis of sectioned otoliths suggests opaque annulus formation during the winter months. Age estimates ranged from 3-28 years for males and 2-25 years for females. Von Bertalanffy growth models derived from total length at age are $L_t = 654.4\{1 - e^{[-0.22(age+0.18)]}\}$ for males and $670.2\{1 - e^{[-0.19(age+0.28)]}\}$ for females. Each model also included 14 unsexed age-0 fish to provide points at the lower end of the curve to better reflect early growth.

KEY WORDS: Gray snapper, growth, otolith

Evaluación Preliminar del Edad y Crecimiento del Pargo Gris (*Lutjanus griseus*) en Aguas de Lousiana

El pargo gris, Lutjanus griseus, es un pez arrecifal de clima templado – tropical que se encuentra comúnmente en la costa del Golfo de México a traves del sureste de los Estados Unidos. La pesquería del pargo gris esta siendo desarrollada rápidamente en el sur de Lousiana debido a las vedas estacionales para la pesquería del huachinango *(Lutjanus campechanus)*. Se examino la edad y el crecimiento del pargo grisen Louisiana mediante el uso de secciones sagitales de otolitos. Un total de 820 individuos (436 machos, 379 hembras, 5 sexo indeterminado) fueron muestreados oportunistamente de la pesquería recreativa de Luisiana durante los años de 1998 a 2002 para datos morfometricos y otolitos. Los machos variaron en tamaño de 222 – 693 mm de talla total y de 200 a 5,670 gr. de peso total. Mientras

que las hembras variaron de 324 – 756 mm. de talla total y de 460 a 5,850 gr. en peso total. El análisis de covarianza no indicó diferencia significativas en coeficientes de regresion entre sexos, por lo tanto se uso una regresion de tendencia de longitud combinada con peso para machos y hembras de la manera siguiente: 4.47 X 10^{-6} (TL^2.81) (r^2 = 0.92). El análisis de otolitos sugiere la formación de anillos opacos durante el invierno. Las edades estimadas mediante otolitos variarion de 1 a 28 años. La curva de crecimiento de Von Bertalanffy basados en longitud total resulto en una estimacion de la edad LT = 634.7{1 – E^[-0.22(edad)]} (r^2 = 0.67) para machos y 650.3{1 – E^-0.21(edad)]} (r^2 = 0.67) para hembras. La ordenada al origen fue forzada a cero para reflejar mejor el crecimiento en vida temprana. Casi un tercio de todos los machos y hembras fueron de 6 a8 años de edad con reclutamiento a la pesquería recreativa del Golfo ocurriendo a la edad 6 años.

PALABRAS CLAVES: Pargo gris, *Lutjanus griseus*, edad y crecimiento

INTRODUCTION

The gray snapper, *Lutjanus griseus*, is a temperate - tropical reef fish that is found along the Gulf of Mexico and Atlantic Ocean of the Southeastern United States. The fishery for gray snapper is rapidly developing in south Louisiana with the advent of seasonal restrictions on the established red snapper fishery.

Some background information on early life history (Rutherford et al. 1989; Domeier et al. 1996), age and growth (Manooch and Matheson 1981, Johnson et al. 1994), and reproduction (Domier et al. 1996) on this species is available for South Florida waters and small portions of the northern Gulf of Mexico, but comprehensive age and growth data from the Louisiana fishery is nonexistent.

Accurate interpretation of presumed otolith annuli is crucial to successful management of the gray snapper. Our goal was to collect gray snapper on a seasonal basis from the recreational fishery to determine timing of opaque zone formation in otoliths and develop an age-size distribution for this species off the coast of Louisiana.

METHODS AND MATERIALS

Louisiana State University Coastal Fisheries Institute personnel sampled gray snapper from July 2001 to August 2002 at charter boat facilities in Fourchon, Louisiana. Morphometric measurements (fork length (FL) and total length (TL) in mm, total weight (TW) and eviscerated body weight (BW) in g) were taken, both sagittal otoliths were removed, and sex was determined for each specimen. For specimens for which TL was unavailable, TL was estimated from FL with the equation TL = 1.048(FL) + 8.35 (linear regression, df = 275; $p < 0.001$; r^2 = 0.98).

Male and female TL - TW regressions were calculated from natural log transformed data with the model ln TW = m (ln TL) + b. Regression coefficients were compared between sexes with analysis of covariance (ANCOVA) and test for

homogeneity of slopes. Age, TL, and TW frequency distributions were examined in 1 yr, 25 mm, and 0.2 kg increments, respectively. Komolgorov-Smirnov two-sample tests (Sokal and Rohlf 1981) were used to test for differences between sexes in each of the frequency distribution comparisons.

Right and left otoliths were weighed to the nearer 0.1mg. The left otolith was sectioned with a Hillquest, model 800, thin-sectioning machine with a slightly modified procedure borrowing petrographic techniques from geology as first described by Cowan et al. (1995). In instances where the left otolith was unavailable, the right was substituted. Otolith cross-sections were examined with a dissecting microscope with transmitted light and polarized light filter. Annuli, or opaque increments, were enumerated along the ventral side of the sulcul groove. Two readers performed increment counts independently without knowledge of capture date or morphometric data. In instances where the initial count differed the otolith section was re-examined by both readers.

Ages were estimated from increment count and edge condition (Beckman et al. 1991) with the equation described in Wilson and Nieland (2001). A birth-date of 1 July was set when calculating age to coincide with previous research indicating that gray snapper spawn from May to September with peak spawning activity occurring in mid-July (Allman and Grimes 2002). Annulus counting error between the two readers was evaluated after the second readings of otolith sections were completed. Reproducibility of the resultant age estimates was evaluated with the coefficient of variation, index of precision (Chang 1982), and average percent error (Beamish and Fournier 1981). The periodicity of opaque increment formation was examined with edge analysis and by plotting the proportions of opaque otolith margins by month of capture (Beckman et al. 1988, Campana 2001).

Theoretical growth parameters derived from TL at age were estimated with the von Bertalanffy growth model and nonlinear regression with least squares based on the formula:

$$L_t = L_\infty (1 - e^{[-k(t - t0)]})$$

where t is age in years, L_t is TL at age t, L_∞ is the theoretical maximum TL, k is the growth coefficient, and t_o is hypothetical age where TL is zero. The resultant models fitting parameters for both males and females were then combined into one full six-parameter model and compared to a reduced model on the pooled data in which sex was not considered. Each of these models also included 14 unsexed age-0 fish to provide points at the lower end of the curve. These individuals ranged in size from 36 mm to 94 mm TL. A likelihood ratio test of the six-parameter and the pooled data models was used to test for differences between sexes. Plots of residuals were used to test for normality of the data. A significance level of 0.05 was used for all statistical analysis.

RESULTS

Our personnel collected morphometric data, otoliths, and determined sexes for 374 gray snapper (202 males, 156 females, 14 juveniles, 2 unknown sex). A Komolgorov - Smirnov two-sample test indicated no significant difference between male and female TL frequencies in 25 mm increments (D = 5.38). Males ranged from 308 mm TL to 732 mm TL while females ranged from 298 mm TL to 756 mm TL (Figure 1). Both males and females showed mutimodal distributions of. A Komolgorov - Smirnov two sample test comparing distributions of TW (in 0.2 kg increments) did not indicate a significant difference between sexes (D = 5.9). Both male and female TW distributions are very similar with males ranging from 0.28 kg TW to 5.67 kg TW and females from 0.34 kg TW to a maximum of 5.62 kg TW.

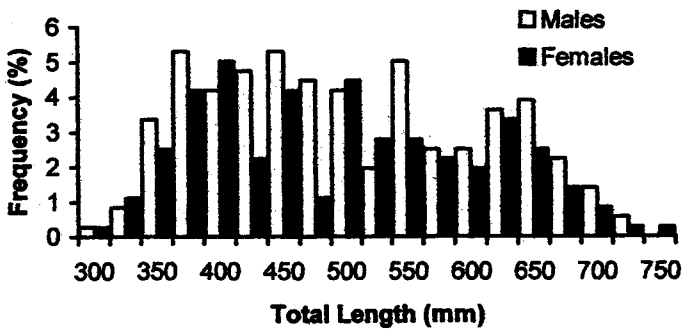

Figure 1. Total length frequency of male (n = 202) and female (n = 156) gray snapper, *Lutjanus griseus*, in 25 mm increments sampled from the Louisiana recreational fishery from July 2001 to August 2002.

No significant differences were detected when plotting TL-TW relationships between sexes (ANCOVA test of homogeneity of slopes, $F_{3, 352} = 0.34$; $p = 0.56$; ANCOVA test for equal intercepts, $F_{3, 352}=0.31$; $p = 0.58$). Therefore, one TL–TW regression was fit for males and females as follows:

$$\text{LogTW (kg)} = 1.15 \times 10^{-5}(\text{LogTL}^{2.96})$$

Examination of the percentage of otoliths with opaque and translucent margins by month of capture suggests that opaque increments are formed during the winter months. Preliminary data suggests that a translucent increment is accreted on the otolith from April to October (Figure 2).

Ages were obtained from transverse otolith sections of 342 gray snapper (184 males, 142 females, 14 juveniles, 2 unknown sex). Opaque rings are easily distinguishable on the ventral side of the sulcul groove (Manooch and Matheson 1981, Shipp 1991, Johnson et. al. 1994) (Figure 3). Readers disagreed on ages for

only four individuals, so the ages of the more experienced reader (AJF) were used in all analyses. Both readers agreed on all other counts (N = 338) or 98.8 % of age estimates after the second reading. The average percent error was 0.5 %, the coefficient of variation was 0.001 and the index of precision was 0.0009.

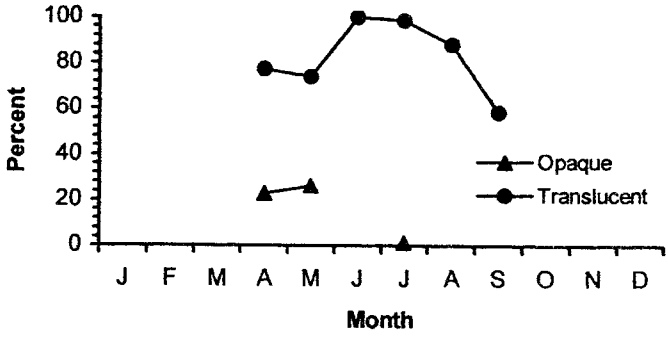

Figure 2. Marginal increment analysis of gray snapper, *Lutjanus griseus*, otoliths sampled from July 2001 to August 2002. Percentages of opaque margin edges are plotted against month of capture.

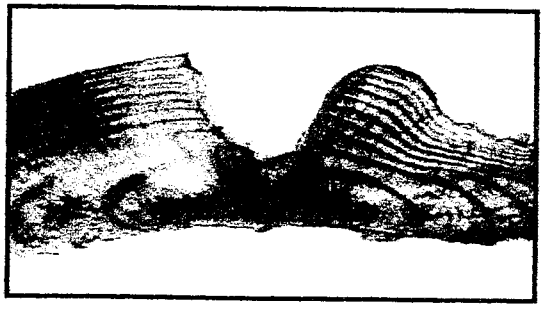

Figure 3. Photomicrograph of gray snapper, *Lutjanus griseus*, sagittal otolith transverse cross section under transmitted light.

A Komolgorov-Smirnov two-sample test revealed no significant difference in age distributions between sexes (D = 8.82). Males ranged in age from 3 to 28 years while females ranged from 2 to 25 years. Males were found in the greatest numbers at age 4 while females were most abundant at 8 years. The fishery is dominated by younger fish with 72 % of males and females aged at 10 years or less.

Data were fit to von Bertalanffy growth models and compared between sexes. A likelihood ratio test indicated a significant difference between a full six-parameter growth model and the pooled data growth model (χ^2 = 35.93; df = 3,341;p < 0.0001). Therefore, separate growth models were fit for each sex (Figure 4). The von Bertalanffy growth models derived from TLs are:

Male $L_t = 654.4\{1 - e^{[-0.22(age+0.18)]}\}$

Female $L_t = 670.2\{1 - e^{[-0.19(age+0.28)]}\}$

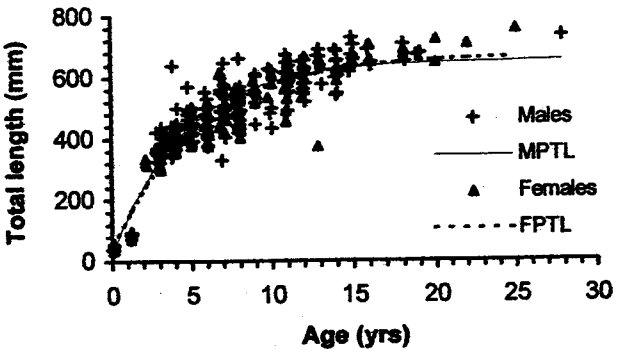

Figure 4. Von Bertalanffy growth models fitting total length at age for male and female gray snapper, *Lutjanus griseus*, sampled from July 2001 to August 2002. Each model includes 14 unsexed juveniles ranging from 36mm to 94mm.

DISCUSSION

Gray snapper otoliths are very similar in morphology, although much smaller in actual size, to those of red snapper. Although the opaque increments are distinct, the small size of the otoliths and apparent longevity of the species pose some challenges in age estimation. Considerable variability is displayed in the position of the first annulus in gray snapper. A similar pattern, also exhibited in red snapper otoliths, finds the first annulus variously located from somewhat distant from the core to close to and continuous with the otolith core (Wilson and Nieland 2001). Additional problems in otolith interpretation include counting the closely spaced annuli in older individuals and accurate interpretation of the otolith margin condition among these older specimens.

The lack of data from the months of November through March precludes our making a definitive statement of timing of opaque annulus formation based on

marginal increment analysis. However, our data suggest that a translucent increment is accreted at the otolith edge from April to October. Burton (2001) used marginal increment analysis to validate the periodicity of gray snapper annulus formation in Florida waters stating that as opaque annulus is deposited on the otolith edge during June and July. Burton measured the distance between the distal edge of the last opaque zone and the otolith edge and then plotted measurement means against month of capture. He stated that the mean minimum distances, or minima, would indicate the month of opaque increment formation. However, measurement of the minimum distance from the distal edge of the last opaque zone may actually represent the beginning of the translucent zone and therefore estimate a late period of opaque zone formation.

Our maximum ages are greater then those found in previous studies. Johnson et. al (1994) reported maximum ages of 23 and 25 years for males and females, respectively, and Burton (2001) reported a non-sex-specific maximum age of 24 years.

The von Bertalanffy growth models estimated a slightly larger maximum theoretical size (L_∞) for females than males at 670.2 mm TL and 654.4 mm TL, respectively. The presence of more large, older fish in our sample population resulted in the model forming an asymptote at a smaller maximum theoretical size compared with Johnson et al. (1994) who predicted greater maximum theoretical lengths for both males and females with the regression method of Manooch and Matheson (1981) to back calculate lengths at age. Johnson et al. also had smaller estimated growth coefficients (k) than this study. Knight (1968) noted the close inverse correlation of L_∞ and k and that caution should be taken in interpretation of these parameters. It should be noted that Johnson et al. (1994) had no individuals below 200 mm TL. Burton (2001) also estimated growth parameters by fitting back-calculated lengths at age to predict larger maximum theoretical lengths. Burton (2001) had a number of fish below 200 mm TL allowing for more accurate estimates of k and t_0.

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Growth of Early Stage Gray Snapper, *Lutjanus griseus*, Across a Latitudinal Gradient

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ABSTRACT

The gray snapper, *Lutjanus griseus*, is an ecologically and commercially important fish throughout the Caribbean. Despite its significant role in the marine ecosystem and its economic value, relatively little is known about the early life history of this species. Length of larval life may influence the geographic boundaries of local populations and linked to this is larval growth rate. Faster growth during larval life may result in shorter pelagic larval durations (PLD) and may give fish a survival advantage. Elucidating latitudinal differences in early life history traits and the environmental conditions leading to faster growth of larval and juvenile snapper should shed insight into the dynamics of larval life and the potential for population connectivity. As part of a larger study of population connectivity, young of the year *L. griseus* were collected from five sites in the southeastern United States during Fall 2000 and 2001: Florida Bay, Biscayne Bay, Sebastian Inlet, and Jupiter, Florida, and Core Sound, North Carolina. Fish were measured, weighed and the sagittal otoliths removed for aging. Standard otolith aging techniques were used to enumerate daily growth increments. Results demonstrated significant differences in growth rates among sites and between years, which may be correlated with environmental factors, such as temperature. There were also significant differences in the PLD of juveniles between years and sites. Despite this, the larval trajectories across sites and years were similar. The similarities among larval growth trajectories suggest that all of the snapper within a given year were either in similar water masses or the same water mass during their larval life. The disconnection between larval growth and PLD may imply that habitat availability during transport, not growth, is determining settlement.

KEY WORDS: Gray snapper, *Lutjanus griseus*, growth

Diferencias Locales y Latitudinales en el Crecimiento del Pargo de Mangle, *Lutjanus griseus*, Durante su Vida Pelagica

El pargo de mangle, *Lutjanus griseus*, es un pez ecologicalmente y commercialmente importante en todo el Caribe. A pesar de su importante función dentro del ecosistema marino y de su valor económico se sabe muy poco sobre el crecimiento de esta especie, especialmente durante los estadios pelágicos de su vida . Como parte de un estudio de conectividad de poblaciones, los *L. griseus* mas jovenes del año fueron colectados en cinco sitios al sureste de los Estados Unidos durante la temporada de otoño de los años 2000 y 2001: Bahia de Florida, Bahia

de Biscayne, Inlet de Sebastian y Jupiter en Florida, y Core Sound en Carolina del Norte. Los peces fueron medidos y pesados y los otolitos sagitales fueron extraidos para determiner la edad. Incrementos diarios de crecimiento fueron contados usando técnicas estandarizadas de edad y la deposición del incremento diario fue validada. La tasa de crecimiento durante los estadios larvales y juveniles, y asi como la duración de las etapas larvales planctonicas parecen estar influenciadas por varios factores medioambientales a lo largo del gradiante de latitud. Los records de otolitos indican diferencias en las tasas de crecimiento entre sitios y años. Comparación de estos datos con datos similares colectados en la costa oeste de la Florida, indican la posibilidad que las diferencias entre las tasas de crecimiento sean causadas por el medio ambiente. Los datos de edad colectados a traves de este proyecto seran utilisados juntos con datos de microquimica para ayudar a dilucidar la probabilidad de conectividad de las ploblaciones de esta especie.

PALABRAS CLAVES: Pargo de mangle, *Lutjanus griseus*, crecimiento

INTRODUCTION

The gray snapper, *Lutjanus griseus*, is a moderate-sized (to 4.5 kg) widely distributed fish, found in the western Atlantic from Florida through Brazil, including Bermuda, the Caribbean and the northern Gulf of Mexico (Robins et. al. 1986). Gray snapper occupy a variety of habitats during their life cycle. Adults are found near complex habitats such as coral reefs, shipwrecks, rocky outcroppings and ledges, and other natural live-bottom areas (Miller and Richards 1980); they aggregate on the outer reef tract to spawn during full moons of late summer months (Starck and Schroeder 1971). Once hatched, pelagic larvae are presumably dispersed offshore, but the specific path they follow is not known. Eventually, late stage larvae enter shallow seagrass and mangrove nursery areas for settlement. The estimated pelagic larval duration (PLD) for this species is between 25 to 42 days (Lindeman 1997). With this PLD and the possibility of entrainment into the Gulf Stream, a broad geographical range of dispersal is possible. Furthermore, there is ample time for high mortality. Shortening this vulnerable stage by growing quickly may enhance survival. Larvae of some reef fish fishes with faster growth settle out of the plankton more quickly and are therefore less exposed to predation (Searcy and Sponaugle 2000). Currently, it is unknown what occurs during the early life stages of gray snapper. The purpose of this study was to measure a number of early life history traits of snapper settling to a latitudinal range of sites as a first step towards a better understanding of population connectivity in this species. Traits of interest include: larval growth, size and age at settlement and juvenile growth rate.

METHODS

Sample Collections

Early-stage juveniles of *L. griseus* were collected from four locations along the Florida coast (Jupiter, Sebastian Inlet, Biscayne Bay and Florida Bay) and one off the coast of North Carolina in the vicinity of Beaufort Inlet (Core Sound) during the year 2000 and 2001. Samples were collected near the end of the recruitment season (Sept./Oct.) as defined by larval ingress work in North Carolina (Tzeng et al. 2002) and in the Florida Keys. During sampling, environmental measurements were collected including: GPS position, bottom type, shore type, water temperature, salinity, and tidal stage. Collected samples were frozen and transported to the University of Miami- Rosenstiel School of Marine and Atmospheric Science for further analysis.

Daily Age Estimation and Growth

All the fish from each location were used for otolith age estimation. Prior to dissection, each fish was weighed and its standard length (SL), total length (TL) and fork length (FL) measured to the nearest 0.1 mm using digital calipers. The fish then were dissected to remove the sagittal otoliths using standard techniques (Brother 1987). First, all unclear, abnormally shaped (non-linear growth axis) sagittae were discarded. One sagittal otolith from each fish was used for aging. All otoliths were mounted in epoxy, sectioned, sanded and read following standard protocols (Secor et al. 1991). Otoliths were examined under a Leica transmitted light microscope at 400X. The microscope image was captured with a frame grabber and displayed on a computer screen. Using the Image-Pro image analysis system, we enumerated increments along the anterior dorsal portion of the otolith from the core to outer edge. Otolith length (radius)-at-age was recorded for every day in the larval and juvenile periods. The timing of settlement was determined by examining otoliths for optical marks associated with settlement. From this information, the larval duration, time of settlement and juvenile age, as well as daily growth rates (increment widths) and size at age during larval and juvenile periods were determined. To obtain a measure of PLD, two days were added to the number of increments to account for time to hatching.

Data Analysis

Analysis of covariance (ANCOVA) was used for comparing growth rates. Analysis of variance (ANOVA) was used to compare PLDs. Where possible Tukey's multiple comparison test was used to look at site specific differences in growth rates and PLDs (Zar 1984). The increment width data (growth trajectories) were analyzed using repeated measures analysis of variance (MANOVA).

RESULTS AND DISCUSSION

The larval snapper growth trajectories were similar across the latitudinal gradient, especially during the beginning of larval life. While there was slight variation in these trajectories, the overall trend was very similar. Growth trajectories are a proxy for somatic growth and also reflect the environment that the larvae were in. The similar nature of the larval trajectories from the various sites suggests that fish were in the same or similar water masses during their larval life.

Although the larval growth trajectories were similar, pelagic larval durations were longer for fish settling to northern sites. In reef fishes it has been shown that faster growth leads to quicker settlement (Searcy and Sponaugle 2000). However, in this case, growth was not faster for those fish with shorter pelagic larval durations. Even though the growth trajectories were similar, the size at settlement (based on otolith radius at settlement) was also larger at northern sites because the fish from the northern sites were in the plankton for a longer period and should therefore be larger. The combination of size at settlement, and similarities in larval growth trajectories, yet differing PLDs indicates that perhaps habitat availability rather than growth rates or competency may be affecting settlement.

The juvenile stage of gray snapper showed a very different trend from the larval stage. Juvenile growth rates were higher at southern locations compared to northern locations. This is especially evident when size-at-age is analyzed. Biscayne Bay fish had a larger size at age than fish from Core Sound in both years of this study. Differences in environmental factors, especially warmer water temperatures at southern locations, likely contribute to this pattern.

Although growth rates at the southernmost site (FLB) may have been influenced by the larger size range of fish collected (assuming progressive selective mortality of slower growers), there was a consistent trend of higher growth at southern sites relative to northern sites.

In the future, these data will be combined with microchemical analysis of the other sagittal otolith from the same fish to develop a model of population connectivity for *L. griseus*. Because of the important economic and ecological role of gray snapper in the coral reef and mangrove ecosystem, understanding where they spawn and how and where they are dispersed has important management implications.

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Estimación de los Parámetros de Crecimiento del Mero *Epinephelus morio* en la Isla de Holbox Quintana Roo, México

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INTRODUCCIÓN

La pesca es una actividad importante en el mundo, en el estado de Quintana Roo, la pesca es una actividad que se practica desde hace muchos años y se encuentra entre las mas importantes para la sobre vivencia humana. Entre los organismos con mayor interés comercial se encuentra el caracol (*Strombus gigas*), la langosta (*Panulirus argus*) y la escama teniendo al mero (*Epinephelus morio*) en primer lugar, el boquinete (*Lachnolaimus maximus*), canane, negrillo (*Mycteroperca bonaci*) entre otros.

La actividad pesquera de esta zona esta considerada como una pesquería artesanal en donde intervienen lanchas de fibra de vidrio y motores fuera de borda, ya que no se alejan mucho de la costa (Miller 1982, Alcalá Moya 1985, Sosa Cordero 1995).

El mero es uno de los principales géneros de mayor explotación desde el Banco de Campeche, en donde intervienen las flotas de Estados Unidos, Cuba y principalmente México, hasta la parte norte del Estado de Quintana Roo.

En México abunda en la plataforma continental frente a la península de Yucatán, aunque existe en cantidades menores en otras localidades del Golfo y del Caribe; se captura de marzo a diciembre a profundidades entre las 12 y 20 brazas. En el Pacifico, la mayor parte de las capturas proceden de Sinaloa, Nayarit, Sonora y Baja California y con frecuencia se pescan como fauna de acompañamiento en las redes camaroneras.

Una breve descripción de su explotación, en donde los volúmenes de captura incremento en un 460% pasando de 1 941 Tn. a 8 929 Tn. (S.I.C. 1964, Del. Est. Pesca 1984). El producto de esta pesquería alcanzo en 1988 un total anual de 13 440 toneladas, correspondiendo al pacifico 115 y el Atlántico 13 325, representa la pesca de escama de mayor valor comercial en el sureste del país. En general se procesa en forma de filetes congelados que, en su mayor parte, se envían a Estados Unidos, donde es muy estimado y solo superado por el guachinango. En el mercado nacional, gran parte de la captura se consume en forma de filetes frescos y congelados; también se comercializa entre eviscerado y en menor proporción se expande como producto seco, salado.

Los meros, pertenecen a la familia Serranidae y se localizan en fondos rocosos o fangosos de bahías profundas, desde 10 metros hasta los limites de la plataforma continental; prefieren lugares sombreados y con poca luz y solo excepcionalmente llegan a los grandes abismos; son carnívoros sumamente voraces y su dieta alimenticia se basa en peces, cangrejos, camarones y moluscos. Como ejemplos esta

el mero pinto o cherna yucateca (*Epinephelus morio*), la cherna (*Epinephelus itaira*), el mero (*Epinephelus striatus*), el mero italiano (*Epinephelus guaza*) y el mero blanco(*Epinephelus geneus*).

El objetivo del presente trabajo fue determinar las principales tallas de captura del mero (*Epinephelus morio*) en la pesquería artesanal que se realiza en la Isla de Holbox, así como la relación longitud-peso de dichos organismos y de esta manera poder determinar los parámetros de crecimiento. Con la realización del presente trabajo y con la ayuda de trabajos sobre la biología de la especie, las condiciones del stock pesquero a través del tiempo; se pretende dar a la pesquería de la zona norte del Estado de Quintana Roo predicciones seguras para tener buenas estrategias alternativas de explotación de una de las especies de mayor importancia comercial en la zona como es el mero (*Epinephelus morio*).

ANTECEDENTES

Respecto a la edad y crecimiento Moe (1969), realizó por primera vez el estudio sobre, trabajando con el mero en la costa Oeste de Florida. Para el mero del Banco de Campeche, Gonzalez (1974) utilizando el hueso Urhoidal y Muhlia (1976), utilizando los otolitos determinan la edad y el crecimiento al estudiar la pesquería del mero.

Ruiz Dura (1978), hace una descripción de las características del recurso *Ephinephelus morio* así como distribución, su situación actual, la ubicación ecotica y talla comercial. Posteriormente Valdes y Padrón (1980) al estudiar la pesquerías de palangre de la misma región determinaron la edad y el crecimiento utilizando el hueso Urohial y Doi, Mendizábal y Contreras 1981 al realizar un análisis preliminar de la población del mero del Banco de Campeche determinaron la edad y crecimiento a partir de la lectura de otolitos.

Ríos Gloria, Zetina Moguel, et al. (1996), realizan un análisis de la comunidad de peces ligados a la pesquería palangrera de mero (*Epinephelus morio*) en el banco de Campeche además de publicar el mismo año notas sobre la reproducción de la misma especie en el banco de Campeche, Golfo de México.

Richardson y Gold en 1997 realizan un estudio de diversidad del DNA mitocondrial y estructura de la población de *Epinephelus morio* para el Golfo de México.

En 1999 Arreguin-Sánchez, Francisco y Tony J. Pitcher, realizan un trabajo llamado "Capturabilidad estimada y su aplicación la red grouper (*Epinephelus morio*) en la pesquería del banco de Campeche, para la realización de modelos que predicen la captura, el modelo se basa en una matriz de transición y datos expresados por la estructura de longitudes en captura por unidad de esfuerzo de la población.

ÁREA DE ESTUDIO

La isla Holbox (Figura 1), se encuentra dentro del área natural protegida, con carácter de área de protección de flora y fauna denominada Yum Balam, entre los paralelos 21°15' y 21°42' de latitud Norte y los meridianos 87°06' y 87°31' de longitud oeste, en el extremo Norte del municipio de Lázaro Cárdenas, sus dimensiones aproximadas son de 34 km de largo y 2km de ancho, situada a 0m/SNM.

Figura 1. Área de estudio

Las características de esta zona son selva mediana, salva baja inundable, humedal y manglar chaparro. Las actividades que se desarrollan son; el turismo ecológico, la investigación y actividad pesquera: captura de escama, langosta y pulpo. Siendo restringida la pesca en la laguna Yalahau.

A nivel municipio el de clima cálido subhúmedo(AWO) con lluvias en verano, pero las variaciones en la cantidad de precipitación anual dan lugar a tres subtipos de este clima. La oscilación térmica entre 5 y 7°C. La temperatura media anual es de 26°C; con lluvias en Julio-Agosto-Septiembre y nortes en Noviembre-Diciembre-Enero-Febrero.

La precipitación pluvial corresponde a la clasificación de régimen tropical lluvioso con lluvias en verano y en invierno, con la presencia de los vientos del norte. Las mayores precipitaciones en la costa de la región alcanzan los 800 mm anuales. Los vientos dominantes en esta parte del estado son los del norte.

METODOLOGÍA

Los muestreos se efectuaron mensualmente de Septiembre, Octubre, Noviembre del 2001, Marzo y Mayo del 2002 en la Isla de Holbox Quintana Roo. Los datos se obtuvieron de la pesca artesanal, donde se obtenían de manera azarosa las longitudes y pesos del mero (*Epinephelus morio)*, contamos con un ictiómetro con precisión de 1mm y una balanza comercial con precisión de 1 gm.

a. Longitud furcal (mm)
b. Peso total (gm)

Los ejemplares fueron tomados de la captura comercial de las embarcaciones de la flota menor en el puerto de arribo de la Isla de Holbox. El arte de pesca que utilizan los pescadores en la captura de dichos organismos es la línea y el anzuelo.

Relación Longitud Peso

Para obtener la relación longitud-peso de los organismos muestreados, se utilizó la ecuación siguiente:

$$W = aL^b$$

donde:
W = peso
L = longitud
a = coeficiente de condición
b = parámetro de ajuste

Para poner los valores de a y b se efectuó una regresión logarítmica con los datos de longitud y peso de los muestreos, en el programa Excel.

Crecimiento Teórico

Para determinar los parámetros de crecimiento, se ingresaron los datos de longitud-frecuencia de los datos obtenidos en los muestreos por los cinco meses, la programa Fisat, en donde, por medio de las aplicaciones de ELEFAN y Shepherd se obtuvieron la Loo y K. Para la estimación de las longitudes que presenta el pez a una edad determinada se aplico la ecuación de Von Bertalanffy (1938).

$$Lt = L_\infty (1-e^{-k(t-to)})$$

RESULTADOS

La pesquería del mero es de importancia en la comunidad de Holbox. En la Figura 2, se ve reflejada la producción durante el periodo comprendido entre 1990-2000.

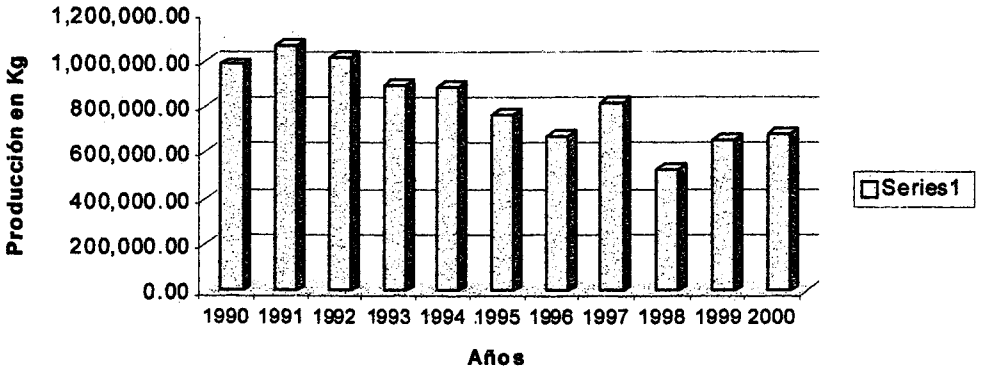

Figura 2. Producción anual del mero (*Epinephelus morio*)

El numero total de organismos muestreados durante los cinco meses fue de 1041 de los cuales solo 668 fueron de longitud y su peso correspondiente. En cuanto a las tallas, la mínima observada fue de 205 mm y la máxima fue de 650 mm. Así como también el peso mínimo de 240 gr y el peso máximo muestreado de 2000 gr. La desviación estándar mayor se registró en el mes de Septiembre (Tabla 1)

Tabla 1.

	Longuitud				
	Septiem 10	Octubre 01	Noviemb 01	Marzo 2002	Mayo 2002
Promedio	371.057803	359.846154	421.356643	330.642857	334.960486
Desv. Estan.	65.8772388	48.7234671	65.1974688	49.6492864	64.8729172
Tmax	595	500	642	450	650
Tmin	281	205	290	260	230
N	147	116	31	84	290

	Peso				
	Septiem 10	Octubre 01	Noviemb 01	Marzo 2002	Mayo 2002
Promedio	771.904762	676.810345	753.870968	475.095238	507.513678
Desv. Estan.	590.386562	226.24957	261.290737	191.707082	263.654038
Tmax	3150	1550	1600	940	2000
Tmin	250	370	400	290	240
n	147	116	31	84	290

La distribución de los intervalos de frecuencia por mes y el total se detallan a continuación en el Figura 3.

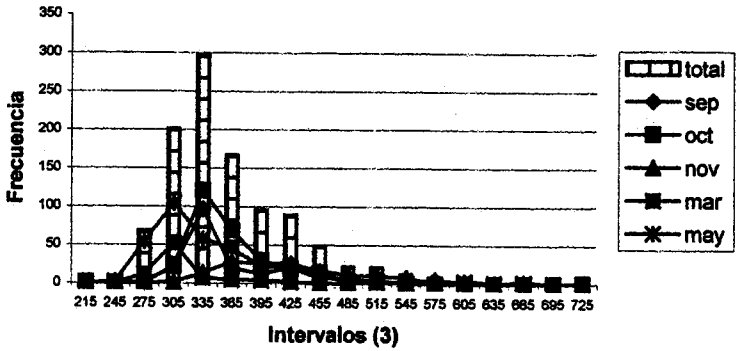

Figura 3. Distribución de los intervalos de frecuencia

Al aplicar la relación longitud-peso, es decir el tipo de crecimiento, dando este un crecimiento alometrico, como se observa en la Figura 4.

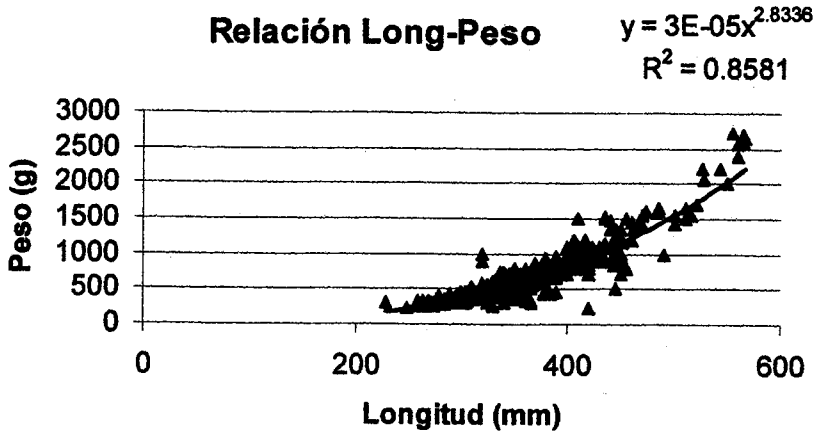

Figura 4. Relación longitud-peso

Los parámetros de crecimiento que se obtuvieron por el programa Fisat, con las aplicaciones de ELEFAN y Shepherd, así como también el calculo de to se pueden observar en la siguiente tabla. (Tabla 2)

Tabla 2. Parámetros de crecimiento del mero, *Epinephelus morio*

	ELEFAN	SHEPHERD
K	0.314	0.366
Loo	795	782
Log To	-0.2335	-0.2510
To	-1.712	-1.641

Las estimaciones de las longitudes que presentó el pez a una edad determinada (Von Bertalanffy) se observan en la Tabla 3, y en la Figura 5 se observa la relación entre la edad y la longitud que presenta le organismo.

Tabla 3.

EDAD	ELEFAN	SHEPHERD
0	56.2030539	68.638189
1	255.294773	287.281586
2	400.735062	438.911394
3	506.981961	544.067091
4	584.597342	616.992861
5	641.296855	667.567087
6	682.716928	702.640454
7	712.975079	726.963933
8	735.079234	743.832333
9	751.226741	755.530616
10	763.022801	763.643408
11	771.640048	769.269652
12	777.93511	773.171468
13	782.533773	775.877388
14	785.893184	777.753952
15	788.347298	779.055354
16	790.140074	779.957879
17	791.449732	780.583784
18	792.406462	781.01785
19	793.105371	781.318876
20	793.615937	781.527639

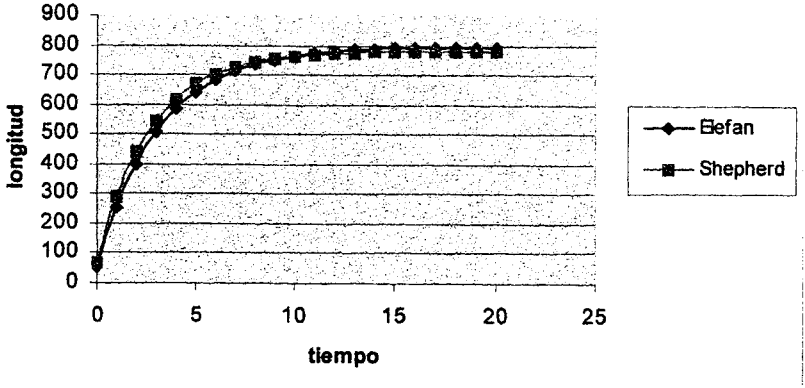

Figura 5. Curva de crecimiento obtenido con los parámetros de crecimiento de Elefant y Shepherd para el mero (*Epinephelus morio*)

DISCUSIÓN

Los parámetros de crecimiento obtenidos por el FISAT, predice una longitud máxima de 650 mm y un coeficiente de crecimiento "k" de 0.314. Estos parámetros de crecimiento comparados con los encontrados por Aguilar Dávila (1989) en el Estado de Yucatán, dan como talla máxima 821 mm y una k de 0.1350, la diferencia es notable en ambos parámetros, tomando en cuenta que en dicho trabajo el tamaño de la muestra fue mayor (23,068 ind.), además de utilizar diferentes modelos como el de Beverton y Holt para la determinación de los mismos.

No obstante, la tasa de crecimiento que muestra *Epinephelus morio*, se considera ligeramente alta, con esto se esperarian tasas de crecimiento mas bajas debido a la biología de la especie, ya que es un organismo longevo; este resultado comparado con otros trabajos de especies pelágicas de crecimiento rápido, como: el macarela *Scomberomorus cavalla*, K= 0.35; y el sabalo del Atlántico *Brevoortia tyranus*, K= 0.391.

Con todo lo anterior se demuestra que el mero (*Epinephelus morio)* es una especie de crecimiento lento y vida larga, (25 años).

Se obtuvieron datos proporcionados por SAGARPA, que reflejan la situación de la pesquería de escama, en las cuales nos avocamos a los valores alcanzados por el mero en la Isla de Holbox en un periodo de 10 años (1990-2000) (grafica 1), la grafica nos indica que la máxima producción se obtuvo en loa años de 1991 y 1992, y no se observa una disminución considerable a la fecha , ya que en los años restantes se ha mantenido en un nivel similar en cuanto a ala producción anual.

En el Figura 3 nos arroja la distribución de los intervalos (3cm) de frecuencia quedando los meses de Septiembre y Octubre con los niveles mas altos de frecuencia y con intervalos de 335, los meses de Noviembre y Marzo con 365 de intervalo y Mayo con 305, eso quiere decir que los organismos capturados en el lapso de estos cinco meses estuvieron entre las tallas de 305 a 365cm, siendo estas tallas encontradas entre las primeras etapas juveniles.

Como se observa en la Figura 4 la relación longitud-peso nos muestra una pendiente de de 2.8336 lo que nos indica que la especie estudiada tiene un crecimiento alométrico, la relación existente ente las dos variables $R^2 = 0.8581$ indica que el 85% de los organismos se ajustaron a la curva potencial.

En la Tabla 3 se muestran las estimaciones de las longitudes del pez a determinada edad (Von Bertalanffy). En el Figura 5 se observa el crecimiento del organismo a través del tiempo por medio de dos métodos indirectos, donde se observa que existe cierta semejanza en cuanto a las curvas.

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Red Snapper (*Lutjanus campechanus*) Associated with a Small Artificial Structure in the Mississippi Sound, a Northern Gulf of Mexico Estuary

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ABSTRACT

During September 1994 - 1997, opportunistic sampling of red snapper (*Lutjanus campechanus*) at a small, artificial structure in the Mississippi Sound estuary provided information on age, reproductive biology, diet and behavior of juvenile and adult red snapper from inshore habitat. The study represents the first detailed account of adult red snapper from a northern Gulf estuary. Red snapper (n = 302) collected from the study site ranged in size from 229 - 714 mm TL; 172 were retained for laboratory examination, and 130 were tagged and released. Age estimates for some specimens (n = 36; 326 - 713 mm TL) ranged from 2 - 5 years. Histological assessment of gonads from a small sample of fish (n = 13) collected primarily during late summer and fall (near the end of the spawning season) revealed sexually mature males (n = 5; 390 - 520 mm TL) and females with regressed ovaries (*n* = 5; 326 - 662 mm TL) or immature ovaries (n = 2; 326 and 330 mm TL). However, ovaries from a single female collected during July (during the peak of the spawning season) contained oocytes in the final oocyte maturation (FOM) stage, an indication of imminent spawning. This finding was of great interest since red snapper are reported to spawn only in offshore waters. Snapper diet consisted of fish, crustaceans and cephalopods. Anchovies (*Anchoa hepsetus* and *A.* sp.) and hardhead catfish (*Arius felis*), were the dominant prey in the diet and occurred in 54 % of stomachs. Gulf crab (*Callinectes similis*), other portunid crabs, and penaeid shrimps were the primary crustaceans in the diet. Tag-recaptures (n = 32) were from the site of tag-release only and extended from 1 - 373 days-at-large. Recaptures documented growth for fish, primarily juveniles and young adults, at the study site and suggested site fidelity and overwintering for some fish. Aspects of the perennial occurrence of adult red snapper in the Mississippi Sound estuary are discussed.

KEY WORDS: *Lutjanus campechanus*, estuarine habitat, Mississippi Sound

Asociacion del Pargo Rojo (*Lutjanus campechanus*) con una Pequeña Estructura Artificial en Mississippi Sound, un Estuario al Norte del Golfo de Mexico

Durante Septiembre 1994 - 1997, el muestreo oportuno del pargo rojo (*Lutjanus campechanus*) en una pequeña estructura artificial en el estuario de Mississippi Sound proporcionó información sobre la edad, biología reproductiva, dieta y comportamiento del pargo rojo (juvenil y adulto) en el habitat costero. Este estudio representa la primera valoracion detallada del pargo rojo adulto en un estuario al norte del Golfo. El pargo rojo (n = 302) colectado en el sitio del estudio fluctuo en tamaño entre 229 - 714 mm LT; 172 fueron conservados para ser examinados en el laboratorio, y 130 fueron marcados con etiquetas y liberados. Las estimaciones de edad para algunos especímenes (n = 36; 326 - 713 mm LT) fluctuaron entre 2 - 5 años. La examinacion histológica de las gónadas en una muestra pequeña de pescados (n = 13) colectados primordialmente a finales del verano y otoño (cerca del final de la estaciòn de desove) revelò a los machos sexualmente maduros (n = 5; 390 - 520 milímetros TL) con el esperma en los lóbulos y en el conducto espermatico y las hembras con los ovarios en regrecion (n = 5; 326 - 662 mm LT) o los ovarios inmaduros (n = 2; 326 - 330 mm LT). Sin embargo, los ovarios de una sola hembra colectada en julio (durante el pico de la estación de desove) contenia los oocitos en su etapa final de maduración (FOM), una indicación del desove inminente. Este descubrimiento fue de gran interes, particularmente debido a que el desove del pargo rojo es descrito solamente en aguas alejadas de la costa. La dieta del pargo consistió en pescados, crustàceos y cefalópodos. Pescados, sobre todo anchoas (*Anchoa hepsetus* y *A.* sp.) y el siluro de cabeza dura (*Arius felis*), fueron la presa dominante y ocurrieron en el 54 % de los estòmagos. El cangrejo azul (*Callinectes sapidus*), otras jaibas (portunidae) y camarones (penaeidae) fueron los crustàceos dominantes en la dieta. El calamar contribuyò muy poco en la dieta. Recapturas (n = 32) fueron establecidas solamente en el sitio de liberacion y fluctuo entre 1 - 373 dias de liberacion. Recapturas documentan el crecimiento de cada pez (juveniles y adultos jovenes) y sugiere no solamente coneccion a largo plazo con el sitio sino su permanencia durante el invierno. Los aspectos de la ocurrencia perenne del pargo rojo adulto en el estuario de Mississippi Sound son discutidos.

PALABRAS CLAVES: Pargo rojo, *Lutjanus campechanus*, estructura artificial

INTRODUCTION

Red snapper occur from the mid-eastern coast of the United States through the Gulf of Mexico (Gulf) to the Yucatan (Hoese and Moore 1998) and support valuable commercial and recreational fisheries throughout their range. The red snapper fishery is the most economically valuable fishery of the snapper/grouper

complex in U.S. waters of the Gulf.

The biology, ecology and behavior of red snapper from the Gulf have been recently studied by Comyns and Lyczkowski-Shultz (1993) - larvae; Render (1995), Collins et al. (1996), Woods et al. (in press) - reproduction; Szedlmayer and Shipp (1994) - habitat; and Wilson et al. (2001), Patterson (1999) and Fischer (2002) - age/growth. Life history studies of red snapper typically focused on associations with offshore artificial reefs and petroleum platforms.

Juvenile red snapper are occasionally collected in research trawl hauls and beam plankton net hauls associated with fisheries assessment and monitoring studies in the Mississippi Sound, a shallow ($\bar{x}$ depth = 3 m) northern Gulf estuary, and are collected from (1) from sea grass flats (shoal grass, *Halophia* sp.), (2) over sand-mud bottom, and (3) from Dog Keys Pass at Horn Island (IFMAP, 2001). Hastings (1979) observed that adult red snapper rarely move into coastal Gulf waters, and adult red snapper have not been reported from the Mississippi Sound.

In September 1994, we encountered an aggregation of large red snapper at a small, isolated, artificial structure within the Mississippi Sound. The inshore occurrence of large red snapper was considered uncharacteristic for this species within the region and prompted us to periodically visit the site to investigate biological and behavioral aspects of red snapper associated with the structure. Although the Mississippi Sound estuary is not considered essential habitat for red snapper, our small-scale study documented the seasonal occurrence of adult and large juvenile red snapper within inshore coastal waters of the northern Gulf.

MATERIALS AND METHODS

Study site

During fisheries sampling activities conducted September 1994 - September 1997, we investigated red snapper associated with a small artificial structure (approximately 2 m^2 in size) which we opportunistically discovered in the Mississippi Sound on 24 September 1994. The structure was located in six meters of water at Lat. 30° 14'N and Long. 88' 30°W, 3 km north of Petit Bois Island and 8 km south of the mainland (Figure 1). The structure lay on the sloping bank of a 14m-deep navigation channel, the Pascagoula Ship Channel. The structure was tentatively identified as a metallic object, however, its exact composition, profile and size were not determined. We did not dive on the site, nor did we deploy underwater cameras to photo the structure. The substrate at the site was a mixture of sand and mud. Hydrological data were recorded during research activities.

Specimen Collection

All specimens were caught by hook-and-line gear using natural and artificial baits. Two research teams (including one consisting of the authors and colleagues) participated in opportunistic field collections and the tagging of red snapper from the study site during the four year study. The authors did not have access to the

overall catch of snapper for purposes of biological sampling, but we did obtain field collection data and size data for all specimens.

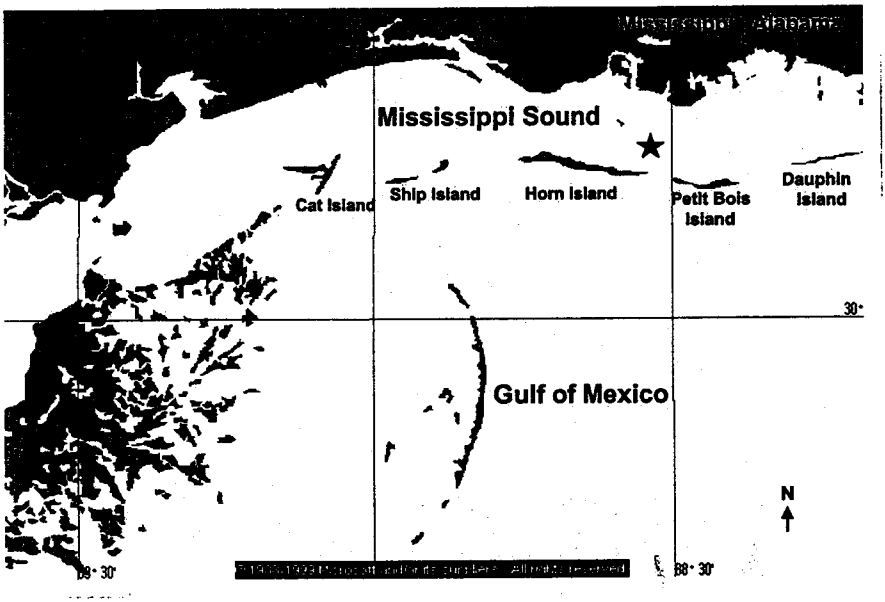

Figure 1. Map of the study area showing the Mississippi Sound and the study site location (shown by star).

Laboratory Processing and Sample Analyses

Most fish examined and sampled in the laboratory were measured (nearest 1.0 mm total length, TL), weighed (nearest 1.0 g., TW) and sexed. The gonads of some specimens were removed by other researchers prior to examination by the authors, and those fish were not sexed. All lengths are reported as TL.

Reproductive Biology — Macroscopic (gross) observations of whole gonads were recorded for a few specimens. During the summer of 1995 and late summer and fall of 1996, gonads were removed from a small number of large specimens and weighed, and a small portion of gonad tissue was placed in 10 % buffered formalin for histological assessment following Brown-Peterson et al. (2001).

Age Estimation — Sagittal otoliths were removed from a small number of specimens caught during late summer and fall of 1997. The left sagitta was processed for ageing following Franks et al. (1999). Opaque bands were counted as annuli from the core of the otolith to the edge (distal margin) of the otolith in the ventral lobe. The first opaque mark (smudge) was counted as the Age-1 mark, a decision based in part on recent red snapper research by Wilson and Nieland (2001).

Diet—Specimens collected during October and November 1994 were examined for stomach contents. Snappers were placed on ice to minimize digestive activity, and in the laboratory the contents were sorted, identified to the lowest possible taxonomic level, counted and measured volumetrically to the nearest 0.1ml by water displacement in a graduated cylinder. Bait was not included in the analyses. Prey were pooled for all stomachs and were represented as percent numeric abundance (%N), percent volume (%V), and percent frequency of occurrence (%F). Empty stomachs were excluded from calculations.

Tag-release

From October 1994 - December 1996 juvenile and adult red snapper were tagged and released by study personnel. Fish were tagged with individually numbered (1) Hallprint polypropylene dart tags with an attached streamer which contained the laboratory's phone number and mailing address, or (2) individually numbered T-bar anchor tags. Tagging date, fish length (mm, TL), condition of fish prior to release and any pertinent comments were recorded on individualized tag-release data cards. Tagged fish were re-captured during subsequent visits to the study site, and the recapture date and fish length were recorded.

Two coded acoustic tags (Sonotronics, Inc., model CT-82-3, 40-day life) were used to examine short-term movements and site fidelity. One transmitter was attached externally to an adult snapper (521 mm TL) on 9 December 1994, and another was implanted into an adult (483 mm TL) on 1 December 1995. Acoustic scans for the fish were conducted during follow-up visits to the study site.

RESULTS

From September 1994 - September 1997, 302 red snapper were collected from the study site (does not include tag-recaptures). Twenty-one (21) of 24 total visits (88 %) to the site produced red snapper. The number of fish caught during individual trips ranged from 1 - 42. The amount of time each research team spent during visits to the site varied from 0.5 - 6 hours. We did not calculate CPUE.

Red snapper caught at the site ranged from 229 - 714 mm. Of the 302 specimens collected, 172 were retained for laboratory examination, and 130 were tagged and released (see section below). Specimens retained for laboratory examination/sampling ranged from 252 - 714 mm ($\bar{x}$ = 524 mm) and 300 - 5,221g TW ($\bar{x}$ = 2,088 g). Sex was determined for 89 of those 172 specimens: males (n = 56; 326 - 713 mm, $\bar{x}$=498 mm); females (n = 33; 380 - 696 mm, $\bar{x}$=532 mm).

The majority of specimens (75 %) were caught during September (n = 54; 279 - 711 mm), October (n = 136; 229 - 714 mm) and November (n = 37; 262 - 686 mm), and others were collected during January (n = 4; 300 - 310 mm), May (n = 11; 252 - 432 mm), June (n = 7; 330 - 381 mm), July (n =12; 300 - 559 mm), August (n = 16; 287 - 622 mm) and December (n = 25; 287 - 483 mm). The largest fish were caught from August - November.

Surface and bottom water temperature at the study site ranged from 15.2 - 24.1^0

C and 16.4 - 24.2^0 C, respectively. Surface and bottom salinity ranged from 17.6 - 30.0 ‰. and 24.6 - 34.0 ‰., respectively. Water clarity (visibility) ranged from < 0.5 m (turbid) to 3.0 m (blue-green). Tide condition (i.e., flooding, high, ebbing or low) did not seem to affect the catch of red snapper.

Reproductive Condition

Gross assessments — Macroscopic assessments of gonads from snapper >430 mm collected primarily during late summer (August and September), fall and winter revealed females with small, reddish-purple, partially flaccid ovaries which appeared spent and males with small, white testes which produced small amounts of milt when squeezed. Numerous females between 275 - 430 mm had ovaries that were small and reddish in color and appeared immature (ovaries of the largest specimens may have been spent), and males between 330 - 430 mm had testes that were gray in color and appeared immature. The ovaries of one specimen (559 mm; 2,111.3g TW) caught in July 1995 appeared well developed and yellow in appearance and weighed 192.5 g. (~9 % of total body weight).

Histological assessments — Male red snapper (n = 5; 390 - 520 mm) sampled for histological assessment were caught in September (n = 1; 390 mm) and October (*n* = 4; 466 - 520 mm), 1996. All five males were sexually mature. Four of the five fish exhibited spermatogenic activity and showed spermatozoa in the lobules and the sperm ducts. One fish caught in late October had spermatozoa in the ducts, but spermatogenic activity had ceased and the testes appeared almost spent. The age of the September fish (390 mm), the only one of these males examined for age, was estimated to be two years.

Female red snapper (n = 8; 326 - 622 mm) sampled for histological assessment were collected in 1995 (July, n = 1, 559 mm; August, n = 1, 662 mm; and September, n = 4, 326 - 483 mm) and 1996 (October, n = 1, 430 mm; and December, n = 1, 330 mm). Ovaries from the July fish were well developed and exhibited final oocyte maturation (FOM), an indication of imminent oocyte hydration and spawning. However, there were no indications of recent spawning by this fish, i.e. we found no postovulatory follicles (POF). Ovaries from the August fish, the largest female examined for reproductive condition during the study, were found to be regressed and exhibited considerable atresia as did the ovaries from the September and October specimens, with the exception of the small September fish (326 mm) which may have been immature. The December female (330 mm) appeared regressed, but since there was no evidence of atresia, may have been immature. The age of the largest September fish (483 mm), the only one of the eight females examined for age, was estimated to be four years.

Age Estimates

Although the overall sample of fish from the study site consisted of specimens which ranged from 229 -713 mm, we collected sagittal otoliths from only a few fish

(n = 40; 326 - 713 mm). Of the 40 otoliths processed for ageing, 33 (88 %) were considered readable (18 males, 15 females), and two readers agreed on the number of opaque bands for those sagittae. Estimated age was assigned as follows: Age-2 (males, n = 2, 326 - 390, $\bar{x}$ = 352 mm; females, n = 1, 430 mm), Age-3 (males, n = 5, 443 - 548 mm, $\bar{x}$ = 481 mm; females, *n* = 2, 380 -601 mm, $\bar{x}$ = 491 mm), Age-4 (males, n = 80, 433 - 675 mm, $\bar{x}$ = 599 mm; females, n = 9, 483 - 610 mm, $\bar{x}$ = 540 mm), Age-5 (males, n = 3, 574 - 713 mm, $\bar{x}$ = 632 mm; females, n = 3, 581 - 696, $\bar{x}$ = 651 mm).

Diet

Stomachs of 54 red snapper which ranged from 360 - 681 mm ($\bar{x}$ = 535 mm) and 0.9 - 5.2 kg TW ($\bar{x}$= 2.66 kg) were examined. Forty-one (76 %) of the 54 stomachs contained a total of 151 prey items. The diet was comprised of fish, crustaceans and cephalopods.

Fishes occurred in 37 (90 %F) of the stomachs and represented 79 % of the total number of prey and 70 % of the total volume of prey. Anchovies were predominant among identified fishes in the diet and were represented by *Anchoa hepsetus* (striped anchovy) (n = 10) (7 %N, 2 %V, 12 %F) and *Anchoa* sp. (n = 52) (34 %N, 5 %V, 24 %F). *Arius felis* (hardhead catfish) (n = 9), ranked first in %V (31) in the diet. Other fishes, due to various states of digestion, could be identified only to genus (*Anchoa* sp., *Hippocampus* sp.), family (Clupeidae and Bothidae), order (Pleuronectiformes) or unidentified fish remains, which ranked first in %F (63) and second in %N (29) and %V (26).

Crustaceans ranked second in importance, numerically (19 %N) and volumetrically (30 %V), in the diet, and occurred in 54 % of the stomachs. Decapods were the primary crustacean prey, and *Callinectes similis* (Gulf crab) (n = 9) was the dominant crustacean in the diet (8 %N, 13 %V, 22 %F). The iridescent swimming crab (*Portunus gibbesii*) and other decapods identifiable only to *Penaeus* sp. (shrimp) and *Callinectes* sp. (crab), combined, accounted for only 3 %N and 2 %V. Decapod remains (1 %V) were categorized as being either those of shrimp or crab and occurred in 20 % of the stomachs. Cephalopods (n = 3) were identified as squid remains and were present in 7 % of the stomachs.

Tag-release

From October 1994 - December 1996, 130 juvenile and adult red snapper were tagged and released at the study site. Tag-released fish ranged from 230 - 660 mm ($\bar{x}$ = 376 mm). Fish were tagged during January (*n* = 4, 300 - 310 mm), May (n = 7, 318 - 432 mm), June (n = 7, 330 - 381 mm), July (n =11, 300 - 432 mm), August (n =15, 287 - 483 mm) September (n = 16, 279 - 389 mm), October (n = 40, 229 - 660 mm), November (n = 7, 262 - 579 mm) and December (n = 23, 287 -483 mm). The amount of predation on tagged juveniles was unknown. Twenty-four (24) of the 130 tagged fish were recaptured; four of those were recaptured twice (double recapture) and two were recaptured three times (triple recapture), for a total of 32 recaptures. All recaptures were made at the study site. Most

recaptures were re-released, all at the study site.

Recaptures occurred during January, July, August, September, October and December. Recaptured fish ranged from 285 - 610 mm. Time-at-large for recaptures ranged from 1 - 373 days ($\bar{x}$=80 days). The "greatest" time-at-large (373 days) was recorded for a fish which measured 305 mm at tag-release (September) and 419 mm at recapture (September). The fish had grown114 mm (0.31 mm/day). The second greatest time-at-large was 300 days recorded for 2 fish: (1) 420 mm at tag-release (October), 508 mm at recapture (August), growth = 88 mm (0.29 mm/day); (2) 506 mm at tag-release (October), 610 mm at recapture (August), growth = 104 mm (0.35 mm/day).

Follow-up acoustic scans for the two fish (sex unknown) fitted with acoustic transmitters were positive only for the external tag. Signals indicated the fish was actively swimming around the study site during December 1994 and January 1995.

DISCUSSION

Our first encounter with red snapper at the study site occurred while cleaning fish remains from the deck of the nine meter research vessel *R/V Seiche* as it drifted along the eastern border of the Pascagoula Ship Channel. We observed approximately 100 red snapper, predominantly large individuals, feeding in a frenzied action on the remains at the surface of the water. Using hook-and-line gear, 20 red snapper (457 - 711 mm) were landed within a period of 0.5 hours.

Our study represents the first investigation of adult red snapper from Mississippi estuarine waters, and apparently is the first such study in the northern Gulf. Bortone et al. (1994) reported *L. campechanus* as a component of the fish assemblage at an artificial reef sited in 6.5 m of water in the Choctawhatchee Bay, Florida estuary, but the size of red snapper observed was not reported and no specimens were reported as collected.

Other species of fish, including small baitfishes (anchovies and menhaden), were also associated with the study site structure, and the following 18 species were caught by hook-and-line: *Dasyatis sayi, Carcharhinus limbatus, Rhizoprionodon terraenovae, Rachycentron canadum, Scomberomorus maculatus, Arius felis, Mycteroperca microlepis, Caranx crysos, Sciaenops ocellatus, Pogonias cromis, Mircopogonius undulatus, Archosargus probatocephalus, Lutjanus griseus, Lagodon rhomboides, Orthopristis chrysoptera, Chaetodipterus faber, Paralichthys lethostigma* and *Opsanus beta*. With the exception of *A. felis, C. crysos, S. ocellatus, M. undulatus, L. griseus, L. rhomboides, O. chrysoptera*, and *O. beta*, the above species were caught only once and were considered transients at the site. The above fishes comprise an interesting mix of species, most of which occur in both Mississippi's estuarine and offshore waters.

Our study prompted numerous questions, including:

i) Did Horn Island Pass and the associated Pascagoula Ship Channel serve as the primary conduit for the ingress of snapper emigrating into the estuary from offshore juvenile and adult red snapper habitat;

ii) Were the size and shape of the bottom structure critical;
iii) What were the factors driving the "ingress and egress" of the snapper;
iv) Why did adult red snapper congregate and persist at the inshore site, i.e., what were the environmental and/or habitat characteristics of the site and adjacent area that attracted and retained adults;
v) Did adult red snapper spawn at the site (only one female specimen gave such indication);
vi) Were juveniles (age-1, age-2) at the site merely "strays" that for some reason failed to remain offshore with the rest of their cohort;
vii) Did snapper reach adulthood at the site;
viii) Could the protection and abundance of food provided by estuarine habitat enhance juvenile growth rates and survival rates relative to that characteristic of offshore habitats; and
ix) Did our collections reflect the size distribution of snapper at the study site.

It is not known if estuarine residency is an integral part of the early life history of some juvenile red snapper. Also, it is not known if adult red snapper are perennial residents of the Mississippi Sound, however, anecdotal information provided by local anglers indicates that large red snapper (~8 kg) congregate during each month of the year at small, unmarked (clandestine), inshore artificial structures located near navigation channels within the Mississippi Sound. Despite a high degree of fidelity demonstrated by some individuals as shown by tag recaptures, there were definite fluctuations in numbers of snapper caught at the site over the study period. This may have been related to seasonality of snapper occurrence, periodic influx of individuals to the site, behavioral changes, harvest by anglers, lack of appropriate food source, or environmental variables.

Lowest bottom temperature at our site was 16.40° C in January, and the highest bottom temperature was 24.20° C in August, both within the acceptable range of temperature and salinity reported for red snapper (Bullis and Jones 1976). Highest bottom salinity recorded was 34.0 ‰, and the lowest bottom salinity recorded was 24.6 ‰., probably the result of freshwater inflow into the estuary during a period of heavy rainfall and subsequent river flushing into the eastern Mississippi Sound.

Age estimates (Age 2 - 5) assigned a small number of fish n = 33) in our sample fall within the range of age estimates reported for red snapper of similar size in recent studies (Wilson and Nieland 2001, Fischer 2002), and red snapper in our study exhibited a large variability in age at a given TL, as reported by Wilson and Nieland (2001) for red snapper from Louisiana. Length-at-age information for Gulf red snapper (Wilson and Nieland 2001, Fischer 2002), size data from our study, estimated age for a few of our specimens, and reproductive assessments (Render 1995, Collins et al. 1996, and this study), showed that numerous fish in our sample were adults.

Red snapper spawning season in the Gulf extends from May to October (Collins et al. 1996), and peak spawning occurs between June and August (Render 1995).

Males sampled for gonad histological assessment (n = 5; 390 - 520 mm; September and October) were sexually mature, although spermatogenic activity was declining in most fish. The female (559 mm) collected in July was ripe (FOM stage) which provided evidence that spawning might have occurred at or near the study site, a tantalizing revelation. Females collected in late summer and fall were regressed and most exhibited considerable atresia.

Our histological assessments of ovaries from fish caught during the spawning season were limited to eight specimens, and only one of those indicated near-term spawning. What are the environmental cues and requirements to trigger estuarine spawning of red snapper? What would be the fate of the fertilized eggs and larvae?

Our finding that fish were the dominant prey of red snapper generally reflects that of others who examined the diet of Gulf red snapper (Bradly and Bryan 1975). Snapper at the study site most likely fed on organisms which occurred at or very near the study site.

Since the mean depth at the study site was six meters, there were no obvious negative effects from the capture and retrieval of fish to be tagged. Tag-recaptures provided the opportunity to examine behavioral aspects of snapper associated with the study site. None of the fish tag-released at the site were caught (or reported caught) at any inshore bottom structures or any offshore artificial reefs or petroleum platforms within the area.

Recaptures of tagged fish suggested that some individuals (juveniles and adults) resided at the site for long periods of time and some apparently overwintered there. The age of the 3 tagged fish which were recaptured in our study after 300 (n = 2) and 373 (n = 1) days-at-large was not known, and it is not known if those fish remained at the tag-release site throughout their entire period at liberty. However, sacrifice of the specimen which was at large for 373 days (September recapture) revealed a female with extremely small, regressed ovaries. The fish was 419 mm at time of recapture (and was likely 3 year old), suggesting that at 305 mm at time of tag-release, it was likely a two year-old, immature fish. Did this fish occupy the study site for it's entire time-at-large and spawn there?

Our study terminated in 1997 when maintenance dredging of the Pascagoula Ship Channel resulted in the removal of the study site. Use of side scan sonar (Edgetech, model 560A) verified the absence of the structure.

Although our work was based in opportunism, opportunistic discovery has often led to more extensive study. Identifying and monitoring estuarine habitat utilized by red snapper could improve the ability to assess and manage productive substrate and provide additional indicators of juvenile red snapper recruitment to estuaries. The study site reported here probably would not qualify as a "reserve" in the truest sense of the word, but the creation of a small network of similar, surreptitious sites within the Mississippi Sound, perhaps within the safety of the "regulated buffer zone" of the Gulf Islands National Seashore, might serve to provide undisturbed study sites to evaluate the effectiveness of "small estuarine reserves" as red snapper habitat. Studies at such sites could provide greater insight into environmental and biotic factors associated with the recruitment, growth and survivorship of young red

snapper associated with estuarine habitat.

Study findings provided here, albeit limited, pertain to the utilization of estuarine habitat by red snapper and contribute information on the biology and behavior of red snapper from the northern Gulf, including the simultaneous occurrence of large juveniles and adults at an inshore artificial structure, indications of long-term site fidelity and possible overwintering at estuarine habitat, and indications of spawning within a northern Gulf estuary.

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Analisis de la Pesquería de Huachinango del Golfo (*Lutjanus campechanus*) en el Banco de Campeche (Temporada de Pesca 2001)

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RESUMEN

La pesquería de huachinango para el estado de Yucatán es una de las actividades más importantes de la flota yucateca. Esta flota utiliza tres métodos de pesca (barcos con alijos, carretes de línea larga y "bicicletas"). En la temporada de pesca del 2001, se registró una captura de 583 t. Las embarcaciones que utilizan bicicleta registraron la mayor proporción de *Lutjanus campechanus* (38.11 %), los barcos que utilizan carrete y alijos registraron aproximadamente el 4 %. Se obtuvo una muestra de 9,667 individuos de *Lutjanus campechanus*, capturados con las diferentes arte de pesca (bicicleta, carrete y alijos) y se realizó un análisis de la distribución de frecuencia de longitudes (DFL). Se presentó un intervalo de tallas entre los 21.0 y 87.0 cm de longitud furcal (LF). La estructura de la captura total estimada por clases de edad, registró un intervalo de individuos capturados por las diferentes artes de pesca de dos a 14 años. La clase de edad tres presentó la mayor proporción (43 %), de ejemplares capturados por esta flota en el Banco de Campeche. Se estimó la captura por unidad de esfuerzo (CPUE) por arte de pesca y se utilizó como unidad de esfuerzo el viaje de pesca. Las embarcaciones que utilizaron bicicletas registraron el mayor CPUE (411 kg de huachinango / por viaje de pesca). El esfuerzo nominal ejercido por la flota yucateca fue estimado en 4, 269 viajes de pesca y fueron realizados por 440 embarcaciones (con un promedio mensual de 356 viajes). En los últimos tres años se ha registrado que el 12 % de la flota yucateca utiliza como arte de pesca la bicicleta y el 45 % de su captura por viaje de pesca es de huachinago (*L. campechanus, L.vivanus, L.bucanella*). Las embarcaciones que utilizan bicicletas y tienen como principal objetivo la captura de huachinango tienden a desplazarse a las zonas de pesca de Cayo Arenas, Bajos del Norte, Arrecife Alacranes y Triángulos.

PALABRAS CLAVES: Huachinangos, pesquerías, artes de pesca.

Analysis of the Fishery for the Red Snapper (*Lutjanus campechanus*) on the Campeche Bank (During 2001)

The red snapper (*Lutjanus campechanus*) fishery of Yucatan is one of the main activities of the industrial fleet of this Mexican State. The industrial fleet utilizes three fishing methods to catch this fish: vessels with small boats ("dinghy"); vessels with long lines and vessels with "bicycles". In the fishing season of 2001 the capture was of 538 t. Based upon interviews and catch sampling to the fishing vessels, it was estimated that those using "bicycles" got the main proportion of the catch (38.11 %), while the vessels using long lines and the "dinghy" got around 4 %. A sample of 9,667 individuals of *Lutjanus campechanus* captured by different methods (long line, bicycles and dinghy) was obtained. A size distribution analysis of the catch by fishing method was carried out, presenting a size distribution between 21.0 and 87.0 cm of furcal length (FL). The estimated structure of the catch by age show that individuals between ages 2 and 14 are captured. The age class that presented the highest proportion (43 %) was that of age 3. The catch per unit of effort (CPUE) by fishing method was estimated, using the fishing trip as effort unit. The vessels using the "bicycles" had the highest CPUE (411 kg of red snapper/fishing trip). The nominal effort of the Yucatecan fleet was estimated to be 4,269 fishing trips. This trips were carried out by 440 vessels, making an average of 356 trips per month. The 54 % of the fishing vessels made between 8 and 13 trips for year. In the last three years it has been register that a 12 % of the Yucatan fleet use the "bicycle" as fishing method and captures the 45 % of the total capture of red snapper. The vessels that use " bicycles" and have the red snapper as their target species tend to go to Cayo Arenas, Bajos del Norte, Arrecife Alacranes, and Triángulos fishing banks.

KEY WORDS: Snappers, fishery, fishing methods

INTRODUCCIÓN

En el estado de Yucatán la captura de especies de escama (Serránidos, Lutjánidos, Carangidos, Spáridos, Haemúlidos, etc.) ha sido una de las actividades del sector pesquero con mayor impacto social y económico. Esto es debido a los volúmenes de captura, al número de empleos que genera y por ser una fuente generadora de divisas para el Estado.

La flota mayor yucateca compuesta por 588 embarcaciones, es muy heterogéneas en términos del tamaño de eslora, manga, material del casco, marca, potencia del motor y métodos de pesca. Esta flota dedica gran parte de su capacidad a la explotación de especies de escama, principalmente a las pesquerías de mero, huachinango. El comportamiento dinámico de esta flota registra tanto patrones especialistas como generalistas. Esta especialización se manifiesta en el uso de artes

y zonas de pesca.

Las embarcaciones que utilizan como método de pesca la "bicicleta" son las que dirigen su esfuerzo a la captura de huachinango (*Lutjanus campechanus*); junto con esta especie se capturan otras especies como: pargos (*L. vivanus, L. bucanella, L. synagris, L. jocu, L. analis, L. griseus, L. cyanopterus*, etc.) meros (*E. morio, E gutatus, M. interstitialis, M. bonaci, M. Mocrolepis*), coronado (*Seriola zonata*) y mojarras (*Calamus sp.*). La proporción de cada una de estas especies en la captura depende de la zona y arte de pesca utilizada (Monroy et al. 2001).

El Banco de Campeche es una de las zonas de pesca de mayor importancia para esta pesquería. Las zonas de mayor captura se registran en la parte oeste de la plataforma, entre los 20° a 24° norte y 91° a 93 oeste (Cayo Arenas, Los Triángulos y Banco Nuevo) y en la zona localizada en la parte noroeste de la plataforma, entre los 22° a 24° norte y 88° a 91° oeste (Isla Pérez, Arrecife Alacranes y los Bajos del Norte) (Monroy et al. 1996) (Figura 1).

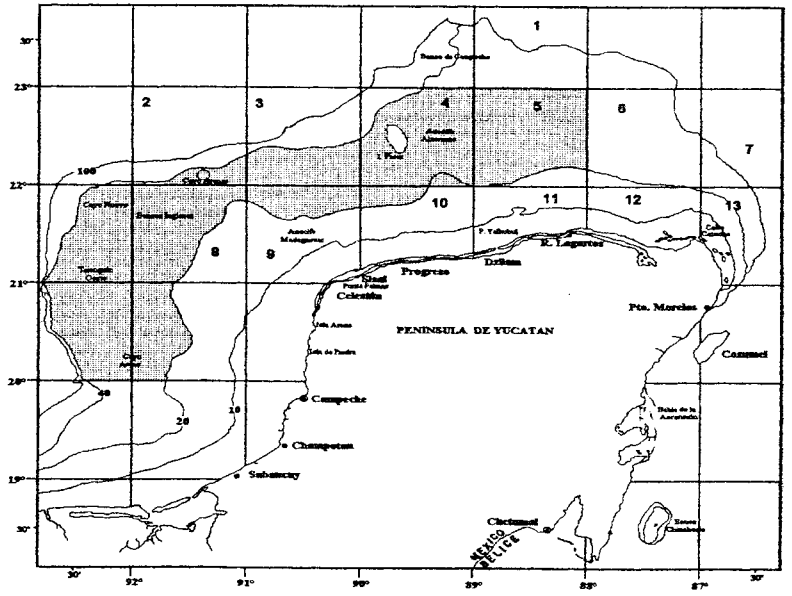

Figura 1. Banco de Campeche y zonas de pesca de la flota yucateca con permiso para la captura de especies de escama y pulpo, (la parte sombreada, muestra los campos pesqueros de la pesquería de huachinango).

En el Banco de Campeche se han desarrollado diferentes trabajos sobre la pesquería de huachinango (*Lutjanus campechanus*). La edad y crecimiento del recurso ha sido abordado por diferentes autores, a través de métodos directos como lectura de estructuras duras y métodos indirectos como análisis de frecuencias de tallas. Se han registrado una gama de valores para los diferentes parámetros de crecimiento (Nelson y Manooch 1982, Nelson et al. 1985, González y de la Rosa 1988, Leonce 1995). Así mismo se han desarrollado otros trabajos enfocados a la pesquería de huachinango del Banco de Campeche. Entre los cuales se encuentran un análisis del esfuerzo y la captura por unidad de esfuerzo ejercido por la flota yucateca (Monroy et al. 1996). El estado de salud de la pesquería en el Golfo de México (González y de la Rosa et al. 1997, Monroy et al., 2000) y un análisis del tamaño del stock (Monroy y Garduño 2001). En este estudio se analiza información de la pesquería de huachinango sobre el Banco de Campeche (temporada de pesca 2001); se hace un análisis de la captura, esfuerzo, frecuencia de longitudes y zonas de pesca. Así como de la captura por unidad de esfuerzo (CPUE).

Esfuerzo y Artes de Pesca

Durante el periodo de pesca de Enero a Diciembre del 2001, aproximadamente el 12 % de las embarcaciones de la flota mayor del estado de Yucatán, dirigieron su esfuerzo a la captura de *huachinango (L. campechanus)*. Estas embarcaciones utilizan como arte de pesca la bicicleta, que consiste en una línea que trabaja a través de un mecanismo manual semejante a una bicicleta de la cual penden de 4 a 5 anzuelos tipo huachinanguero del número 7 y/u 8 que se recobra por medio de una polea. El número de bicicletas varía entre 3 y 4 por embarcación. Estas embarcaciones operan sobre el Banco de Campeche, desplazándose a las diferentes zonas de pesca, generalmente entre las 40 y 60 brazas de profundidad.

Existen otras embarcaciones que tienen como especie objetivo el mero, pero que también registran aunque en forma incidental capturas significativas de huachinango. Estas utilizan dos sistemas de pesca: el primero y más antiguo es la embarcación nodriza que lleva de 7 a 10 alijos, embarcaciones de madera de 3 m de eslora sin motor. Estos llevan un pescador a bordo el cual maneja una línea de mano con dos o tres anzuelos y un palangre corto o de mano con 50 a 100 anzuelos, aproximadamente el 28 % de la flota utiliza este método de pesca. El segundo es el palangre de línea larga con carrete hidráulico, que lleva entre 1,500 y 2,000 anzuelos huachinangueros del número 5 ó 6. En la actualidad el 35 % de la flota con permiso para pesca de escama lo utiliza todo el año. Además el 25 % de la flota cambia de arte de pesca en el transcurso del año (de carrete a embarcaciones con alijos).

Tendencia Histórica de la Captura

La captura de huachinango extraída por la flota yucateca ha registrado un máximo histórico de 1,704 toneladas en 1990, con una tendencia descendente hasta

un mínimo de 789 toneladas en 1995. Posteriormente la captura se incremento hasta alcanzar las 1,433 toneladas en 1997 y en los últimos dos años la captura ha fluctuado alrededor de las 685 toneladas (SAGARPA 2001) (Figura 2).

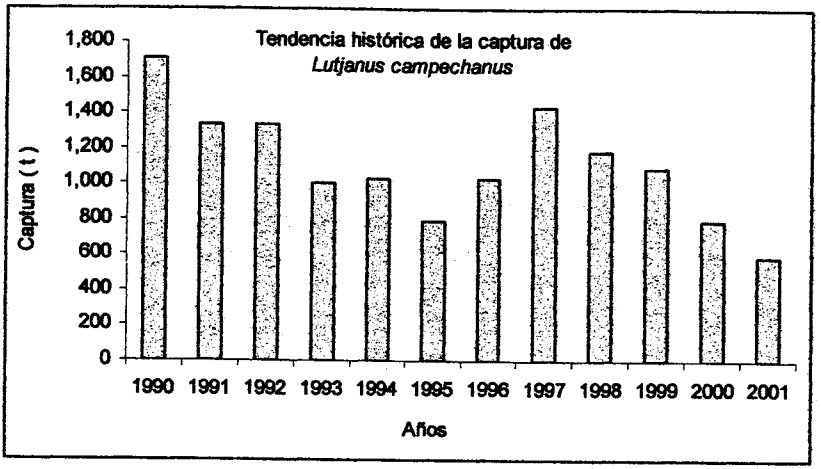

Figura 2. Tendencia histórica de la captura de huachinango (*Lutjanus Campechanus*), registrada por la flota yucateca que ejerce su esfuerzo en el Banco de Campeche.

METODOLOGIA

La información utilizada se obtuvo de muestreos mensuales de las descargas comerciales en las congeladoras de Progreso, Yucatán y el Puerto de Abrigo Yucalpetén. Se obtuvieron datos sobre la composición de la captura, profundidad, número de artes de pesca, días de viaje, número de tripulantes y la distribución de frecuencia de longitudes (DFL). Además, se utilizó información de las bitácoras de pesca que se aplica a todas las embarcaciones de la flota mayor de Progreso, Yucatán. Otra fuente secundaria de información son las estadísticas de captura, proporcionada por la Dirección de Pesquerías y Estadísticas de la Delegación Federal de la SAGARPA, en el estado de Yucatán.

Para obtener la estructura de la captura se utilizó la captura mensual de las estadistas oficiales de la SAGARPA. A esta captura se le aplicó un factor de corrección de acuerdo a lo establecido por Monroy et al. (2000), con el fin de eliminar el efecto de otras especies registradas como *L. campechanus*. La estructura de la captura de *L. campechanus* fue estimada mensualmente, para ello se utilizaron los muestreos de desembarco realizados de enero a diciembre del 2001. Con la DFL fue posible obtener la estructura por tallas de la captura de esta flota.

Con la DFL de la captura obtenida de la flota yucateca, se estimó la estructura de la captura en peso, para lo cual se utilizó la relación peso-longitud:

$$W = 0.0000342L^{2.884}$$

donde el W es el peso eviscerado en kg y L es la longitud furcal en cm (González y de la Rosa 1992). Para estimar la relación Edad-Longitud del recurso, se utilizaron los parámetros de crecimiento estimados por Leonce (1995): L_{inf} = 0.92 cm, k = 0.16/año, to = -0.16/año . Se realizó un análisis de la DFL por tallas registrado por los diferentes artes de pesca (bicicleta, carrete y barcos con alijos). Para estimar la captura por unidad de esfuerzo (CPUE), se utilizó la información registrada en las bitácoras de pesca y la registrada en los monitoreos a las embarcaciones. Se estimó la CPUE por arte de pesca (bicicleta, carrete y alijo) y se obtuvo como kilogramos de la captura total y/o de huachinango por viaje de pesca.

RESULTADOS

Producción Pesquera del Estado de Yucatán

Durante la temporada de pesca del 2001 el registro oficial de la producción pesquera del estado de Yucatán, alcanzó un volumen de captura de 29,645 toneladas. Las especies de escama registraron el 53.88 % de la captura total con 15,972 toneladas, la captura de pulpo con dos especies (*Octopus maya* y *Octopus vulgaris*) el 38.67 % con una captura de 11,464.

La captura de huachinango se realiza a lo largo de todo el año, sin embargo los meses de febrero a julio se registraron los mayores rendimientos de la pesquería (Figura 3). Esta captura incluye tres especies, el huachinango del Golfo o de Castilla (*Lutjanus campechanus)* que aporta el 89 %, el huachinango ojo amarillo (*Lutjanus. Vivanus)* con el 6 % y el huachinango aleta negra (*Lutjanus bucanella)* con el 5 %. Esta captura es registrada por las diferentes artes de pesca que utiliza la flota yucateca (bicicletas, carrete y alijos).

Proporción y Composición de la Captura por Arte de Pesca

Se registró la proporción de cada grupo de especies en la captura. Las embarcaciones que utilizaron bicicletas registraron el mayor porcentaje (48.9 %), de especies de la familia Lutjanidae (Huachinangos, Pargos y Rubia-Canane). Mientras que las embarcaciones que utilizan carrete capturan el mayor porcentaje (81 %) de especies de la familia Epinephelidae (mero, negrillo, cabrilla, abadejo, gallina, payaso etc.). Así mismo, se pudo observar que en el transcurso del año, las embarcaciones que utilizan alijos cambian la proporción y composición de su captura, de enero a

julio registran el 90 % de especies de la familia Epinephelidae y de agosto a diciembre la mayor proporción de su captura es de pulpo (67 %) (Tabla 1).

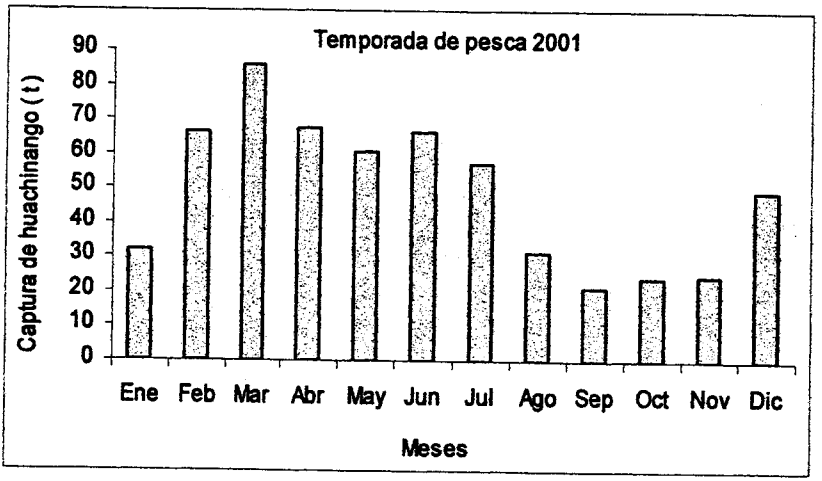

Figura 3. Captura mensual de huachinango que se registró durante el 2001 en el estado de Yucatán (información con registro oficial).

Tabla 1. Proporción y composición de la captura por grupos de especies y artes de pesca que utiliza la flota mayor del estado de Yucatán sobre el Banco de Campeche.

Grupos de especies	Artes de Pesca (%)			
	Bicicleta	Carrete	Alijos (Ene-Jul)	Alijos (Ago-Sep)
Huachinangos	44.90	4.65	4.35	-
Pargos	3.50	3.99	1.49	-
Rubia-Canane	0.50	2.00	1.23	-
Meros	32.00	81.16	90.04	32.60
Mojarras	1.80	0.43	-	-
Corvinato	-	2.18	1.74	-
Coronado	9.20	1.18	-	-
Tiburon-Cazón	1.30	2.90	0.19	-
Pulpo	-	-	-	67.40
Otras Spp.	6.80	1.51	0.96	-
TOTAL	100 %	100 %	100 %	100 %

Se estimó la proporción y composición por especies la captura registrada por la flota yucateca que pesca sobre el Banco de Campeche. Las embarcaciones que utilizan la bicicleta como arte de pesca, fueron las que registraron la mayor proporción de *Lutjanus campechanus* (38.11 %). Las embarcaciones que utilizan carrete registran la mayor proporción de *Epinephelus morio* (68.55 %) y para las embarcaciones que utilizan alijos puede ser *Epinephelus morio* y/o pulpo con dos especies (*Octopus maya* y *Octopus vulgaris*), según la época del año (Tabla 2).

Tabla 2. Especies registradas en la captura por artes de pesca (bicicleta, carrete y alijos), en las embarcaciones de la flota mayor yucateca que capturan sobre el Banco de campeche.

Nombre científico	Bicicletas	Carrete	Alijos (Ene-Jul)	Alijos (Ago-Dic)
	%	%	%	%
L. campechanus	38.11	4.32	4.35	-
L. bucanella	2.68	0.29	-	-
L. vivanus	4.10	0.04	-	-
L. jocu	0.04	1.70	-	-
L. analis	1.46	2.04	1.47	-
L. griseus	0.17	0.21	0.03	-
R. aurorubens	1.88	0.04	-	-
L. sinagris	0.31	0.04	-	-
O. chrysurus	0.14	1.96	1.21	-
E. morio	12.92	68.55	84.23	32.60
E. adscensionis	0.06	1.17	0.09	-
E. drummondhayi	0.25	0.07	-	-
M. bonaci	6.97	9.21	3.66	-
M. microlepis	1.41	0.43	0.39	-
M. interstitialis	10.20	1.32	1.67	-
M. venenosa	0.14	0.42	-	-
Calamus bajonado	1.83	0.43	-	-
L .chamaeleonticeps	-	2.18	1.74	-
Seriola zonata	9.21	1.18		-
Tiburon-Cazón	1.33	2.9	0.19	-
O. maya y O. vulgaris	-	-	-	67.40
Otras Spp.	6.79	1.51	0.96	-
TOTAL	100 %	100 %	100 %	100 %

Frecuencia de Longitudes y Estructura de la Captura

Se obtuvo una muestra de 9,667 individuos de *Lutjanus campechanus* capturados por la flota yucateca y se hizo un análisis de la distribución de frecuencia de longitudes (DFL); se presentó un intervalo de tallas de 21.0 y 87.0 cm de longitud furcal (LF). En la figura 4 se presenta la DFL obtenida en las embarcaciones que utilizaron como arte de pesca la bicicleta. La DFL en estas embarcaciones presentó un intervalo entre 21.0 y 870 cm de LF, una media de 40.6 cm y una moda de 35.0

cm. El 44 % de los organismos capturados con este arte de pesca, se encuentran por abajo de la talla minina impuesta a los permisionarios mexicanos por el mercado de Estados Unidos de 16 pulgadas de Longitud total (LT), que equivale a 40.6 cm de LT y 38.4 cm de LF.

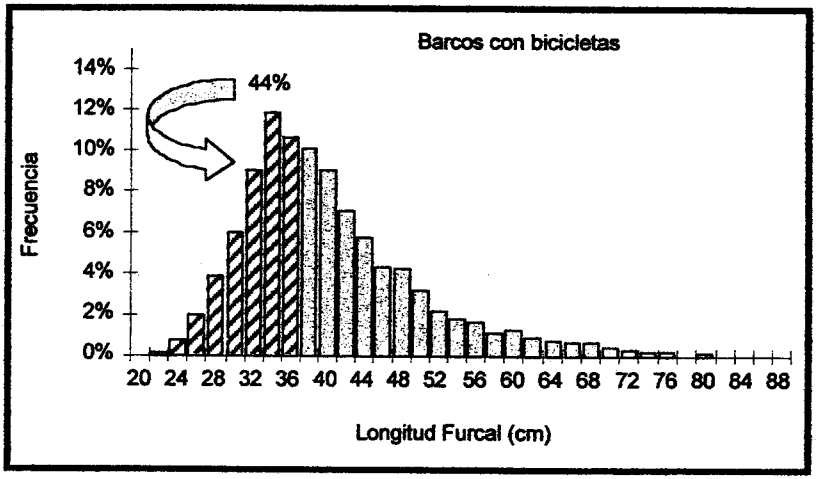

Figura 4. Frecuencia de longitudes del huachinango (*Lutjanus campechanus*), obtenida en la captura de las embarcaciones que utilizan bicicleta como arte de pesca y ejerce su esfuerzo en el Banco de Campeche (temporada 2001).

En la figura 5 se presenta la DFL *de Lutjanus campechanus*; estos organismos fueron capturados por las embarcaciones que utilizaron como arte de pesca el carrete de línea larga. La DFL presentó un intervalo entre 29.0 y 87.0 cm de LF, una media de 52.2 cm y una moda de 47.0 cm. Con este arte de pesca el 5 % de los organismos capturados se encontraron por debajo de la talla minina de las 16 pulgadas (40. 6 cm de LT y 38.4 cm de LF).

En la figura 6 se presenta la distribución de frecuencias de longitudes *de Lutjanus campechanus* registrada por las embarcaciones con alijos que utilizan una línea de mano y un palangre corto. La DFL presentó un intervalo entre 21.0 y 69 cm de LF, una media de 37.6 cm y una moda de 33 cm. El 59 % de organismos capturados por estas embarcaciones se encuentran por abajo de la talla minina de las 16 pulgadas (40. 6 cm de LT y 38.4 cm de LF).

La prueba t-Student a un nivel de confianza del 95 % no mostró diferencias significativas entre la DFL de las embarcaciones que utilizan bicicleta y alijos, mientras que la DFL de las embarcaciones con carrete difirió significativamente de los otros dos métodos de pesca, ($p < 0.05$). Las embarcaciones que utilizan alijos son las que capturan la mayor proporción de organismos pequeños (Figura 7).

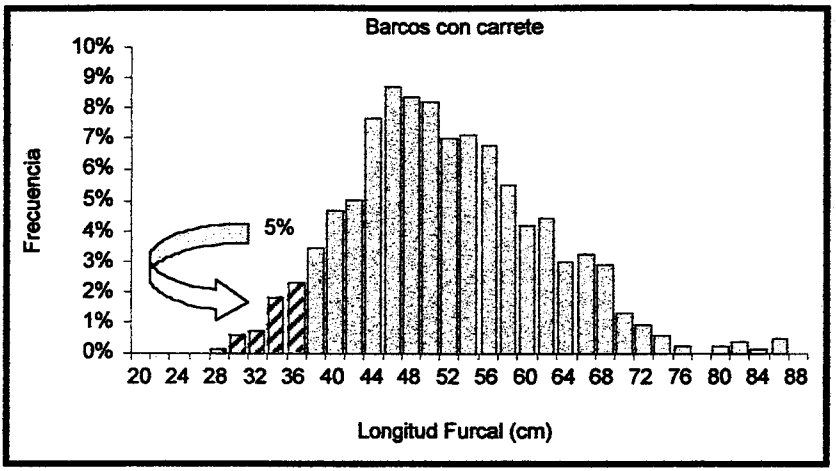

Figura 5. Frecuencia de longitudes del huachinango (*Lutjanus campechanus*), obtenida en la captura de las embarcaciones que utilizan carrete de línea larga como arte de pesca y ejerce su esfuerzo sobre el Banco de Campeche (temporada 2001).

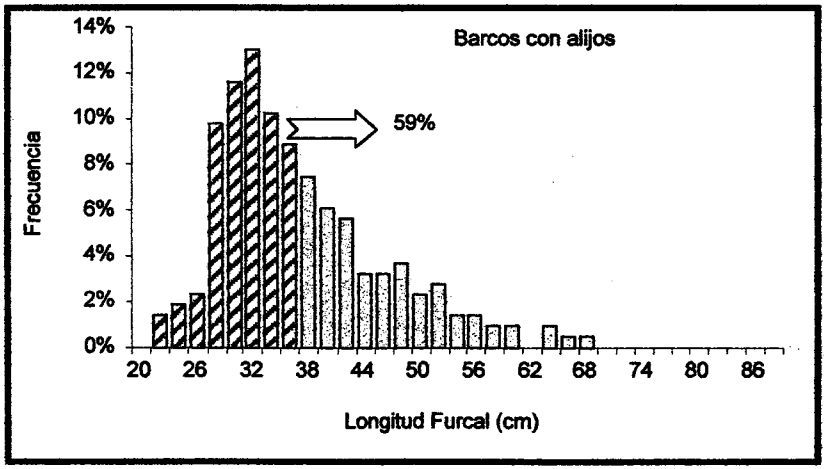

Figura 6. Frecuencia de longitudes del huachinango (*Lutjanus campechanus*), obtenida en la captura de las embarcaciones con alijos que pescan en el Banco de Campeche (temporada 2001).

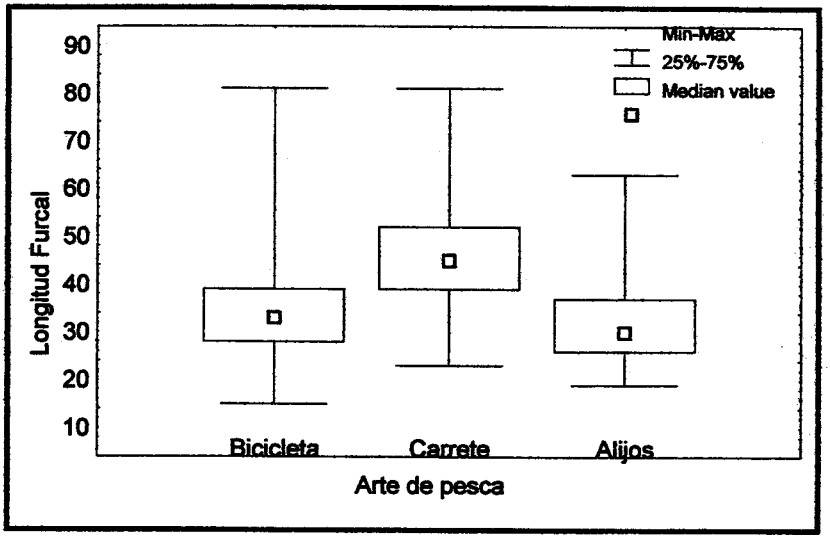

Figura 7. Impacto de las diferentes artes de pesca (bicicleta, carrete y alijos) en la frecuencia de tallas de la captura del huachinango (*Lutjanus campechanus*).

La estructura de la captura total de *L. campechanus*, estimada por clases de edad, registró un intervalo de individuos capturados por las diferentes artes de pesca de dos a 14 años. La clase de edad tres presentó la mayor proporción (43 %), de ejemplares capturados por esta flota en el Banco de Campeche (Figura 8).

Captura por unidad de esfuerzo (CPUE)

Se estimó la captura por unidad de esfuerzo por arte de pesca (bicicleta, carrete y alijo) y se utilizó como unidad de esfuerzo el viaje de pesca. En la tabla 3 se presenta el CPUE promedio de la captura total y de huachinango generado por las embarcaciones con los diferentes artes de pesca

Para estimar la CPUE mensual se utilizó la información registrada en las bitácoras de pesca; para su análisis solo se tomaron en cuenta los viajes donde la captura de huachinango fue mayor o igual al 20 % de la captura total (684 bitácoras). En la tabla 4 se presenta la CPUE mensual y sus estadísticas descriptivas. Los valores más bajos se registraron de julio a octubre.

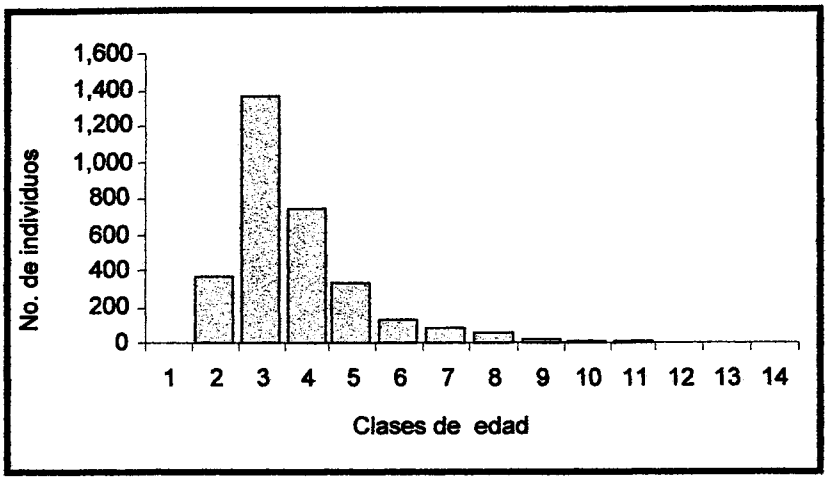

Figura 8. Numero de individuos por clases de edad en la captura total de huachinango (*Lutjanus campechanus*), registrada por la flota yucateca (temporada de pesca del 2001).

Tabla 3. Captura por unidad de esfuerzo (CPUE) total y de huachinango de las embarcaciones de la flota yucateca que pesca en el Banco de Campeche.

Embarcaciones	n	$CPUE_{total}$ (kg/Viaje de pesca)	$CPUE_{huachinango}$ (kg/Viaje de pesca)
Bicicletas	97	1,079	411
Carrete	75	2,052	90
Alijos	37	2,341 - 4,175	86 - 0

Esfuerzo de Pesca

Para analizar la dinámica de la flota yucateca solo se consideraron las embarcaciones que tienen permiso para la captura de especies de escama y pulpo (588) y que descargan en el puerto de Progreso Yucatán. Con la información registrada en las bitácoras de pesca se estimo el esfuerzo ejercido (cada bitácora fue considerada un viaje de pesca). Se registraron 4,269 viajes de pesca que fueron realizados por 440 embarcaciones que equivalen al 75 % de la flota y el 25 % de las embarcaciones estuvieron inactivas. Se estimó un promedio mensual de 356 viajes de pesca; el 12 % de los viajes utilizaron bicicleta, el 48 % carrete y el 40 % alijos (Figura 9).

Tabla 4. Captura por unidad de esfuerzo mensual de la pesquería de huachinango (*Lutjanus campechanus*), en el Banco de Campeche y sus estadísticas descriptivas (información bitácoras de pesca, 2001).

	CPUE (kg de huachinango / viaje de pesca)			
Mes	n	Media	Moda	Desviación estándar
Ene	69	596	400	319
Feb	86	615	600	440
Mar	81	691	500	461
Abr	65	560	600	416
May	79	542	300	309
Jun	64	559	550	323
Jul	47	408	300	318
Ago	33	273	300	264
Sep	38	336	150	320
Oct	29	397	200	245
Nov	44	572	400	416
Dic	49	558	500	318

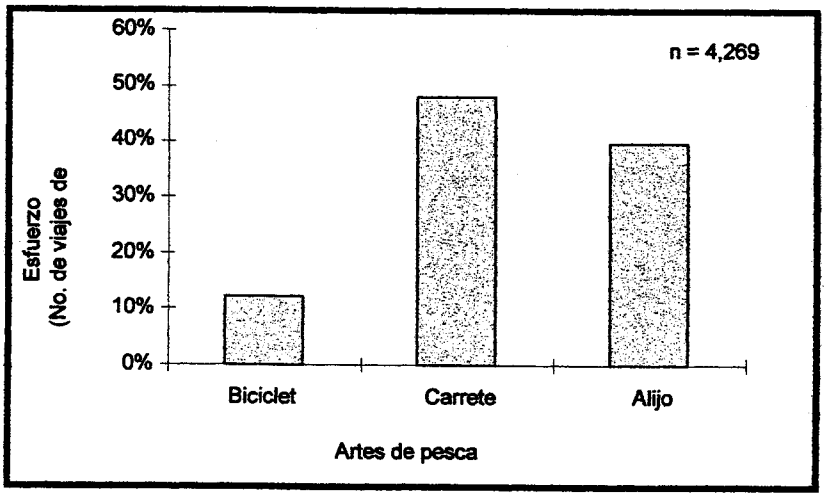

Figura 9. Esfuerzo de pesca (viajes de pesca), ejercido por la flota yucateca sobre el Banco de Campeche.

Coma ya se mencionó la flota yucateca es multiespecifica y ejerce su esfuerzo sobre las pesquerías de Mero, huachinango y pulpo, esta última con veda de enero a julio. Cuando la temporada de pesca de pulpo comienza, parte de la flota deja de pescar mero y huachinango y dirige su esfuerzo a esta pesquería. En esta temporada

de pesca se estimó que el 25 % de las 440 embarcaciones cambiaron de arte de pesca en el transcurso del año, principalmente de carrete a alijos. En la tabla 5 se muestra la asignación del esfuerzo por arte de pesca.

Tabla 5. Asignación del arte de pesca (bicicleta, carrete y alijo), por las embarcaciones de la flota yucateca que estuvieron activas de enero a diciembre del 2001.

Arte de pesca	No. de embarcaciones	Porcentaje (%)
Bicicleta	51	12
Carrete	156	35
Alijos	121	28
Carrete → Alijos	112	25
TOTAL	440	100 %

Esfuerzo y Captura por Zona de Pesca

Para el análisis de las zonas de pesca, se utilizó información de encuestas realizadas directamente a los pescadores. Las embarcaciones que utilizan bicicletas y tienen como principal objetivo la captura de huachinango tienden a desplazarse a las zonas de pesca de Cayo Arenas, Bajos del Norte, Arrecife Alacranes y Triángulos (cuadrantes 2, 3, 4, 5, 8, 14 y 15). Las que utilizan carrete de línea larga y tienen como objetivo la captura de mero y pescan incidentalmente el huachinango, tienden a desplazarse al noroeste de Progreso y al norte entre Dzilam de Bravo y convoy (cuadrantes 4, 5, 6, 7, 12 y 13). Las embarcaciones con alijos y que dirigen su esfuerzo a la captura del molusco tienden a desplazarse entre el norte de Progreso y Cabo Catoche (los cuadrantes 10, 11, 12 y 13) (Figura 1).

DISCUSIÓN

El huachinango (*Lutjanus campechanus*) en el Banco de Campeche, es explotado por la flota mayor del estado de Yucatán. Esta flota es multiespecifica y dirige su esfuerzo a las pesquerías de mero, huachinango y pulpo. Cada una de estas pesquerías captura incidentalmente otras especies y su proporción en la captura depende de la zona y arte de pesca utilizado (bicicleta, carrete y alijos).

Del análisis de la información se concluye que una parte de la flota yucateca dirige su esfuerzo exclusivamente a la captura de huachinango. Las embarcaciones que utilizaron bicicletas registraron por viaje de pesca el 45 % de su captura de huachinango (38 % *L. campechanus*, el 3 % *L. bucanella* y el 4 % *L. vivanus*). Sin embargo, González y de la Rosa (1988) reportó que en el Banco de Campeche el 90 % de la captura de las embarcaciones que utilizan bicicleta correspondía a

huachinango. Esto significa que la proporción de la captura ha cambiado a través del tiempo.

Del análisis de la DFL de la captura, se observo que el 60 % de los organismos capturados por la flota yucateca se encuentran por arriba de la talla mínima de las 16 pulgadas (40. 6 cm de LT y 38.4 cm de LF), la cual es aplicada a los permisionarios mexicanos que exportan su producto a los Estados Unidos. La prueba t-Student mostró diferencia significativa en la estructura de tallas de *Lutjanus campechanus*, cuando se analizan por arte de pesca. Las embarcaciones que usan carrete capturan organismos más grandes, con una longitud media mayor que los organismos que se capturan con bicicleta y alijos. También fue evidente que las embarcaciones que utilizan alijos capturan en mayor porcentaje a los organismos más pequeños.

Si se considera el viaje de pesca, como la unidad de esfuerzo nominal, se tiene registrado que esta flota ha mantenido un esfuerzo constante cercano a los 4,000 viajes por año, entre 1997 y 2001. Este mismo patrón se observa si se considera como medida de esfuerzo pesquero al número de barcos que han estado activos. En este mismo intervalo de tiempo (1997 - 2001), se ha registrado un promedio 450 embarcaciones activas por año, con un intervalo entre 409 y 495 embarcaciones.

La asignación del esfuerzo entre pesquerías ha cambiado, buscando maximizar sus capturas y sus rentas. Hay que considerar que desde 1996 las capturas de pulpo tuvieron un incremento con volúmenes mayores a los registrados en años anteriores. Se puede decir que a partir de entonces cuando empieza la temporada de pulpo una parte de la flota cambia de pesquería, dejando de pescar mero y/o huachinango para ir a la captura del molusco. Este cambio tiene un comportamiento a corto plazo intranual que corresponde al inicio de la temporada de pulpo y otro a largo plazo entre los años que esta relacionado con la demanda y la apertura de los mercados europeos y orientales sobre el pulpo de aguas yucatecas. Además, de la variabilidad en la demanda del mercado de Estados Unidos por las especies de escama (mero-huachinango). En la segunda mitad del año existe una estrategia de incrementar el esfuerzo, ya sea introduciendo más embarcaciones, alijos y/o número de días en el mar para mantener y aumentar los beneficios de la pesquería de pulpo.

En el transcurso del año la asignación del esfuerzo entre pesquerías se ve reflejado en una disminución de la captura de mero y/o de huachinango (Monroy et al. 2001). En los últimos tres años se ha registrado que aproximadamente el 25 % de las embarcaciones de la flota yucateca cambian de pesquería y por lo tanto de arte de pesca ya que dejan de utilizar carrete y/o bicicleta por los alijos. Sin embargo, una parte de la flota mantiene su esfuerzo dirigido ha la captura de huachinango durante todo el año y por viaje de pesca registran aproximadamente el 45 % de huachinago (*L. campechanus, L.vivanus, L.bucanella*).

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Addressing Recruitment in *Mycteroperca microlepis* Populations of the North Coast of Yucatan Peninsula: An Otolith Aging Approach

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ABSTRACT

Gag (*Mycteroperca microlepis*) is one of the grouper species that supports a major commercial fishery in the Yucatan Peninsula and also a recreational one in the southeastern United States. In the state of Yucatan it is a very important fishery resource since it represents the third most abundant species in the total catch biomass. Despite its importance, there is scarce information in Mexico about its population biology, recruitment, and juvenile period. Therefore, this work is focused on defining the time, age, and size in which settlement and recruitment take place. During a 19 months survey at the northern coast of Yucatan during 2000 and 2001, 928 gags were caught. All of these were juveniles since they have completed their metamorphosis, lived in a benthic habitat, and were sexually immature. Otoliths microstructure analysis was done using a polishing and etching technique and counting the number of annual rings and daily marks through a compound microscope. In order to authenticate the number and the source of each mark observation, an image analysis with a SEM was carried out. Two cohorts were established, the first one takes account of individuals of less than a year old displaying several daily and lunar marks, as the second one comprises individuals with two or more years of life, exhibiting two or more annual rings and other source marks. The otolith aging technique points out that recruitment is discontinuous for gag in the Yucatan coast and that the determined nursery areas support more than one annual cohort.

KEY WORDS: *Mycteroperca microlepis*, age, otoliths, recruitment

Abordando el Reclutamiento de las Poblaciones de *Mycteroperca Microlepis* de la Costa Norte de la Península de Yucatán : Un Enfoque de Otolimetría

El Abadejo (*Mycteroperca microlepis*), es una de las especies de meros que es explotada por pesquerías comerciales en el sur del Golfo de México, así como pesquerías recreativas en el sureste de Estados Unidos. En el estado de Yucatán, es un recurso pesquero muy importante ya que representa la tercera especie mas

abundante en el volumen total de captura. A pesar de su importancia, la información en México sobre la biología de sus poblaciones, el recultamiento y su fase juvenil, es muy escasa o inexistente. Por lo tanto este trabajo tiene como objetivo definir el tiempo, edad y tamaño en el cual se da el asentamiento y el reclutamiento de esta especie. Novecientos veintiocho abadejos fueron capturados durante un período de muestreo de 12 meses, en la costa norte de Yucatán, durante el 2001. Todos los individuos fueron considerados como juveniles ya que presentaron una metamorfosis completa, inmadurez sexual y se encontraron asentados en ambientes bénticos. La técnica de otolimetría utilizada fue la de pulido y descalcificación, con conteo del número de anillos anuales o marcas diarias a través de un microscopio compuesto . Para verificar el numero y origen de cada marca observada, se realizó un análisis de imagen por medio de un MEB. Se estableció la existencia de 2 cohortes, la primera con individuos menores a un año de vida, que presentaron varias marcas diarias y lunares. La segunda cohorte con individuos de 2 o mas años de edad fue establecida ya que presentaban 2 o mas anillos de crecimiento u otras marcas. La técnica de otolimetría muestra que el reclutamiento del abadejo en las costas de Yucatán es discontinuo y que en las areas de crianza registradas se pueden encontrar individuos de diferentes cohortes anuales.

PALABRAS CLAVES: Abadejo, *Mycteroperca microlepis*, el recultamiento, Península de Yucatán

INTRODUCTION

The coastal zone of the Yucatan State in Mexico has exceptional diversity and abundance of marine resources due to the physical and chemical characteristics prevailing there. Juvenile gags appear to be dependent on estuaries and near shore waters. Larvae are pelagic and drift towards shore with the influence of tides and currents (Rutten in press). Postlarval gags enter near shore waters where they settle and stay in these nursery areas for a period of time searching for food and protection. Settlement is apparently well synchronized with the spring increase in primary and secondary productivity in oyster beds, seagrass beds and other complex habitats. All of the juveniles are sexually immature. Five to six months later, juvenile gags leave the nursery area and egress to near shore reefs and wrecks (Koenig and Colin 1999). Changes in weather patterns and/ or rapid changes in water temperatures may precipitate mass emigration of gag from the estuaries (Ross and Moser, 1995).

Gags are heavily fished using a variety of gear and in different phases of their lives (Sadovy 1997). The fishing pressure on this species in Yucatan, as in other groupers, is greatest on larger individuals that are mainly males, since it is a protogynous hermaphrodite, resulting in the females changing sex at a smaller size (Koenig et al. 1996, Coleman et al. 1996). Juveniles are also captured within the coastal zone of the state since there are no management regulations on the minimum legal size.

The overfishing of adults and juveniles as well as the destruction or modification of their nursery have lead the Mycteroperca microlepis to be considered as a vulnerable specie in the Red List of the UICN (Morris et al. 2000). It is becoming generally accepted the only way to effectively protect this specie is by protecting their habitat. There is a clear need for more and better data on the biology of this grouper and so this article will provide information on the biology of juvenile gags and their recruitment. Using an otolith aging technique, time, age and size in which settlement and recruitment took place in the northern coast of Yucatan will be determined so as to have more tools to manage this resource.

MATERIALS AND METHODS

All juvenile gags were captured with a small trawl net at Punta Caracol (21° 29.24 N, 87° 30.18 W) and Dzilam de Bravo (21° 25.05 N, 88° 52.20 W) in the northern coast of Yucatan where seagrass beds are conspicuous during 19 months survey from June 2000 to December 2001 (Figure1). Data registered for each sampled fish included collection date, location (using a GPS), total (TL) and standard length (SL) (cm), whole (TW) and gutted body weight (GW) (g). Both sagittae were carefully removed up through the gills and placed in an aqueous solution of alcohol for more than a week in order to clean all the membranes off them. Some gags were too small so the otoliths were not removed and some otoliths were broken, leaving only 715 pairs able to use and to establish the time in which settlement and recruitment took place.

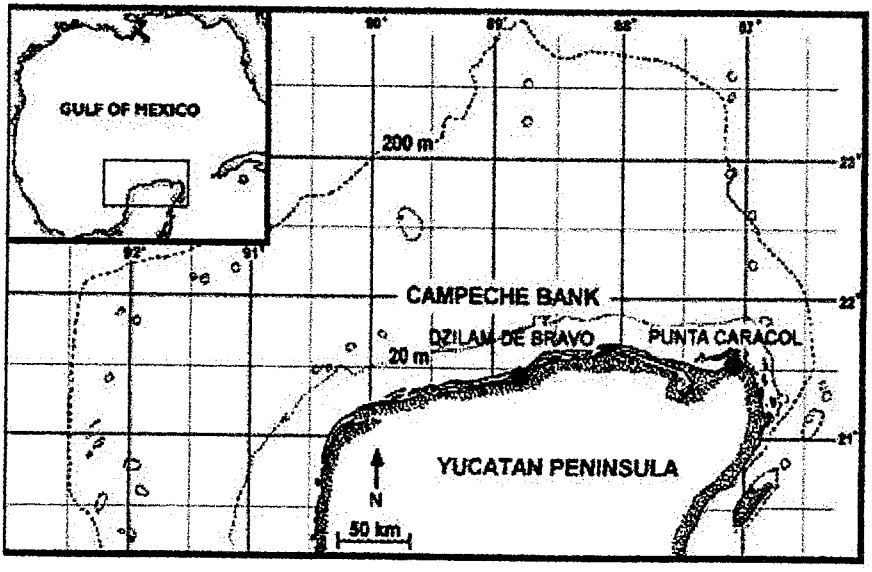

Figure 1. Map of the Campeche Bank and the northern coast of Yucatan Peninsula, showing the two fishing sites where gags were collected.

Once clean, the pair of otoliths was stored dry in paper bags. Only the left otolith was chosen, but in case it was lost or damaged the right one was used. Every pair of sagittae was weighed to the nearest milligram in order to obtain the average weight. For length and width, one sagitta was measured using a graph paper to the nearest millimeter. A correlation between the fish and otolith weight and the standard length and the otolith length were carried out. For the aging technique, 53 sagittae of 0.5 cm and 0.9 cm length were chosen. Each of the selected otoliths was observed by using a compound binocular microscope under reflected light immersed in camomil aromatic oil, which acts as a clearing agent. The number of opaque marks were read from the nucleus outward along their axis at a magnification of 0.7 X and 2.5 X for each one by two readers and the mean value was taken into account. It was taken into account that the underlying daily increment pattern is usually smooth and regular (Campana 1992).

The number of marks from each specimen was used to estimate the age of the fish in days for the smallest otoliths. For the largest otoliths, annual rings (annuli) in each sagitta were counted since the daily marks could not be clearly read. The same otoliths were cleansed with a paper towel and embedded in transparent epoxy resin. Each otolith was polished to the sagittal plane with 600 and 1000 grit paper until the nucleus was exposed. The cross-section was etched with EDTA (9% solution) for five minutes for the smaller otoliths and for 15 minutes the larger ones. The otoliths were then stained with Toludine blue in order to make the marks and annuli more evident to observe. Although greater time is required per sample, the quality of sample preparation and the precision of later microstructural examination is enhanced over other methods (Secor et al. 1992).

Once the source of the mark was established, a back calculation procedure was performed considering that every seven daily marks stands for a lunar mark and that the pelagic phase of the gag was 40 days (Koenig and Coleman 1998). The back calculation procedure used in this study only determines the probable settlement and birth date of each juvenile. Increments or marks were considered daily as they are formed at a constant frequency, and they often appear as a regular sequence with smooth transitions in both increment width and increment contrast (Campana 1992).

In order to authenticate the number and the source of each mark or annulus observation, an image analysis with a scanning electronic microscope (Hitachi S 520) was carried out (110 X to 600 X magnification). The otoliths were rinsed with alcohol before being rotary coated in a vacuum evaporator with 150 Å of gold-palladium alloy. The image analysis system was used because it provides three major advantages such as image enhancement, image manipulation and quantification of annuli (Campana 1992).

RESULTS

From June 2000 to December 2001, 928 gags were caught at the northern coast of Yucatan in Punta Caracol and Dzilam de Bravo. Lengths for 715 individuals ranged in size from 6.2 to 48.7 cm and 5.9 to 43 cm total and standard length

respectively. Whole weight range from 4.2 to 1,105.9 g while gutted weight was 3.4 g to 1,008.4 g.

Otoliths length ranged from 0.25 to 2.2 cm and otoliths weight from 0.00053 to 0.54629 g. Fish standard length and fish weight correlated strongly with sagitta length (r^2 = 0.8056) (Figure 2) and sagitta weight (r^2 = 0.7099) (Figure 3) respectively.

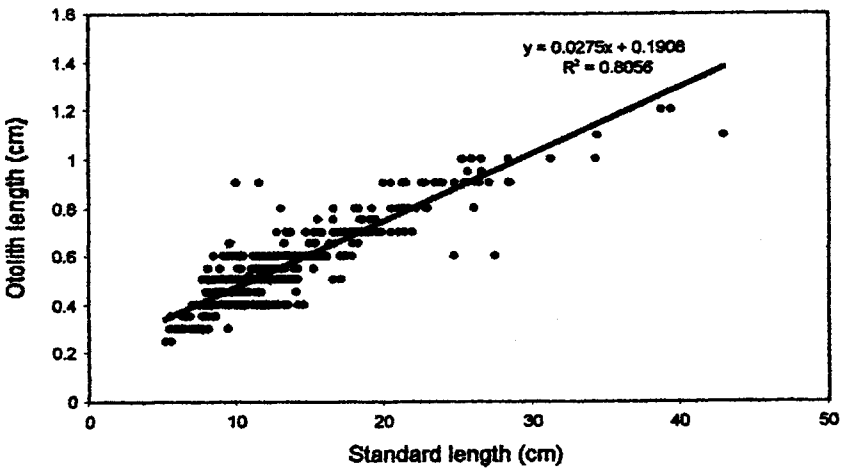

Figure 2. Regression of 715 gags between standard fish length and otolith length

The number of marks and annuli were read in 53 chosen otoliths It could be assessed that 30 sagittae, whose length was 0.5 cm display no annual ring or annuli. The largest 23 otoliths of 0.9 cm length display one or more annuli and no lunar mark was visible. It was established that these otoliths where from fishes of two different cohorts, the smallest ones belonging to a first cohort and the largest to a second.

Otoliths of fishes in the first cohort, seen with camomile oil, display several records from 5 to 20 lunar marks that represent an individual age of 75 days to 180 days, including 40 days that lasts the larval phase (Table1). The 30 individuals studied were younger than a year. Of these individuals 6 had 4 months, 2 had 5 months, 4 had 6 months, 11 individuals had 7 months and 7 had 8 months of life. These gags were captured between July 2000 and November 2001, and the probable date of recruitment was April to May for the smallest individuals (10.6cm mean standard length). The aging technique points out that juveniles had been recruited

primary in April and May to June or August.

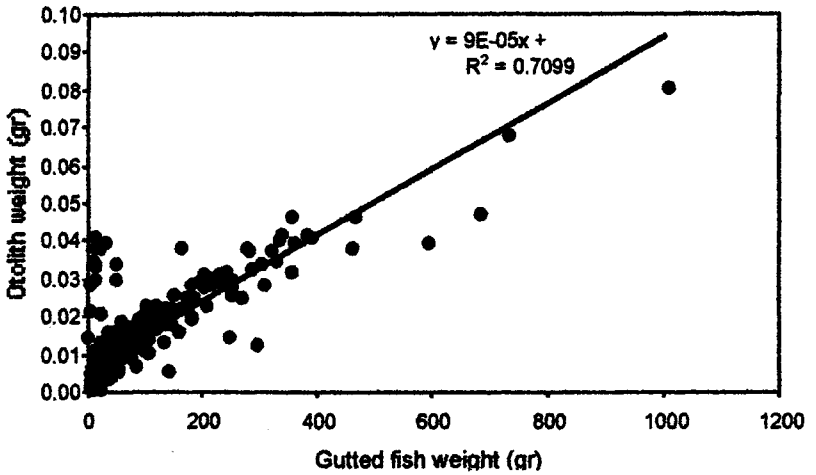

Figure 3. Regression of 715 gags between gutted fish weight and otolith weight

The standard length of cohort one (range 7.8- 27.5 cm) was significantly less than those of cohort two (ranges 10.0 - 28.6 cm). The relationship between the standard length of each individual of the cohort one, and the number of marks in their otoliths was statistically significant ($p = 0.142118$; $\alpha = 0.01$) but the correlation between variables was very weak (correlation coefficient = 0.078074).

Juvenile gags belonging to cohort the second cohort displayed 1 to 4 annuli, after the polishing and etching technique (Table 1). These annuli represent an age of one to four years for the juveniles. The standard length for individuals with one annulus, or one year of age, ranged form 11.5 to 28.6 cm and for individuals with two annuli ranged from 20.5 to 28.5 cm. Specimens with three and four annuli presented a standard length of 20.0 to 25.7 and 23.8 to 26.5 cm, respectively. The relationship between the standard length of each juvenile and the number of annuli displayed in each otolith was statistically significant ($p = 0.197684$; $\alpha = 0.01$) but the correlation between variables was very weak (correlation coefficient = 0.07772). All of these 23 individuals were capture between July 2000 to October 2001.

For the early recruits, or juveniles belonging to the first cohort, the deposition of lunar marks was observed every seven days. I was also assessed the number and source of the annuli seen in individuals of the second cohort, which display one to three annual rings. This was authenticated by taking into account the microstructure of the otolith seen through the SEM (Table 1).

Table 1. Results for the two different cohorts defined. A comparison between the three methods used.

	Camomile Oil		Polishing and Etching		Image Analysis (SEM)	
	Lunar Mark	Annuli	Lunar Mark	Annuli	Lunar Mark	Annuli
Cohort 1	5 - 20	0	0	0	5 - 20	0
Cohort 2	0	1 - 3	0	1 - 3	0	1 - 3

DISCUSSION

Mycteroperca microlepis is a protogynous hermaphrodite (Bullock and Smith 1991), which exhibits a bathymetric distribution (Johnson and Collins 1994) and whose principal environments for their juvenile stage are in shallow water seagrass beds (Renán In press.). Through this study it can be assessed that early juvenile gags require this habitat as a nursery area although dependency for estuaries (Keener et al. 1988, Koenig and Colin 1999) was not observed since in Yucatan shore there are no estuaries

The stations where the individuals were captured in this study, Punta Caracol and Dzilam de Bravo, belong to two different natural protected areas which include one mile of sea habitat from the coastline. Notwithstanding, when these areas were decreed, the marine environment was not taken into account, and there are no management plans or fishing restrictions in any of them.

All of the gags studied were considered as juveniles since they have completed their metamorphosis, had settled in a benthic habitat, and were sexually immature (Kovác and Copp 1999). Pelagic gags recruited to the sea grass habitat as a single cohort in April and May after 40 days of pelagic stage, which agree with the time established by other authors (Koenig and Coleman 1998, Koenig and Colin 1999).

For these early recruits the deposition of lunar marks was observed every seven days. The mean size of the individuals at age 0 or younger than a year (10.6 cm) determined in this study agreed with the length established by Hood and Schlieder (1992) of 32.2 cm (maximum value TL) for individuals of the same age. The first individuals from this cohort were captured in July, and with the back-calculation analysis it could be determined that the first individuals ingress to the seagrass beds in April and May which agrees with the results from other authors (Rutten, In press; Ross and Moser, 1995).

From individuals belonging to cohort, two sectioned otoliths showed that annuli were laid down once a year. Although the validation to assert this was not carried out, different authors support this by the consistency of ring location from the otolith core and the positive correlation of otolith size and fish length (Hood and Schlieder 1992, Collins et al. 1996). The periods of peak annulus reported was in May to August, but in order to establish the time when these rings were formed in the otoliths studied, a marginal increment analysis is needed (Collins et al. 1987)

The otolith aging technique points out that recruitment is discontinuous for gag in the Yucatan coast where there is an evident peak of ingress once a year. Individuals spend their first years of life in these nursery areas where they become established to feed and protect themselves from predators (Jory and Iversen 1989). The results also determined that these nursery areas support more than one annual cohort, which indicates that gags are not a threat to each other and that they are recruitment-limited rather than resource-limited (Sadovy 1997).

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Pêches Expérimentales de L'œil de Bœuf (*Etelis oculatus*) aux Filets Profonds en Guadeloupe (F.W.I.)

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GOURBEYRE, Guadeloupe (F.W.I.)

RÉSUMÉ

La modernisation de la flottille de pêche artisanale de la Guadeloupe autorise désormais l'exploitation des ressources profondes du talus insulaire. Dans les années 1990, est apparue la pêche de l'œil de bœuf (*Etelis oculatus*) à l'aide de filets, dans des profondeurs d'environ 300 m. Ces ressources étaient précédemment exploitées par les techniques traditionnelles artisanales : les palangres profondes. L'arrivée de cette nouvelle technique est à l'origine de conflits de métiers au sein de la communauté de pêcheurs. Une étude a été entreprise par l'Institut Régional de Pêche et de Marine (IRPM) afin d'étudier l'impact de l'introduction de cette technique sur ces stocks et les moyens de les préserver de la surexploitation. Une analyse économique de la rentabilité cette pêche a été également conduite.

La campagne a permis de mouiller 28 km de filets entre les mois d'avril et d'octobre 2001, au sud et à l'ouest de la Basse-Terre, en Guadeloupe. 2 400 individus appartenant à 48 espèces ont été capturés. Les rendements obtenus sont de 19,5 kg/100 m de filet ou 48 kg par heure de pêche.

L'œil de bœuf, espèce cible, représente 47 % des effectifs pour 52 % du poids vif et 77 % de la valeur commerciale. 86 % des individus capturés sont matures. D'autres espèces présentant un potentiel commercial ont été capturées (*Gephyroberyx darwini*, *Polymixia lowei*).

Les inconnues qui demeurent concernant la reproduction et la croissance de cette espèce incitent à recommander l'élaboration d'une réglementation spécifique concernant cette pêcherie. Des études complémentaires concernant l'analyse des pêcheries commerciales guadeloupéennes ainsi que la détermination de la croissance et des périodes de reproduction d'*Etelis oculatus* vont être prochainement entreprises.

MOTS CLEFS : *Etelis oculatus*, pêches profondes, Guadeloupe

Experimental Deep Sea Gill Net Fishery of Queen Snapper (*Etelis oculatus*) in Guadeloupe (F.W.I.)

Modernization of fishing boats in Guadeloupe now allows deep-sea resources exploitation of the insular slope. In the mid 1990s, net fisheries targeting queen snapper (*Etelis oculatus*), began at around 300 m depth. This specie was previously fished utilizing small scale traditional techniques, primarily hook and line. The introduction of gillnets led to conflicts between communities of professional

fishermen. A program was undertaken by the regional fisheries institute (IRPM) to study the impact of net introduction on those stocks in order to prevent overfishing. An economical analysis of the profitability of the queen snapper net fishery was conducted at the same time.

This experimental campaign lasted seven months, from April to October 2001, in the South and West of Basse-Terre, in Guadeloupe. 28 km of gill nets, were soaked in 142 sampling sites, allowing 2 400 catches belonging to 48 species. Average CPUE of 19,5 kg/100 m or 48 kg/fishing hour were obtained.

Queen snapper represents 47 % of the catches, the equivalent of 52 % of total weights and 77 % of commercial value. Average individual weight for queen snapper is 2.6 kg. 86 % of the individuals fished were adults. Other commercial fishes were caught namely *Gephyroberyx darwini* and *Polymixia lowei*.

Aspects of the reproduction and growth of this specie remains unknown, leading us to recommend regulation of this new technique. Studies will soon be undertaken to assess commercial deep sea fisheries in Guadeloupe and to determine localization and seasonality of reproduction as well as growth of queen snapper.

KEY WORDS: *Etelis oculatus*, deep-sea fisheries, Guadeloupe

Pescas Experimentales del Pargo Cachucho *(Etelis oculatus)* con Redes Profundas en Guadeloupe (F.W.I.)

La modernización de la flotilla de pesca artesanal de Guadeloupe permite ahora la explotación de los recursos profundos del pendiente insular. En los años 1990, est apareció la pesca del pargo cachucho (*Etelis oculatus*) con redes, alrededor de 300 m de profundidad. Anteriormente, este recurso era explotado con artes tradicionales : palangres profundos. La llegada de aquella nueva practica fue fuente de conflictos entre comunidades de pescadores. Un estudio ha sido réalizado por el Instituto Regional de Pesca y de Marina (IRPM), para estudiar el impacto de la introducción de este nuevo arte de pesca en los recursos para preservarlos de una sobre explotación. El trabajo incluye también un análisis económico de la rentabilidad de esta pesca.

La campaña de mostreos permitió colocar 28 km de redes alreddor de 300 m de profundidad, en el sur-oeste de Basse-Terre, en Guadeloupe, entre abril y octubre de 2001. 2 400 individuos perteneciendo a 48 especies fueron capturados. Les rendimientos obtenidos son de 19,5 kg/100 m de red o 48 kg por hora de pesca.

El pargo cachucho,especie enfocada, representa 47 % de los individuos, 52 % del peso total y 77 % del valor económico de la pesca. 86 % de los individuos capturados son adultos. Otras especies con potencial comercial han sido capturadas en cantidades significativas (*Gephyroberyx darwini, Polymixia lowei*).

La reproducción, el crecimiento y el estado del stock del pargo cachucho siguen poco investigados, lo que nos ha conducido a recomendar una réglementación cautelar para esta pesqueria. La análisis de las pescas comerciales del pargo cachucho programadas en Guadeloupe permitiran adaptar un reglamento que

permita un desarollo sostenible de esta pesqueria.

PALABRAS CLAVES: *Etelis oculatus*, pescas profundas, Guadeloupe

INTRODUCTION

La pêche guadeloupéenne, majoritairement artisanale, se concentre sur l'exploitation des secteurs peu profonds du plateau insulaire, conduisant à une situation de surexploitation des zones côtières. Depuis une quinzaine d'années, l'Institut Régional de Pêche et de Marine (IRPM), réalise des travaux ayant pour objectif la diversification des pêcheries et le redéploiement d'une partie de l'effort de pêche vers l'exploitation de nouvelles ressources afin de soulager le plateau insulaire. Dans ce cadre, l'IRPM a conduit, en 2001 et 2002, un programme intitulé "Optimisation de l'exploitation des ressources nouvelles en Guadeloupe, ressources profondes et DCP". La rentabilité de d'exploitation ces ressources innovantes a été étudiée en conditions d'exploitation commerciales, en tenant compte de la nécessité de préserver les capacités de renouvellement des espèces (Diaz et al. 2002).

Diverses techniques et engins de pêche ont été expérimentés :

i) La palangre profonde ciblant particulièrement les requins,
ii) La pêche des grands pélagiques autour des DCP,
iii) La pêche aux casiers profonds ciblant les Crustacés.
iv) La pêche au filet profond ciblant principalement l'œil de bœuf (*Etelis oculatus*)

Cette dernière technique qui fait l'objet des développements suivants. L'état des connaissances concernant l'espèce cible sont rappelés. Les matériels et méthodes employés durant l 'étude sont mentionnés. Les résultats globaux sont illustrés avec un développement particulier concernant l'espèce *Etelis oculatus*, pour conclure à propos de la portée de ce travail sur l'aménagement réglementaire des pêches en Guadeloupe.

CONNAISSANCES SUR L'EXPLOITATION DE L'ŒIL DE BŒUF DANS LES PETITES ANTILLES

Les Lutjanidés profonds et principalement les espèces *Lutjanus vivanus* (« vivaneau ») et *Etelis oculatus* (« œil de bœuf ») font l'objet d'une pêche traditionnelle dans les Petites Antilles à l'aide de lignes de fonds et de palangres diverses. Ces pêches sont pratiquées sur le talus insulaire et sur les pentes des hauts-fonds, en dehors de la saison de pêche des pélagiques. Pour l'espèce *Etelis oculatus*, Allen (1985) note qu' il s'agit d'une "ressource potentielle particulièrement abondante aux Bahamas et aux Antilles". Des pêches expérimentales concernant ces ressources ont été menées par IFREMER, sur le talus insulaire de la Martinique (Guillou, 1989) et autour des îles de Saint-Martin et Saint-Barthélemy (Lorance 1989). Les travaux de Murray (1989), Murray et Charles (1991) et Murray *et al.* (1992) et ont contribué à une meilleure connaissance de la biologie et de la pêche

d'*Etelis oculatus*, à partir de l'analyse de la pêcherie traditionnelle de Sainte-Lucie. Ces travaux ont été poursuivis par la mise en place d'une coopération régionale avec les îles de la Dominique et de Sainte-Lucie concernant l'exploitation des Lutjanidés profonds. Une synthèse des connaissances sur la pêche et la biologie de l'espèce *Etelis oculatus* a été produite en 1996 (Guillou et al. 1996).

On sait de cette espèce que sa répartition bathymétrique se situe entre 100 et 600 m (ce qui correspond à des températures ambaintes comprises entre 10 et 25°C), qu'il s'agit d'une espèce mobile et grégaire. Les captures semblent attester de la présence plus profond des plus gros individus. Son régime alimentaire est principalement constitué de calmars et crustacés. Le sex-ratio observés dans les captures est de 1 : 1 mais il apparaît une prédominance des femelles parmi les individus de grande taille (>55 cm LF) alors que les mâles sont plus abondants parmi les individus de petite taille (<55 cm LF). La saison de reproduction est mal définie. La taille de maturité sexuelle se situe entre 43 et 47 cm LF pour les femelles et entre 37 et 42 cm LF pour les mâles. Les paramètres de croissance de von Bertalanffy sont les suivants L8 = 102 cm LT et K = 0,290, ce qui est cohérent avec la taille maximale observée : 76 cm LF (96 cm LT) pour 6,3 kg. La longévité est probablement supérieure à 30 ans.

L'exploitation de cette espèce à l'aide de filets maillants est apparue, en Guadeloupe. Elle semble avoir été initiée par les pêcheurs de l'île de la Désirade, sur le banc Flandres, et s'est développée, depuis 1995. Les filets utilisés sont des filets maillants (maille minimum autorisée 35 mm ou 70 mm étirée). L'augmentation des puissances des navires et des moyens de levage ont permis l'intensification de ces pêches. Ces pratiques et leurs impacts sur les ressources n'ont pas été suivis mais les pêcheurs pratiquant les techniques traditionnelles dénoncent une raréfaction des prises qu'ils attribuent à ces nouvelles pratiques. Les pêcheurs désiradiens confirment que l'augmentation de la pression de pêche aux filets profonds autour de la Désirade a rapidement conduit à une diminution significative des captures, menaçant la rentabilité de cette activité.

MATERIEL ET METHODES

Le navire de pêche utilisé, "Le Polka", est un navire ponté d'une longueur de 12 mètres, intégrant un équipement électronique de bord complet (dont la cartographie des fonds par sondeur couplé au GPS) et un vire-filet d'une puissance de 600 kg à 90 m/mn.

Des repérages cartographiques et bathymétriques ont été systématiquement réalisés, préalablement aux mouillages des filets afin d'identifier les secteurs de cale les plus propices.

Des images sous-marines ont également été réalisées afin de caractériser le type de fond et d'observer les espèces *in situ*.

Engins de Pêche

Des filets droits de maille 60 mm (120 mm étiré) ont été montés. Les longueurs travaillées sont de 200 m pour une hauteur de 4 m. Ces montages ont nécessité de nombreux ajustements pour une parfaite compatibilité avec le vire-filet et pour limiter les pertes et déchirures trop importantes de la nappe en cas d'accrochage au fond. Ces longueurs de filet réduites permettent de cibler précisément les positions de cale sur les secteurs très hétérogènes prospectés.

Effort de Pêche Expérimental

Cinquante-cinq jours de mer ont été totalisés, permettant le mouillage de 28440 m de filet en 142 stations. Les bathymétries correspondant aux « yeux de bœuf » (*Etelis oculatus*), aux alentours de 300 m, ont été privilégiées. Les pêches ont été concentrées sur les pentes des « secs » (monts sous-marins) de Pointe-Noire, de Vieux-Fort et du sec Paté, dans le canal des Saintes, à des profondeurs comprises entre 195 et 410 m. Quelques cales ont également été réalisées sur le talus continental, à proximité de Basse-Terre.

Les marées ont été réalisées à la journée. L'organisation type de cette pêche consiste à mouiller les filets en fin d'après midi et à les relever le lendemain, à partir du milieu de matinée, puis à les remouiller en fin d'après-midi.

Informations Collectées

Pour chaque cale, les informations suivantes sont relevées : les positions, dates et heures de cale, dates et heures de levée ainsi que les profondeurs de cale. Les prises sont identifiées et dénombrées. Des mesures individuelles sont également réalisées : longueur à la fourche (LF) et/ou longueur totale (LT). Lorsque l'identification des espèces a été impossible, des spécimens ont été confiés à des spécialistes de l'Université des Antilles et de la Guyane ainsi qu'au Muséum National d'Histoire Naturelle. Des collections de spécimens et photographiques ont également été réalisées pour chaque espèce.

Les travaux portant sur la rentabilité de l'activité ont nécessité la commercialisation des captures dans les conditions du marché local. La valeur commerciale des prises a donc également été relevée. Les rendements pondéraux et financiers ont été extraits par longueur de filet et par heure de pêche pour chaque espèce.

RESULTATS ET DISCUSSION

Résultats Globaux

D'un point de vue technique, ces travaux ont permis de constater l'aisance de mise en œuvre des filets profonds à partir d'une unité de 12 m pontée et équipée spécifiquement pour cette pêche. Les pertes d'engins ont été limitées à 1,9 % des longueurs mouillées grâce aux repérages cartographiques minutieux préalables.

Un total de 2394 captures appartenant à 48 espèces a été enregistré, pour un

poids vif total calculé de 5 624 kg (Tableau 1).

Tableau 1. Caractéristiques des espèces capturées aux filets profonds pour l'ensemble de la campagne

Genre espèce	Auteur	Famille	N	L	Lmoy (cm)	Lmax (cm)	Lmin (cm)	Poids Tot (kg)
CRUSTACES								
Eumephrops cadenasi	Chace, 1939	Nephropidae	1	LC	6	6	6	0,1
POISSONS								
Chimaera sp (monstrosa)	Linnaeus, 1758	Chimaeridae	47	LT	74	88	57	184,6
Carcharhinus falciformis	Bibron, 1839	Carcharhinidae	2	LF	158	186	130	72,1
Sphyrna lewini	Griffith et Smith, 1834	Sphyrnidae	1	LT	223	223	223	146,1
Sphyrna zygaena	Linnaeus, 1758	Sphyrnidae	1	LT	295	295	295	100,6
Scyliorhinus boa	Goode et Bean, 1896	Scyliorhinidae	37	LT	50	60	30	33,0
Carcharias taurus	Rafinesque, 1810	Odontaspididae	1	LT	295	295	295	193,5
Heptranchias perlo	Bonaterre, 1788	Hexanchidae	23	LT	86	116	55	80,4
Hexanchus griseus	Bonaterre, 1788	Hexanchidae	5	LT	106	160	76	58,8
Hexanchus vitulus	Springer et Waller, 1969	Hexanchidae	6	LT	139	155	94	151,8
Centrophorus granulosus	Bloch et schneider, 1801	Squalidae	166	LT	84	108	40	542,6
Dalatias licha	Bonaterre, 1788	Squalidae	4	LT	133	156	105	75,8
Squalus cubensis	Howell-Rivero, 1936	Squalidae	37	LT	72	102	60	132,5
Cirrhigaleus asper	Merrett, 1973	Squalidae	12	LT	75	100	51	28,8
Cynoponticus savanna	Bancroft, 1831	Muraenosocidae	2	LT	113	115	110	7,5
Saurida normani	Longley, 1935	Synodontidae	12	LF	37	48	22	6,9
Brotula barbata	Bloch 1801	Brotulinae	16	LT	58	70	32	28,4
Polymixia lowei	Gunther, 1859	Polymixiidae	150	LF	25	53	12	70,2
Gephyroberyx darwini	Johnson, 1866	Trachichthyidae	439	LF	37	65	5	420,9
Antigonia capros	Lowe, 1843	Caproidae	5	LF	18	20	16	1,3
Peristedion brevirostre	Gunther, 1860	Triglidae	3	LT	20	21	19	0,5
Peristedion gracile	Goode et Bean, 1896	Triglidae	3	LT	21	22	19	0,7
Priacanthus arenatus	Cuvier, 1829	Priacanthidae	16	LF	42	47	35	16,5
Caranx lugubris	Poey, 1860	Carangidae	22	LF	47	56	40	44,9
Decapterus macarellus	Cuvier, 1833	Carangidae	38	LF	32	35	24	15,4
Decapterus tabl	Berry, 1968	Carangidae	2	LF	34	35	33	1,0
Seriola dumerili	Risso, 1810	Carangidae	2	LT	88	94	82	29,6
Taractichthys longipinnis	Lowe, 1843	Bramidae	1	LF	43	43	43	1,6
Epinnula magistralis	Poey, 1854	Gempylidae	4	LF	68	81	60	9,6
Promethichthys prometheus	Cuvier, 1832	Gempylidae	26	LF	56	95	27	36,4
Ruvettus pretiosus	Cocco, 1834	Gempylidae	9	LF	98	122	61	134,2
Thunnus atlanticus	Lesson, 1830	Scombridae	5	LF	45	60	35	11,5
Etelis occulatus	Valenciennes, 1828	Lutjanidae	1133	LF	55	90	6	2917,2
Lutjanus vivanus	Cuvier, 1828	Lutjanidae	6	LF	43	51	34	8,9
Ostichthys trachipoma	Gunther, 1859	Holocentridae	13	LF	20	27	14	2,8
Erythrocles monodi	Poll et Cadenat, 1954	Emmelichthyidae	55	LF	44	51	34	72,5
"requin" sp 1	non identifiée		1	LT	14	14	14	0,1
"requin" sp 2	non identifiée		2	LT	90	93	87	7,3
"raie" sp1	non identifiée		2	LT	20	25	15	0,4
"raie" sp2	non identifiée		1	LT	62	62	62	4,0
"murène" sp (jaune)	non identifiée		1	LT	100	100	100	5,0
Pontinus sp	non identifiée	Scorpaenidae	14	LT	26	60	19	9,2
Prionotus sp	non identifiée	Triglidae	6	LF	22	24	20	0,6
Neoscombrops sp	non identifiée	Percichthyidae	47	LF	32	51	19	40,2
"poisson banane"	non identifiée		1	LT	26	26	26	0,2
"limande" sp	non identifiée		4	LT	29	33	21	1,6
"sole"	non identifiée		2	LT	30	30	30	0,6
"vieille"	non identifiée		1	LT	124	124	124	44,0

Les principales espèces capturées (en effectifs) sont *Etelis oculatus* (Lutjanidae ; 1133 individus) suivi de *Gephyroberyx darwini* (Trachichtyidae ; 439 individus) Le rendement pondéral moyen obtenu est de 19,5 kg pour 100 m de filet. Le rendement économique est de 96 US$/100 m de filet. Par heure de pêche (durée du mouillage, du virage et du traitement des captures), ces rendements sont de 47,9 kg ou 235 US$.

Résultats Concernant l'esPèce cible *Etelis oculatus*

Au total, 1 133 individus de l'espèce *Etelis oculatus* ont été capturés, pour 2 918 kg de poids vif et une valeur commerciale 22 236 US$. Les longueurs à la fourche des captures varient de 6 à 90 cm, pour une moyenne de 55,2 cm. Les poids sont compris entre 10 g et 9,4 kg, pour une moyenne de 2,6 kg. Les « yeux de bœuf » ont été capturés entre 217 et 340 m pour une profondeur moyenne de 284 m.

Cette espèce représente globalement 47 % des effectifs totaux pour 52 % du poids vif et 77,5 % de la valeur commerciale (Figures 1 et 2). Il s'agit de l'espèce cible de cette pêche en raison de sa forte valeur commerciale sur marché local (10 US$/kg), à l'instar de tous les Lutjanidés (« pagres » et « vivaneaux »).

Rendements

Les rendements mensuels ont varié de 2,6 kg par heure de pêche, en avril, à 48,5 kg par heure de pêche, en septembre (Figure 1). La moyenne est de 24,8 kg par heure de pêche. Ramenés à 100 m de filet, ces rendements vont de 1,1 kg, en avril, à 15,8 kg en septembre, pour une moyenne de 10,1 kg/100m de filet. Les meilleurs rendements correspondent à ceux mentionnés par Guillou (1989) pour des captures réalisées entre -200 et -300 m, sur le banc d'Amérique, à la Martinique : 15,3 kg/100 m de filet. En moyenne, pour l'ensemble de la Martinique et pour des pêches au trémail, ces mêmes auteurs reportent des rendements de 3,36 kg/100 m de filet en saison humide, et de 5,03 kg/100 m de filet en saison sèche, pour une moyenne de 3,83 kg/100 m. Les résultats obtenus au cours du présent travail sont donc nettement supérieurs. Toutefois, il faut préciser que dans le cas des pêches expérimentales menées en Martinique, la stratégie de cale des engins était aléatoire alors qu'elle ciblait l'«œil de bœuf » dans le cas présent.

Cette espèce est manifestement présente sur les secteurs exploités durant toute la période. si l'on considère que les captures modestes du mois d'avril correspondent à une phase d'essais préliminaires concernant la technique de pêche. Guillou et al. (1996) ne mentionnent pas de variations saisonnières apparentes de la présence de cette espèce.

Les rendements obtenus sont particulièrement élevés et prouvent l'abondance de l'espèce ainsi que l'efficacité de l'engin de pêche. Il faut cependant préciser que les secteurs explorés étaient vraisemblablement vierges d'exploitation au filet, au début de la campagne. Le maintien d'un effort de pêche modéré durant cette campagne n'a pas permis de voir apparaître de diminution des rendements.

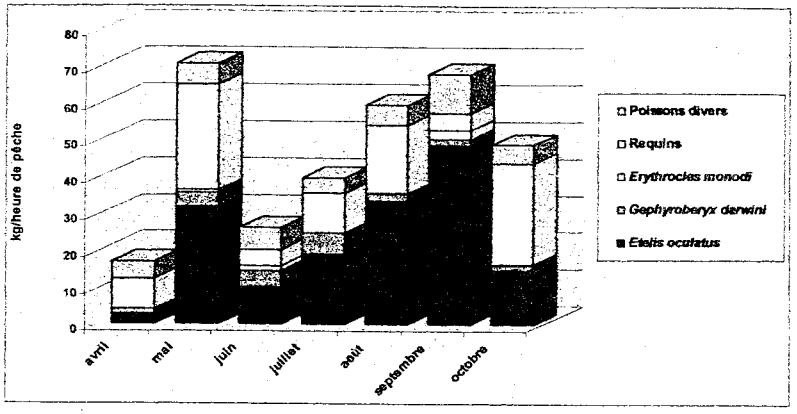

Figure 1. Rendement pondéraux par mois et par espèce de la pêche aux filets profonds obtenus durant la campagne.

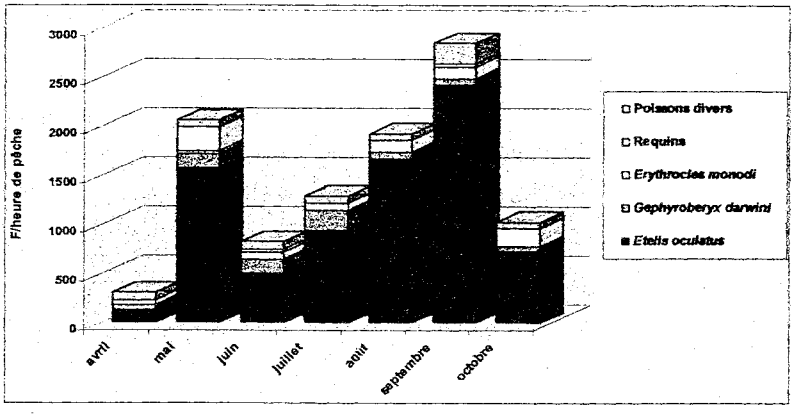

Figure 2. Rendement économiques par mois et par espèce de la pêche aux filets profonds obtenus durant la campagne.

Répartition par Classes de Taille

La répartition par classes de taille obtenue à partir des mesures de 779 individus est illustrée sur la figure 3. Il apparaît un mode principal autour de la classe 62 cm LF avec 43 individus. Un mode secondaire se détache autour de la classe 46 cm LF avec 26 individus. Les structures de distribution des tailles par mois n'ont pas montré de différences significatives au cours de la période d'échantillonnage.

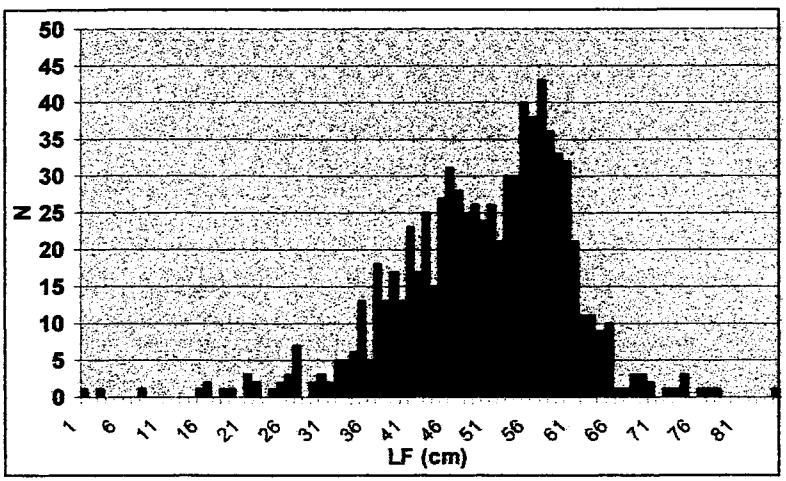

Figure 3. Distribution des tailles de l'espèce *Etelis oculatus* dans les captures.

Sélectivité des Filets

Les plus petits individus capturés mesurent 6 et 8 cm LF. Ils ont été capturés au mois de juin. Le plus grand individu mesure 90 cm LF, capturé au mois d'août. Ceci démontre que les filets maillants de maille 60 mm employés s'avèrent peu sélectifs en ce qui concerne la taille. Il est observé que les prises s'emmêlent dans le filet davantage qu'elles ne se maillent, ce qui explique la capture d'individus de très petite taille. Les prises d'individus de très petite taille demeurent cependant anecdotiques. Les captures de petits individus peuvent apporter quelques éléments de réponses quant à la période de reproduction. La présence simultanée dans les captures d'individus très petits (<10 cm LF) et d'individus de taille moyenne semble indiquer que différentes générations d'individus cohabitent dans le même milieu.

Si l'on considère une taille moyenne de première maturité sexuelle des femelles de 43 cm LF (taille inférieure de la plage de variation définie par Guillou et al., 1996), 92 % des effectifs capturés sont matures. Si l'on considère une taille moyenne de première maturité sexuelle des femelles de 47 cm LF (taille supérieure de la plage de variation définie par Guillou et al. 1996), 86,5 % des effectifs capturés sont matures. Cette pêche s'exerce donc très majoritairement sur des adultes ce qui est un facteur en faveur de la conservation de la ressource. Des professionnels

guadeloupéens pratiquant cette pêche avec des filets de mailles 40 mm rapportent que l'essentiel de leurs pêches sont constituées d'individus de plus de 50 cm LF. La taille des mailles ne semble pas avoir une influence déterminante sur la structure en taille des captures.

Il est apparu que les meilleurs résultats de pêche ont été obtenus à proximité des secteurs rocheux accidentés sur le pourtour des monts sous-marins. Les pêches réalisées sur les pentes sédimentaires du talus continental, à proximité de Basse-Terre ont semblée être, globalement, moins productives. Cette espèce semble préférer la proximité des affleurements rocheux offrant des possibilités de refuge.

Reproduction

L'état des gonades n'a pas été suivi et analysé au cours de ce travail, les captures étant instantanément vidées à bord. Seuls quelques indices qualitatifs ont été relevés. Ainsi, des observations de gonades de femelles à un stade de vitellogenèse avancé ont été réalisées en septembre. Cet état ne concernait que quelques individus. Aucun phénomène d'activité de reproduction synchronisée et d'envergure n'a été relevé durant ces travaux.

Des juvéniles de l'espèce (5 cm LF) ont été capturés en quantité significatives, aux casiers profonds, à 500 m de profondeur, sur les mêmes secteurs, en janvier 2002 (Gervain com. pers.). Il est possible d'imaginer des migrations bathymétriques des individus matures qui regagneraient les secteurs plus profonds pour la ponte, échappant ainsi aux pêches commerciales.

Autres Espèces

Gephyroberyx darwini (« empereur ») — 439 individus de cette espèce ont été capturés pour un total de 421 kg. Cette espèce représente globalement 18,5 % des effectifs totaux capturés pour 7,5 % du poids et 7,5 % de la valeur commerciale.

Les tailles sont comprises entre 5 et 65 cm LF, pour une moyenne de 37 cm LF. Les poids varient de quelques grammes à 4,8 kg, pour une moyenne de 0,96 kg. Les captures ont été réalisées entre 245 et 380 m de profondeur, pour une moyenne de 310 m. La profondeur de répartition de cette espèce semble légèrement supérieure à celle d'*Etelis oculatus*. Cette espèce a rarement été rencontrée en association avec *Etelis oculatus* dans les captures.

Cette espèce n'est pas capturée à la palangre et est peu présente dans les captures de la façade Atlantique. Peu connue des consommateurs, un effort de promotion a été nécessaire pour sa commercialisation. Néanmoins, la qualité de sa chair lui autorise un potentiel commercial indéniable.

Les Requins — 12 espèces de requins ont été identifiées dans les captures. L'effectif total des requins est de 297 individus, pour un poids vif calculé de 1 430 kg. Les requins représentent 12,5 % des effectifs totaux capturés au filet, pour 29 % du poids et seulement 6,5 % de la valeur commerciale, en raison de prix de vente très modestes.

Les principales espèces rencontrées sont de petite taille : « requin chagrin » (*Centrophorus granulosus*, 166 individus), aiguillat cubain (*Squalus cubensis*, 37 individus), Hexanchidae (*Hexanchus vitullus*, 6 individus : *H. griseus*, 5 individus)... Les pêcheurs pratiquant le filet profond en Guadeloupe rapportent des captures de requins en diminution constante depuis le début de cette activité, au milieu des années 90.

Autres — L'ensemble des 34 autres espèces rencontrées ne présentent qu'un intérêt économique mineur ou nul, à l'exception, peut-être, de l'espèce *Polymixia lowei* (Polymixiidae, 150 individus).

Rentabilité

Ces travaux ont parallèlement permis une analyse de rentabilité en confrontant les rendements financiers horaires de la pêche aux charges d'exploitation d'un navire en configuration de pêches commerciales. Des modélisations réalisées dans plusieurs cas de figure (variation de la taille des navires, de l'équipage, du temps de pêche et des rendements...) ont montré une pêche assurément plus rentable que l'exploitation des autres pêcheries profondes investiguées : crustacés profonds au casiers et requins profonds à la palangre (Diaz et al. 2002). Il s'agissait néanmoins d'une analyse instantanée au vue des rendements obtenus expérimentalement et non d'une rentabilité à long terme, qui implique un maintien des stocks. Cette dernière condition nécessite une approche précautionneuse du développement de cette pêcherie passant par une limitation de l'accès à la ressource.

CONCLUSIONS

Ces travaux devaient déboucher sur des conclusions pragmatiques à destination des pouvoirs publics et des décideurs concernant les conditions de développement durable de cette pêche.

D'un Point de Vue Technique

Les résultats enregistrés ont montré que la mise en œuvre des filets ne pose pas de problèmes techniques particuliers et que l'acquisition de la maîtrise de cette pêche peut être rapide pour un professionnel désirant se convertir à cette pratique. Une parfaite connaissance des secteurs exploités et une cartographie détaillée de leur bathymétrie permet de cibler les stations de cale et donc d'augmenter les rendements tout en minimisant les pertes d'engins.

Les filets maillants de maille carrée de 60 mm (120 mm étirée) au minimum semblent indiqués. Des sections de filets réduites (200 m) permettent de cibler précisément les secteurs de cale dans des milieux hétérogènes. Les secteurs les plus favorables sont situés à proximité de reliefs accidentés, autour de – 300 m, sur le pourtour des monts sous-marins. La présence de ces ressources est vérifiée pour l'ensemble du talus insulaire et des monts sous-marins de l'archipel guadeloupéen et ne semble pas être l'objet de variations saisonnières significatives.

Du Point de Vue des Espèces

L'espèce cible, avec 77 % de la valeur commerciale totale, est indiscutablement l'«œil de bœuf» *Etelis oculatus*. D'autres espèces offrent un potentiel de valorisation intéressant : l'«empereur» (*Gephyroberyx darwini*) ou la « chèvre » (*Polymixia lowei*), par exemple. Les captures de requins semblent en déclin et n'ont représenté que 6,5 % de la valeur commerciale pour 29 % des poids totaux.

Du Point de Vue de la Rentabilité

Les rendements pondéraux et financiers obtenus sur les secteurs exploités sont particulièrement favorables et ont pour conséquence une rentabilité instantanée de cette pêche indiscutable.

Du Point de Vue du Développement Durable

En raison d'une aire de répartition réduite, ce stock est forcément limité pour l'ensemble de l'archipel guadeloupéen. A l'instar de l'ensemble des ressources profondes, les capacités de renouvellement de ces ressources doivent être considérées comme réduites, bien que les informations précises sur la reproduction et la croissance des espèces soient à compléter. Pour l'heure aucune étude n'a mis en évidence les conséquences de cette pêche sur ces ressources. Le développement incontrôlé de la pratique des filets semble cependant avoir aboutit rapidement à un nette diminution des captures à la Désirade.

Ces considérations impliquaient de se donner les moyens de réguler l'effort de pêche et de suivre les évolutions de l'activité commerciale pesant sur ces ressources. Ces recommandations ont été suivies d'effets puisque la nouvelle réglementation des pêches, en vigueur en Guadeloupe depuis le mois d'août 2002, introduit un article spécifique à la pêche aux filets maillants profonds. Cet article précise que l'emploi des filets maillants à des profondeurs de plus de 200 m est interdit. L'emploi de filets peut cependant faire l'objet d'une autorisation annuelle des autorités maritimes, sous réserve de la déclaration des captures, de l'emploi de filets de mailles carrées de 60 mm de côté au minimum, d'une hauteur maximum de 4 m et de longueurs de filets de à 400 m par marin embarqué, dans la limite de 1 200 m au total.

L'instauration d'un système déclaratif est une première concernant les pêcheries de Guadeloupe et augure de la possibilité nouvelle d'un suivi d'une pêcherie à partir de l'analyse des fiches de pêches.

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Genetica Poblacional del Caracol Rosado *Strombus gigas* en la Peninsula de Yucatan : Implicaciones para su Manejo y Pesqueria

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RESUMEN

La estructura genética poblacional del caracol rosado *Strombus gigas* en la Península de Yucatán, México, se determinó mediante la expresión de isoenzimas en geles de poliacrilamida.

Muestras de músculo de cincuenta organismos, capturados en cuatro sitios de la Península de Yucatán, se utilizaron para detectar la expresión genotípica revelada por la expresión de cincuenta y cinco loci, como resultados de treinta sistemas enzimáticos.

Se utilizó el programa TFPGA (Tools for population genetics analices), para efectuar el análisis de datos de frecuencias génicas de aloenzimas de las poblaciones en su versión 1.3. Los parámetros determinados fueron: Estadística descriptiva, Estadística F, Distancias genéticas, Equilibrio de Hardy – Weinberg, UPGMA y el número de migrantes como indicador del flujo de genes.

Los valores de heterocigósis, en un rango de 0.3240 para la OCTDH 2 y un valor de 0.0440 para FUM, con un valor de heterocigósis promedio de 0.0366, los de **Fis** con un rango de 0.0835 para la OCTDH 2 hasta 0.3600 para la FUM y un valor promedio de –0.0492, los de **Fst** de 0.1039 con un rango de 0.0082 para LAP 2 hasta 0.1967 para MDH 2 nos indican una deficiencia de heterocigósis, pero que corresponden a los reportados para especies de invertebrados marinos. El número de migrantes derivado de la ecuación de Slatkin resulto de 2.156 por generación, que en forma global nos indican un cierto grado de variabilidad entre las poblaciones y que corroboran los bajos valores de distancia genética de Nei, que con 0.0053 en el nodo que relaciona a la población de Alacranes nos señalo la separación de esta con las otras poblaciones.

En función de los resultados señalados se puede considerar que las poblaciones de *Strombus gigas* en el Caribe Mexicano presentan un cierto grado variabilidad.

PALABRAS CLAVES: Caracol rosado, *Strombus gigas,* estructura genética poblacional, Yucatán, México

Population Genetics of the queen conch *Strombus gigas* on the Yucatan Peninsula: Implications for its Management and Fisheries

Genetic population structure of the pink snail, *Strombus gigas*, in the Yucatan Peninsula, Mexico, was determined by means of the isozymes expression in poliacrylamide gels.

Samples of muscle of fifty organisms, captured in four places of the Yucatan Peninsula, were used to detect the genotypic expression revealed by the expression of fifty five loci, as results of thirty enzymatic systems.

The TFPGA program was used (Tools for population genetics analyzes), to make the analysis of genics frequencies data of the populations in its version 1.3. The parameters used were: Descriptive statistical, statistic F, Genetic distances, Equilibrium of Hardy - Weinberg, UPGMA and the number of migrants as indicator of the gene flow.

The heterozygosity values, in a range of 0.3240 for the OCTDH 2 and a value of0.0440 for FUM, with a value of heterozigosity average of 0.0366, values of **Fis** with a range of 0.0835 for the OCTDH 2 up to 0.3600 for the FUM and a value average of -0.0492, those of **Fst** 0.1039 with a range of 0.0082 for LAP 2 up to 0.1967 for MDH 2 indicate us a heterozigosity deficiency, but they correspond to reported for moluscs marines species. The derived number of migrants of the equation of Slatkin is of 2.156 by generation indicate a certain grade of variability among the populations in global form and they corroborate the first values of genetics distance of Nei that with 0.0053 in the node that relates the population of Alacranes point out the separation of this population with the others populations.

The results of this study suggest that the populations of *Strombus gigas* in the Mexican Caribbean present a certain grade of variability.

KEY WORDS: Queen conch, *Strombus gigas*, population genetics, isozymes, Yucatán, México

INTRODUCCIÓN

La caracterización de la estructura genética poblacional es vital para especies de importancia comercial y ecológica ya que esta nos indica la heterogeneidad o homogeneidad de poblaciones sobre grandes regiones geográficas (Bates y Innes 1995).

El caracol rosado (*Strombus gigas* Linnaeus, 1758) es un gran molusco gasterópodo marino de significativa importancia económica para el área marina del Caribe. El rango nativo de la distribución de la especie se extiende desde el sur de la Florida a Venezuela y el este de América central a las Bahamás y las Islas Indias del oeste, una población aislada habita también las aguas costeras de las Bermudas.

Sin embargo, y como resultado de un severo esfuerzo de pesca y la destrucción del

hábitat de este molusco, las pesquerías de *S.gigas* en la mayoría de las regiones del Caribe (Stoner y Ray 1993) se han visto seriamente disminuidas y en algunos casos se ha llegado a la desaparición del recurso, lo que motivó que *S. gigas* fuera considerada una especie comercialmente amenazada a nivel mundial en 1983 (Stoner 1994) y añadida, en 1992, al apéndice II del convenio sobre comercio internacional de especies en peligro de extinción (CITES) (Stoner et al. 1996), propiciándose con esta medida que la pesquería de *S. gigas* en áreas de Venezuela, México, Belice, Cuba, Colombia y los Estados Unidos hayan sido cerradas estacionalmente por periodos multianuales. (Stoner et al. 1996). Este problema se agrava debido a la falta de datos sobre la especie en algunas áreas del Caribe, principalmente aquellos sobre abundancia de juveniles y adultos, la distribución y abundancia de larvas y la estructura genética de los mismos. El recurso caracol, en México se maneja actualmente con una veda que va de abril a noviembre y que aparentemente coincide con la temporada reproductiva. Otra medida reguladora es la talla mínima, que se bajó de 22 cm a 20 cm de longitud sifonal debido a presiones de los pescadores. Es claro que esta nueva talla afecta también al stock reproductivo y al reclutamiento. Finalmente, la cuota de captura de 2.5 toneladas por mes, no es respetada por los pescadores, quienes además completan sus cuotas con caracoles juveniles.

En este sentido y considerando las características de *S. gigas* en la Península de Yucatán, como son: su desconocimiento genético poblacional, su elevada importancia económica y el alto nivel de explotación a la que se encuentra sometida la pesquería, se hizo necesario realizar este trabajo el cual con sus resultados coadyuvará en la determinación en forma conjunta con las dependencias correspondientes y al establecimiento de los mecanismos y estrategias que tiendan a manejar la pesquería del caracol rosado *Strombus gigas* en el país, de un modo científico y razonado para que con ello se pugne por preservar el recurso en beneficio de la economía del país y de la vida misma.

METODOLOGÍA

La colecta de los organismos se realizó en cuatro sitios en las costas de la Península de Yucatán (Figura 1). Con la ayuda de pescadores, cincuenta caracoles de todas las tallas se obtuvieron por medio de buceo a pulmón en Punta Allen, Banco Chinchorro y Arrecife de Alacranes.

Muestras de músculo, se homogeneizaron en un volumen igual de buffer de extracción consistente de Tris Hcl 12.1 g, EDTA 336 mg, $NADP^+$ mg y ajustado a un pH de 7 (Shaklee y Keenan, 1986), se centrifugaron a 10 000 rpm por 10 min. a 7 °C en una centrífuga refrigerada. Geles de poliacrilamida al 7.7 %, preparados para ser utilizados con el sistema nativo (Brewer, 1970), se utilizaron para efectuar el corrido electroforético, el revelado histoquímico y la determinación fenotípica de las muestras.

La presencia fenotípica se determinó siguiendo los procedimientos dados por de Shaw y Prasad (1970), Brewer et al., (1970) y Shaal y Anderson (1974). Loci presumidos y alelos fueron designados por medio del sistema de nomenclatura

utilizado por Shaklee y Keenan (1986). Múltiples loci de una enzima en particular se designaron numéricamente (1,2,3, etc.) considerando el de más rápida a más baja movilidad anodal. Alelos de un locus en particular fueron designados por su movilidad anódica relativa y nombrando al alelo como 100 y los demás por arriba y por debajo de este con los valores respectivos. Loci y alelos fueron designados de acuerdo al sistema de nomenclatura propuesto por Shaklee y Keenan (1986). Múltiples loci de una enzima en particular se designaron numéricamente en relación de la más alta a la más baja movilidad anódica. Un locus se considera polimorfico si el alelo más frecuente tiene una probabilidad menor que 95 %. (Towsend y Shing, 1984) y el nivel de Heterocigósis con relación a la ley de Equilibrio de Hardy-Weinberg.

Se utilizó el programa denominado TFPGA (Tools for population genetics analices), para efectuar el análisis de datos genéticos de aloenzimas de poblaciones (Miller, 2000) en su versión 1.3. Los diversos parámetros determinados son: Estadística descriptiva, Estadística F, Distancias genéticas, Pruebas de robustez para Hardy – Weinberg, UPGMA.

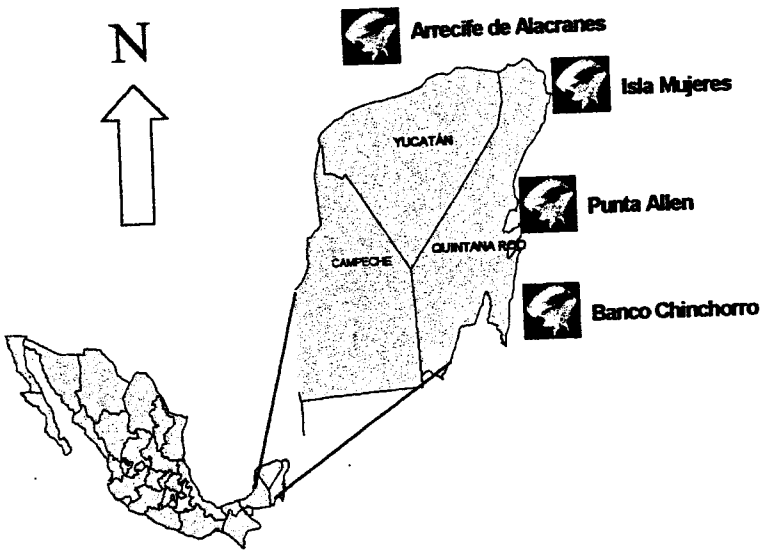


Figura 1. Sitio de colecta del caracol Strombus gigas en la Península de Yucatán

RESULTADOS

Los loci que no fueron monomórficos se utilizaron para determinar el nivel de polimorfismo. En la Tabla 1 se presentan los resultados promedio de los valores de heterocigósis, así como los de polimorfismo en tres formas diferentes y los valores globales. El valor de 0.0366 de heterocigósis global, se puede considerar bajo. Sin

embargo, al efectuar el análisis con los loci que presentaron variabilidad, 8 en el caso del músculo se determinó que el valor de heterocigósis utilizando ese criterio es de 0.2203.

Tabla 1. Resultados de estadística descriptiva para las poblaciones y el total de músculo de *Strombus gigas*

Parámetro	Alacranes	Chinchorro	Isla Mujeres	Punta Allen	Global
Tamaño promedio de muestra	50	50	50	50	187.500
Heterocigósis promedio	0.0375	0.0354	0.0310	0.0155	0.0366
Heterocigósis promedio insesgada	0.0379	0.0358	0.0313	0.0157	0.0367
Heterocigósis promedio directa	0.0353	0.0357	0.0366	0.0181	0.0356
% Loci polimorficos sin criterio	9.3023	14.8936	14.8936	6.9767	16.6667
% Loci polimorficos 99 %	9.3023	14.8936	14.8936	6.9767	16.6667
% Loci polimorficos 95 %	9.3023	14.8936	14.8936	6.9767	12.5000

Se presentan los valores de polimorfismo, 9.3023 % para el Arrecife de Alacranes, 14.8936 % para Banco Chinchorro, 14.8936 % para Isla Mujeres, de 6.9707 % para Punta Allen con un valor global del 12.5000 % en todas las poblaciones, no indicándose una diversidad apreciable y una clara heterogeneidad de las poblaciones.

En la prueba de Chi Cuadrada y de Haldane, sus resultados en forma global se aprecian en la Tabla 2, en la que se tiene que la EST 2, la G6PDH 2, la LAP 2 y la MDH 2 son los loci que presentaron significancia para la primera prueba y para la segunda, efectuada en las mismas poblaciones, nos indicó que los loci EST 2, LAP 2 y MDH 2 resultaron ser significativamente diferentes, estableciéndose que de los 8 loci que presentaron variación en el tejido de músculo en las cuatro poblaciones analizadas casi el 50 de ellos se apartan de la condición de equilibrio.

Cuando se efectuó el análisis de remuestreo utilizando los métodos de Monte Carlo y la Cadena de Markov para cada uno de los sitios de muestreo se confirmó que la EST 2 y la MDH 2 son los loci que presentan variabilidad y estableciéndose que posiblemente sean las mismas causas las causantes de la baja heterogeneidad en las poblaciones.

Tabla 2. Pruebas de Bondad de ajuste para el equilibrio de Hardy – Weinberg, Haldane y Chi Cuadrada, en músculo de *Strombus gigas* para todas las poblaciones.

Locus	Genotipo	Observados	Esperados	Haldane	X^2
	1 1	122	129.6050		
	1 2	78	62.7900		
EST 2	2 2	0	7.6050	0.0002***	0.0006 ***
	1 1	160	162.0000		
	1 2	40	36.0000		
PGM 2	2 2	0	2.0000	0.2285	0.1161
	1 1	191	191.1013		
	1 2	9	8.7975		
FUM	2 2	0	0.1013	1.0000	0.7448
	1 1	69	69.7225		
	1 2	29	27.5550		
G6PDH 1	2 2	2	2.7225	1.0000	0.6000
	1 1	190	189.1513		
	1 2	9	10.6975		
G6PDH 2	2 2	1	0.1513	0.0317***	0.0248 ***
	1 1	107	110.0817		
	1 2	43	36.8367		
LAP 2	2 2	0	3.0817	0.0444***	0.0404 ***
	1 1	142	128.0000		
	1 2	36	64.0000		
MDH 2	2 2	2	8.0000	0.0000***	0.0000 ***
	1 1	99	95.2017		
	1 2	41	48.5967		
OCTDH 2	2 2	10	6.2017	0.0735	0.0556

Los valores de **Fis** y los del índice de fijación **Fst**, Tabla 3, van desde 0.0835 para la OCTDH 2 hasta 0.3600 para la FUM con un valor promedio de –0.0492, para el primer parámetro y los segundos presentan un valor promedio de 0.1039 con un rango de 0.0082 para LAP 2 hasta 0.1967 para MDH 2.

Los valores de Distancia genética se presentan en forma resumida en la Tabla 4, todas las poblaciones son comparadas de manera pareada, los establecidos por el modelo de la distancia insesgada de Nei 1978 fueron los que tuvieron los valores más bajos en todas las poblaciones y los de distancia establecidos con el modelo de Roger's y modificado por Wright fueron los mayores. En el primer caso la relación Banco Chinchorro – Isla Mujeres tuvo el valor menor de 0.0011 y la relación Arrecife de Alacranes – Punta Allen fue el de mayor valor, en el segundo caso la relación Banco Chinchorro – Isla Mujeres fue el de menor valor con 0.0378 y la relación Arrecife de Alacranes – Punta Allen con 0.0834 fue el mayor, e independientemente de cual haya sido el modelo que se utilizara los valores menores y mayores siempre se mantuvieron entre las poblaciones de Banco Chinchorro – Isla

Mujeres y la de Arrecife de Alacranes – Punta Allen y ocurriendo lo mismo en el caso de los valores de identidad independientemente del modelo que se utilice.

Tabla 3. Resultados de estadístico F en músculo de *Strombus gigas*

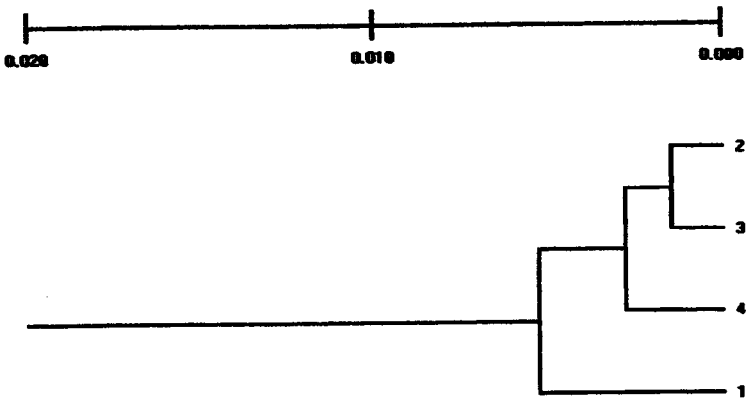
Loci	Alelo	F	è	f
EST 2	1	–0.2036	0.1189	0.3660
	2	–0.2036	0.1189	0.3660
	Alelos totales	–0.2036	0.1189	0.3660
PGM 2	1	–0.0935	0.0555	0.1577
	2	–0.0935	0.0555	0.1577
	Alelos totales	–0.0935	0.0555	0.1577
FUM	1	0.0000	0.0816	0.0889
	2	0.0000	0.0816	0.0889
	Alelos totales	0.0000	0.0816	0.0889
G6PDH 1	1	0.0000	0.0915	0.1007
	2	0.0000	0.0915	0.1007
	Alelos totales	0.0000	0.0915	0.1007
G6PDH 2	1	0.1667	0.0268	0.1437
	2	0.1667	0.0268	0.1437
	Alelos totales	0.1667	0.0268	0.1437
LAP 2	1	–0.1609	0.0082	0.1706
	2	–0.1609	0.0082	0.1706
	Alelos totales	–0.1609	0.0082	0.1706
MDH 2	1	0.4667	0.1967	0.3361
	2	0.4667	0.1967	0.3361
	Alelos totales	0.4667	0.1967	0.3361
OCT 2	1	0.1924	0.1189	0.0835
	2	0.1924	0.1189	0.0835
	Alelos totales	0.1924	0.1189	0.0835
Todos Los Loci		0.0598	0.1039	– 0.0492

En la Figura 2 se puede ver el Dendográma obtenido del análisis Cluster utilizando el modelo de distancia original de Nei 1972 en el cual el máximo valor de distancia de 0.0053 lo presentó el nodo que relaciona a las poblaciones del Arrecife de Alacranes con las demás y el menor valor lo presenta el nodo de Banco Chinchorro – Isla Mujeres con 0.0015.

Tabla 4. Distancias genéticas para músculo de *Strombus gigas*

Fuente	Relación de poblaciones					
	1 – 2	1 - 3	1 – 4	2 – 3	2 – 4	3 - 4
Distancia original de Nei 1972	0.0045	0.0043	0.0070	0.0015	0.0034	0.0022
Distancia mínima de Nei 1972	0.0044	0.0042	0.0070	0.0014	0.0034	0.0022
Distancia mínima insesgada de Nei 1978	0.0041	0.0039	0.0068	0.0011	0.0031	0.0019
Distancia original de Roger 1972	0.0171	0.0179	0.0220	0.01109	0.0188	0.0136
Distancia de Roger modificada por Wright	0.0663	0.0646	0.0834	0.0378	0.0580	0.0466

1. Arrecife Alacranes 2.- Banco Chinchorro 3.- Punta Allen 4.- Isla Mujeres



1.- Arrecife de Alacranes, 2.- Banco Chinchorro, 3.- Isla Mujeres, 4.- Punta Allen

Figura 2. UPGMA Cluster de músculo de *Strombus gigas* usando la distancia original de Nei 1972.

DISCUSIÓN

Las cuatro poblaciones de *Strombus gigas* analizadas en las costas de la Península de Yucatán presentan una baja variabilidad y una poca diferenciación geográfica entre ellas, los valores de heterocigósis son relativamente bajos e indican una cierta deficiencia de heterocigotos, el por ciento de polimorfismo es relativamente bajo, 12.50 % global para el músculo, si se compara con el 58 % en promedio para invertebrados marinos (Saavedra et al. 1993).

Estos bajos niveles de variabilidad pueden tener diversos orígenes o causas desde el poder considerar que sea una causa intrínseca de la especie o bien deberse a la historia de vida de los organismos y al nivel de explotación de las poblaciones en el área, así como a un posible bajo número del tamaño de muestra utilizado o bien a errores de interpretación en la resolución o conteo de las frecuencias génicas expresadas en los geles (Heist et al. 1995).

Los niveles de heterocigósis promedio global, de 0.0366 para el músculo, aunque se puede considerar bajo cae dentro de los típicamente esperados para especies de invertebrados marinos en general ya que la deficiencia de heterocigotos es una característica común encontrada en estudios en invertebrados marinos (Mamuri et al. 1998, Boisselier et al. 1999) aunque las características reproductoras de muchas de esas especies reflejen el clásico modelo panmítico de las poblaciones genéticas (Bierley et al. 1996) y que pudiendo concluir que los bajos niveles de heterocigotos pueden ser debidos al resultado de la mezcla de poblaciones (Efecto Wahalund), varios tipos de selección, la presencia de alelos nulos o la pérdida de cromosomas causando estimaciones incorrectas de las fracciones fenotípicas (Creasey et al. 1996).

En el caso de *S. gigas* los bajos valores de **Fst** entre las poblaciones nos indican que no se puede considerar al efecto Wahalund como la causa de este fenómeno, aunque se mantiene la idea de que existe la entrada de migrantes (**2.156**) en las poblaciones. Como no se consideró la presencia de alelos nulos, es menester pensar que la alternativa factible de que esta ocurriendo en las poblaciones se deba al efecto de algún tipo de selección.

No obstante que se ha sugerido y en algunos casos demostrado el flujo de genes, los resultados obtenidos mediante el análisis por Chi – Cuadrada y la prueba de Haldane nos indican que solo un mínimo de loci son significativamente diferentes. Así mismo las pruebas de randomización efectuadas en los loci que mostraron significancia también soportaron lo antes establecido, lo cual corrobora que algún factor desconocido como puede ser el error de muestreo, la mala interpretación de geles, la selección en un locus, entre otros afectando estos loci podrían ser los responsables para la significancia de la prueba.

Aunque el fenómeno de baja heterocigósis observada puede causar problemas con el uso de datos electroforéticos en la discriminación de poblaciones de las poblaciones de *Strombus gigas*, al utilizar parámetros como lo son la identidad y la distancia genética estos trabajan bien cuando los valores de heterocigósis encontrados en especies bajo investigación son bajos y se tiene un número suficiente

de loci, con los cuales se subsana el problema de contar con un tamaño pequeño de muestra (Bierley et al. 1996).

Los valores de distancia e identidad para *S. gigas* en gónada y los de músculo nos indican que son valores típicos para especies o poblaciones que se encuentran bien mezcladas.

Los valores de identidad marcadamente altos, así como los similares y bajos de distancia genética son comunes para especies con vida planctónica de gran dispersión similares a *S. gigas.*

Los dendográmas generados por las medidas de distancia utilizadas y el análisis UPGMA Cluster fueron similares pero no idénticos al agrupar las poblaciones. Los valores de distancias fueron diferentes en todos los casos, sin embargo, en ninguno se cambio la distribución de las poblaciones en el análisis Cluster. El cambio sustancial se tiene al efectuar el análisis en tejidos diferente, la población que presenta la mayor separación o distancia respecto a las otras es la de Alacranes.

La población del Arrecife de Alacranes es la que presenta el mayor valor de distancia y que en función del análisis de corrientes que privan en el área del Golfo de México, se puede considerar lógico que la distribución y variación de esta población con las otras tres sea lo esperado, al ser la más diferente de las cuatro.

No obstante variaciones estocásticas en la corriente de agua, los vientos de superficie, eventos meteorológicos y aun remolinos localizados podrían afectar la dispersión de las larvas y modificar el reclutamiento de estas en localidades particulares, (Bucklin et al. 1989) corroboraron y concluyeron que tales eventos pueden mantener el estado de discreción de las poblaciones en forma espacial o temporalmente, lo que a final de cuentas evitan la homogenización del plancton durante el transporte y si consideramos el hecho de que en Punta Allen se tiene la presencia de la Bahía de la Ascensión se puede pensar en procesos locales que hayan permitido el asentamiento de larvas y su posterior aislamiento que a final de cuentas nos de la pauta par establecer la diferenciación y valores de distancia de esta población con las otras analizadas en las otras localidades.

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Análisis de la Estructura Genetica de Poblaciones del Caracol Rosado, *Strombus gigas* (L.) en la Peninsula de Yucatan

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RESUMEN

La estructura genética poblacional es el parámetro más fundamental de información para las especies que requieren manejo pesquero. En efecto, las especies que constituyen un solo "stock" en un área muy amplia del océano deberán ser manejadas de manera diferente a aquellas especies constituidas por "stock" discretos que habitan un área particular y que raramente migran de un lugar a otro. De tal manera, el hecho de que existan especies altamente migratorias y con fases inmaduras con amplias capacidades de dispersión ha impulsado investigaciones cada vez mas detallada para explicar el fenómeno, provocando gran discusión el saber si estas especies están estructuradas en subpoblaciones. Estos aspectos pueden aplicarse al caracol marino (*Strombus gigas*, Linnaeus 1758). Este es un recurso de considerable importancia económica y amplio consumo en toda la región del Caribe. En el presente estudio se realizó un análisis genético utilizando el ADN mitocondrial con RFLP's de muestras colectadas en las localidades de Banco Chinchorros, Isla mujeres y Arrecife Alacranes. Con la finalidad de determinar la variabilidad del ADN mitocondrial y analizar la estructura genética poblacional del caracol marino S. gigas, en la Península de Yucatán. Se colectaron un total 123 individuos en el mes de agosto del 2000: Isla Mujeres 41, en Arrecife Alacranes 36 y en Banco Chinchorro 46. Se empleó la técnica de PCR para amplificar un fragmento 581 pb del ARN ribosómico (rARN) de las subunidad 16S del ADN mitocondrial. Se buscó el polimorfismo en base a RFLP's usando una batería de tres enzimas de restricción. Los análisis estadísticos se efectuaron utilizando el programa de genética de poblaciones denominado Arlequín ver 2.000. Los parámetros de los FST de Wright (1965) estimados entre las tres poblaciones muestran una diferenciación ó estructuración, entre la población del Golfo de México Arrecife Alacranes con respectos a las dos poblaciones del Caribe Mexicano: Isla Mujeres y Banco Chinchorro (Tabla 1).

Tabla 1. Valores de FST por pares de poblaciones.

	A. Alacranes	B. Chinchorro
B. Chinchorro	0.61637 **	
I. Mujeres	0.63703 **	-0.00854

La población con diversidad genética significativa fue Arrecife Alacranes (Tabla 2).

Tabla 2. Valores de diversidad genética.

Población	Diversidad genética
A. Alacranes	0.3984 +/- 0.0812 **
I. Mujeres	0.3305 +/- 0.0817
B. Chinchorro	0.3710 +/- 0.0820

Con respecto al flujo genético es infinito entre las localidades del Caribe (Isla Mujeres y Banco Chinchorro, y el flujo genético de las localidades de Caribe (Isla Mujeres y Banco Chinchorro) hacia la localidad del Golfo (Arrecife Alacranes) es reducido(Tabla 3).

Tabla 3. Valores de flujo genético.

	A. Alacranes	B. Chinchorro
B. Chinchorro	0.31120	-
I. Mujeres	0.28489	μ? (infinito)

Bajo los supuestos anteriores los sitios del Caribe Mexicano pertenecen a la misma población, y la localidad de Arrecife Alacranes en el Golfo de México a otra población. Estos resultados son una base científica para que las autoridades pesqueras efectúen un manejo adecuado y por separado para cada población.

PALABRAS CLAVES: ADN mitocondrial, estructura genética Strombus gigas.

INTRODUCCION

El concepto del "stock" es importante para la sociedad porque ayuda a manejar los recursos pesqueros desde un punto de vista razonado y científico, para uso alimenticio y también para preservar la diversidad genética (Booke 1981). Se han sondeado numerosas definiciones del concepto "stock" a lo largo de la literatura de las pesquerías. Aunque todavía existen quienes consideran a los "stock" como meras unidades de explotación (Royce 1984), el interés mundial de poder definir el concepto "stock" con una base biológica está reflejado en las memorias del Symposium sobre el concepto "stock" (Berst y Simon 1981). Inssen et al. (1981) definen "stock" como un grupo intraespecifico de individuos que se reproducen al azar con integridad biológica espacial y temporal. Desde un punto de vista pesquero, esta integridad se refiere a una homogeneidad en las tasas de reclutamiento crecimiento y mortalidad (Cushing 1968). Desde un punto de vista genético, la integridad implica un acervo genético en común que debe mantenerse diferenciado de otros "stock" (Kutkuhn 1981). Aunque en su forma presente el concepto del "stock" describe las características de una unidad homogénea de la población que particularmente es asumida para los propósitos de manejo. Por consiguiente el concepto "stock" en su forma actual define a grupos semi-discretos

de peces con algunos atributos definibles de interés para el manejo (Begg et al. 1999).

La mayoría de las especies consisten de grupos de individuos que están de cierta forma aislados uno del otro. Los mecanismos de aislamientos pueden ser: geográficos, ecológicos o etológicos y el grado de aislamiento varia entre las especies y sus poblaciones que lo componen. Las especies locales típicamente exhiben algún grado de diferenciación genética, y el patrón de distribución de estas diferencias genéticas entre las poblaciones normalmente es denominado estructura genética poblacional. Esta estructura genética poblacional es el parámetro más fundamental de información para las especies que requieren manejo de sus recursos de conservación (Richardson et al. 1986, Slatkin 1987).

La estrategia por conservar la variación genética dentro de las especies depende de la estructura genética de cada especie. La extinción de una población en particular puede tener un efecto pequeño en los recursos genéticos global de una especie que sólo exhibe menor o ninguna divergencia entre las poblaciones constitutivas. En contraste, una extirpación de una especie con estructura genética diferenciadas implica la pérdida de una porción significante del "pool" genético de esa especie (Allendorf et al. 1987).

En efecto, las especies que constituyen un solo "stock" en un área muy amplia de océano deberán ser manejadas de manera diferente a aquellas especies constituidas por "stock" discretos que habitan un área particular y que raramente migran de un lugar a otro. De tal manera, el hecho de que existan especies altamente migratorias y con fases inmaduras con amplias capacidades de dispersión ha impulsado investigaciones cada vez mas detallada para explicar el fenómeno, provocando gran discusión el saber si estas especies están estructuradas en subpoblaciones (Allendorf et al. 1987).

Estos aspectos pueden aplicarse al caracol marino (*Strombus gigas,* Linnaeus 1758). Este organismo es un recurso de considerable importancia económica y amplio consumo en toda la región del Caribe.

En los últimos años se han realizado avances significativos en el conocimiento de la biología y potencial de cultivo de este recurso, al mismo tiempo se han desarrollado varios programas de manejo, como las regulaciones que se han propuesto, las cuales, van desde el cierre total de la pesquería, hasta el uso de talla límite de captura, períodos de veda, cuotas de captura y restricciones en el manejo en los artes de pesca (Appeldoorn y Rodríguez 1994, Rodríguez 1999). Todos estos estudios de manejo son tan importantes como los estudios científicos basados en la determinación del manejo del "stock" mediante análisis de la estructura genética poblacional de este recurso pesquero.

Por todas estas características y con la finalidad de gestionar su pesquería en la región del Gran Caribe. Varios investigadores han realizado estudios de genética de poblaciones de *S. gigas* a lo largo del Caribe. Sus resultados indicaron que el caracol marino constituye una sola población no estructurada, tomando en cuenta muestras colectadas desde Belice hasta Santa Lucia en las Antillas Menores,

aunque sus estudios no incluyeron muestras de la costa de la Península de Yucatán México, (Mitton, 1989).

Por esta razón, el objetivo de este trabajo esta enfocado a determinar la variabilidad del ADN mitocondrial, analizar la estructura genética y el flujo genético por medio de analizar el polimorfismo del ADN mitocondrial mediante los Polimorfismos en Longitudes de los Fragmentos de Restricción (RFLP's), usando enzimas de restricción en poblaciones del caracol marino *Strombus gigas*, en la Península de Yucatán de muestras colectadas en diferentes localidades como Banco Chinchorro, Isla Mujeres y Arrecife Alacranes, con la finalidad de saber si estas poblaciones son homogéneas o si están estructuradas.

MATERIALES Y METODOS

Area de Estudio

Los organismos fueron colectados en tres áreas de la Península de Yucatán. Parque Nacional Arrecife Alacranes al Norte de la Península de Yucatán, Isla Mujeres en el Norte de Quintana Roo y la Reserva Ecológica Banco Chinchorro en el Sur de Quintana Roo.

Arrecife de Alacranes en las costas de Yucatán — (Figura 1), esta situado aproximadamente 72 millas (130 Km.) de la costa del Norte de la Península de Yucatán entre los 22°37' y 22°22' Latitud Norte y los 89°33' y 89°48' Latitud Oeste. Hay seis islas en fila, la isla principal es Isla Pérez, donde se localiza el faro, las otras son: Desterrada, Chica, Pájaros, Muertos y Desaparecida, esta ultima isla es una batería de arena que aparece durante mareas bajas, y su altura sobre el nivel del mar es dada por el sedimento que fluye. En esta área existen agregaciones de *S. gigas* pero sobre las cuales desde 1987 la Secretaría de Pesca decreto la veda permanente como medida de protección del recurso (Rodríguez 1994). Los caracoles se capturaron en las inmediaciones de Isla Pérez.

Isla Mujeres — (Figura 1), es una pequeña isla enclavada en la parte noroeste del Estado de Quintana Roo y se localiza entre los 21°11' y 21°15' Latitud Norte y los 86°41' y 86°45' Latitud Oeste en donde se encuentran agregaciones de caracoles marinos pero ya muy diezmados debido a la gran presión de pesca y a la elevada actividad turística de la zona, esto ha propiciado que los organismos se encuentren a profundidades superiores a los veinte metros. En esta zona, la secretaría de pesca desde 1991 decretó la veda del recurso (Rodríguez 1994).

Banco Chinchorro se encuentra en la zona Sur de Quintana Roo — (Figura 1), esta localizado en los 18° 47' -18° 23' Latitud Norte y 87° 14' -87°27' Longitud Oeste. Este banco es un complejo arrecifal localizado frente a la costa Sureste del Estado de Quintana Roo, entre las poblaciones de Rió Indio y Xcalac. Se encuentra separado casi 30 km. del continente por un gran canal con profundidades que

alcanzan hasta los 1000 m (Jordán y Martín 1987). Tres zonas bien definidas se encuentran en este arrecife Cayo Lobos, Cayo Norte y Cayo Centro, los cuales es el sitio de campamento de los pescadores y en cuyas inmediaciones se capturaron los organismos. Es la única zona del Caribe mexicano en donde existen las mayores agregaciones de *Strombus gigas* y en donde la captura por cuota del caracol marino (Rodríguez 1994).

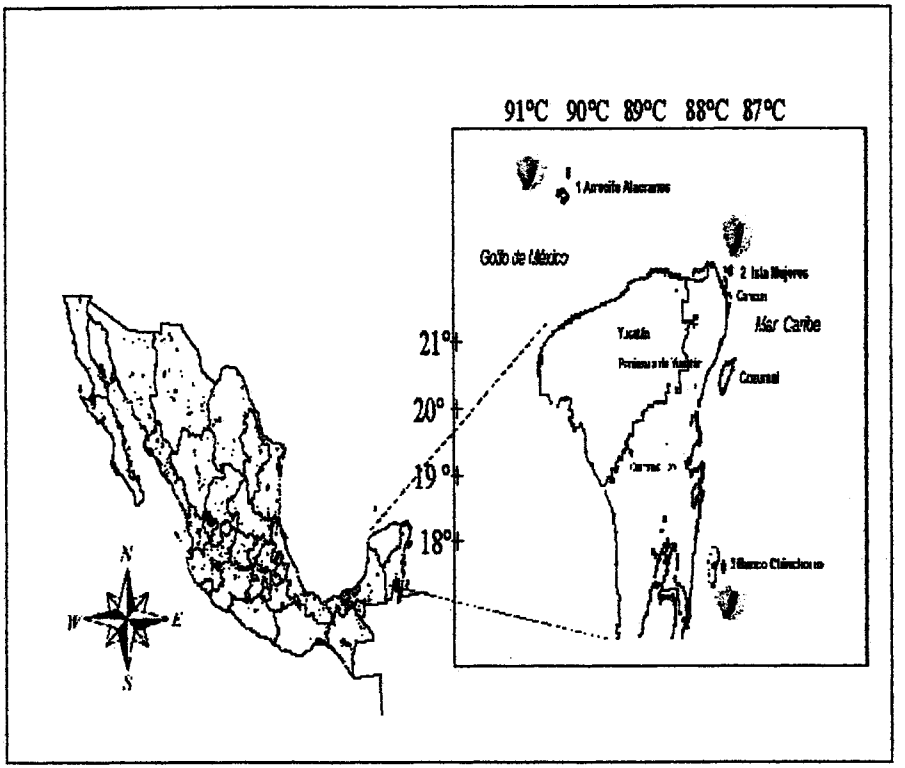

Figura 1. Sitios de colecta de *Strombus gigas* en la Península de Yucatán (1. Arrecife Alacranes, 2 Isla Mujeres y 3 Banco Chinchorro).

Colecta

Las colectas se realizaron por buceo libre. Se colectaron un total 123 organismos de forma aleatoria. En Isla Mujeres 41, en Arrecife Alacranes 36 y en Banco Chinchorro 46. Cada organismo se diseccionó y se le extrajo el corazón. Los corazones de cada organismo fueron almacenados en tubos criogénicos y se transportaron en nitrógeno líquido al laboratorio de Recursos Marinos y Agropecuarios del Instituto Tecnológico de Mérida para su análisis posterior.

Extracción del ADN Total

Para la extracción del ADN total del tejido se utilizo un kit denominado "Dneasy Tissue" marca (Giagen) siguiendo el protocolo que indicó el Kit. La concentración del ADN total se realizó por comparación de bandas en geles de agarosa al 0.8% y teñidos con bromuro de etidio.

Reacción en Cadena de Polimerasa

La utilización de los siguientes "primers" 16H1: 5' CTC CGG TCT GAA CTC AGA TCA CGT AGG 3' y 16L1: 5' CTG ACC GTG CAA AGG TAG CGT AAT CAC T 3' (Hillis et al. 1996) sintetizados por la compañía (GibcoBRL) los cuales sirvieron para amplificar un fragmento de la región 16S RNA ribosomal de genoma mitocondrial de aproximadamente 581 bp. La amplificación se realizó con un termociclador Perkin – Elmer (Gene Amp "PCR" System 2400). La concentración de los componentes para una reacción 1X con un volumen total de 50 ml e muestran en la Tabla 1.

Tabla 1. Componentes para llevar a cabo la amplificación de "PCR".

Componente	Marca	Concentración	Cantidad
Mg Cl_2	Promega	25 mM	3.0 µl
Buffer	Promega	10 X	5.0 µl
Primer I	Gibco BRL	20 mM	2.5 µl
Primer II	Gibco BRL	20 mM	2.5 µl
DNTP mix	Promega	10 mM	1.0 µl
Taq DNA polimerasa	Promega	5 u/µl	0.4 µl
Agua ultrapura estéril libre de nucleasas	Promega		32.6 µl
ADN MOLDE			3.0 µl
		Total	50 µl

La amplificación de este fragmento de ADN se realizó siguiendo los protocolos reportados por Hillis et al. (1996) incluyendo un total de 35 ciclos con las siguientes temperaturas y tiempos (Tabla 2).

Tabla 2. Características en temperatura y tiempo del "PCR".

Etapa	Temperatura y tiempo
Desnaturalización de ADN	94 °C por 2 minutos
	94 °C por 30 segundos
Alineación de las cadenas de ADN	48 °C por 30 segundos
Extensión de las cadenas de ADN	72 °C por 1 minuto
	72 °C por 7 segundos

Condiciones de Electroforesis

La migración de los productos de "PCR", se realizaron en geles de agarosa al 0.8 % en una cámara horizontal con Buffer TAE 1X a 60 miliAmperes durante 90 minutos. Los fragmentos de ADN fueron estimados con un marcador de peso molecular (50 pb DNA Step lader, promega), la tinción se llevó acabo con bromuro de etidio y visualizado bajo luz UV y fotografiado con film polaroid® Figura 2).

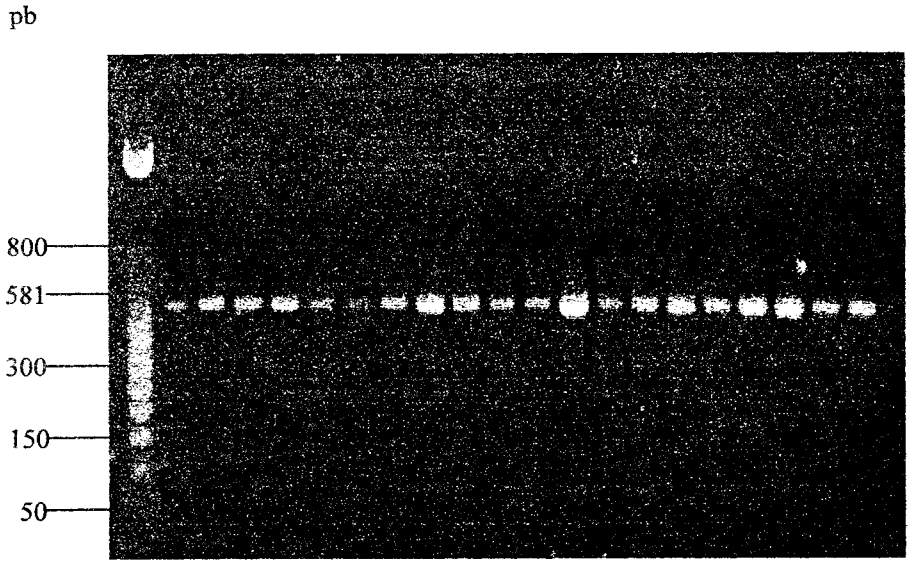

Figura 2. Fotografía que muestra los productos amplificados correspondientes al segmento 16S rRNA del genoma mitocondrial de 20 muestras de caracol marino *Strombus gigas*. pb = pares de bases.

Digestión de los Productos de "PCR"

La búsqueda de polimorfismo en el fragmento amplificado, se realizó con 3 enzimas de restricción siguiendo las especificaciones proporcionadas por el fabricante (Promega). La digestión de todas las muestra fue hecha en un volumen total de 20 μl. Con 2 μl de buffer (proporcionados con las enzimas), 0.2 μl de "Bovine Serum Albumin" (B.S.A), 0.5 μl de enzima (10 u/μl l), 2.0 μl del producto "PCR" y 15.3 μl de agua estéril libre de nucleasas. La incubación se realizó en un baño maría programable a 37 °C durante toda la noche, con excepción para la enzima Taq I que se realizó a 65 °C.

Posteriormente se realizó la visualización de los perfiles de restricción, esto se llevó acabo en geles de agarosa al 2 % teñidos con bromuro de etidio. En los geles se observaron patrones de bandas correspondientes a los diferentes fragmentos del ADN obtenido de la digestión. Dicho patrones de bandas se denominan haplotipos

(Figuras 3, 4, y 5).

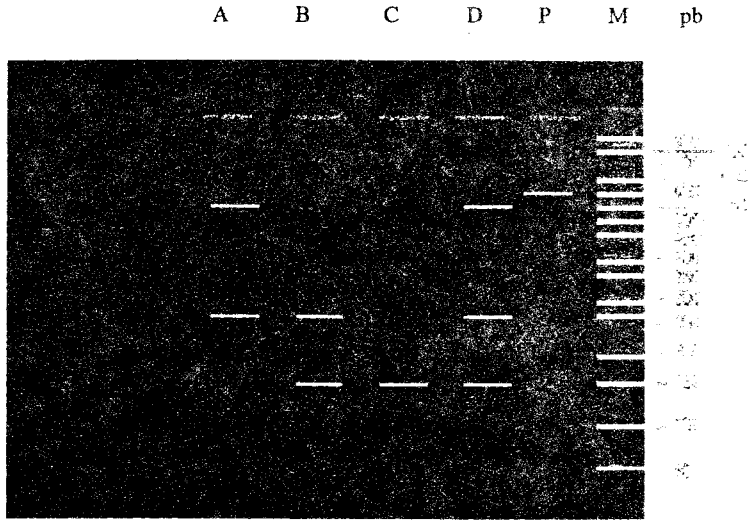

Figura 3. Fotografía que muestra los haplotipos obtenidos con la enzima de restricción Hind III del fragmento 16S rRNA del ADN del caracol marino *Strombus gigas* en las tres localidades de la Península de Yucatán. (Haplotipos = A,B,C, D; P = Amplicón; M = Marcador de Talla, pb = Pares de bases).

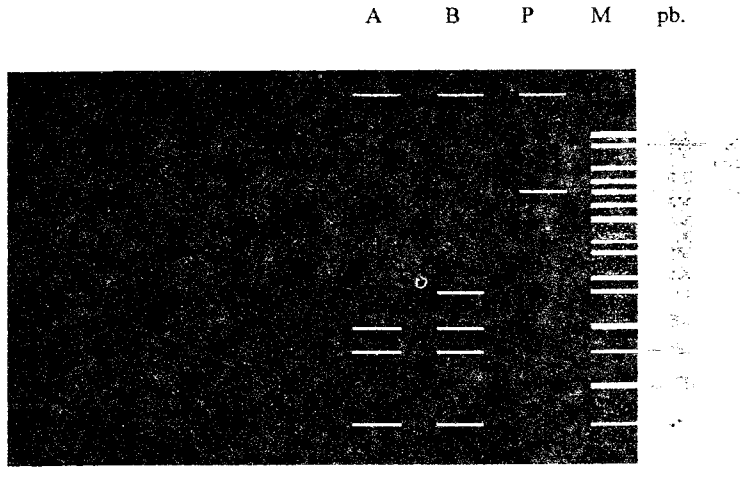

Figura 4. Fotografía que muestra los haplotipos obtenidos con la enzima de restricción Taq I del fragmento 16S rRNA del ADN del caracol marino *Strombus gigas* en las tres localidades de la Península de Yucatán. (Haplotipos = A, B; P = Amplicón; M = Marcador de Talla, pb = pares de bases).

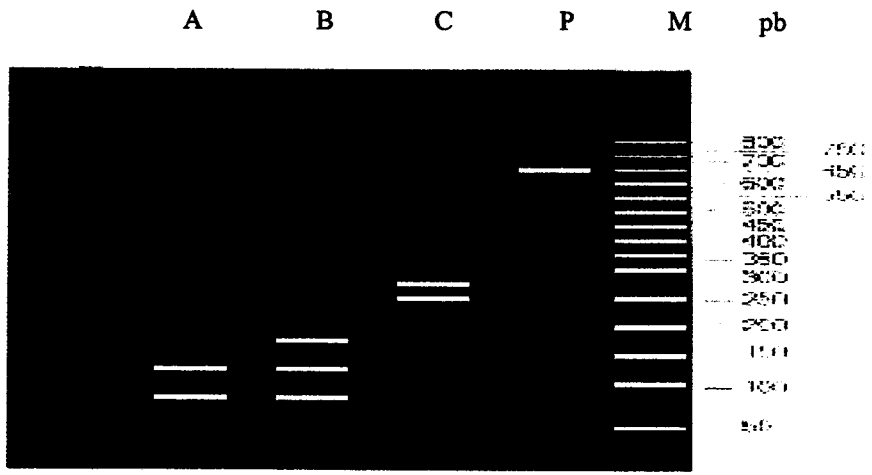

Figura 5. Fotografía que muestra los haplotipos obtenidos con la enzima de restricción Alu I del fragmento 16S rRNA del ADN del caracol marino *Strombus gigas* en las tres localidades de la Península de Yucatán. (Haplotipos = A, B, C; P = Amplicón; M = Marcador de talla, pb = pares de bases).

Si el patrón de bandas obtenido era igual para todos los individuos esta enzima se consideró monomórfica es decir la enzima no encontró sitio de corte en el fragmento y por lo tanto, no informativa para el objetivo de diferenciar poblaciones. Aquellas enzimas que arrojaron patrones de bandas diferentes entre los individuos se consideran polimórficas, y por lo tanto, útiles para los fines de genética de poblaciones.

La nomenclatura utilizada para este estudio es la reportada por (Acuña 2000).
A para el haplotipo más frecuente
B para el haplotipo menos frecuentes
C y D para los haplotipos que siguieron en frecuencia.

Posteriormente, se tomaron las fotografías de todas las digestiones realizadas así como monomórficas y polimórficas sobre un transluminador de luz UV (Marca Ultra Lum). Posteriormente, con las enzimas polimórficas se elaboró una matriz de datos enlistando el número de identificación del organismo y su haplotipo compuesto, es decir, la suma de los haplotipos que arrojaron cada una de las enzimas polimórficas.

Tratamientos Estadísticos

Para los análisis estadísticos de los datos del ADN mitocondrial, se utilizó el programa computacional Arlequín (Schneider et al. 2000), el cual permite calcular a partir de frecuencias haplotípicas parámetros como la diversidad genética,

estructuración genética de poblaciones utilizando los índices de fijación (F estadísticos) de Wright (1951,1965) y sus estimadores de Weir y Cockerman (1984). También se calcularon distancias genéticas de Reynolds et al. (1983). Finalmente, con la información obtenida se comparó con las características de las corrientes oceánicas del Golfo de México y el Caribe con la finalidad de dar una explicación a los resultados y apoyar o rechazar la hipótesis aquí planteada para este estudio.

RESULTADOS

De las 14 enzimas de restricción utilizadas Hind III, Taq I y Alu I, resultaron ser polimórficas. Se obtuvieron un total de 7 haplotipos compuestos. La codificación original fué traducida a números presencia (1) y ausencia (0) de acuerdo a los perfiles de restricción que presento cada haplotipo. Por ejemplo, los haplotipos A, B, C y D producidos por digestión de Hind III (Figura 3) tuvieron un total de 3 bandas. Los haplotipos A y B de la digestión por Taq I produjeron 4 bandas (Figura 4). La digestión con Alu I produjo los haplotipos A, B, y C, con 5 bandas o fragmentos (Figura 5). De esta forma se obtuvieron los haplotipos compuestos (Anexo, Tabla 3), y finalmente la composición genotípica de cada uno de los 7 haplotipos como se muestra en la Tabla 5.

Tabla 5. Composición genotípica y patrón de restricción obtenidos a partir de haplotipos compuestos del fragmento 16S rRNA mitocondrial del caracol marino *Strombus gigas*.

Haplotipo	Composición Genotípica	Patrón de Restricción.
Mt 1	BAA	011011100011
Mt 2	BAB	011011100111
Mt 3	DAA	111011100011
Mt 4	AAA	110011100011
Mt 5	AAB	110011100111
Mt 6	ABA	110111100011
Mt 7	BAA	011011111000

Se realizó un análisis estadístico preliminar (FST por pares de poblaciones) con el paquete computacional Arlequín (Scheneider et al. 2000) para comparar entre sí las poblaciones muestreadas en la Península de Yucatán. La población del Golfo de México (Arrecife Alacranes) presentó valores de FST altamente significativos ($p < 0.05$) cuando se comparó con las poblaciones del Caribe (Isla Mujeres y Banco Chinchorro). De esta forma el análisis indicó que existe una separación entre las poblaciones del Golfo de México y el Caribe Mexicano (Tabla 6). Las poblaciones de Banco Chinchorro e Isla Mujeres no presentaron diferencias significativas ($p > 0.05$), esto infiere que no existe una separación entre estas dos poblaciones.

Tabla 6. Valores de FST obtenido por la prueba de diferencia por pares de poblaciones Calculados a partir de las frecuencias de haplotipos del fragmento 16S rRNA del ADNmt del caracol marino *Strombus gigas* en la Península de Yucatán.

	Arrecife Alacranes	Banco Chinchorro
Banco Chinchorro	0.61637 **	
Isla Mujeres	0.63703 **	-0.00854

**: significativo, nivel de significancia = 0.05.

Variabilidad Genética Intrapoblacional

A continuación se detallan los resultados obtenidos del análisis de variabilidad genética sobre los haplotipos del fragmento 16S rRNA del ADNmt del caracol rosado *S. gigas* en las tres poblaciones de la Península de Yucatán. Se calcularon los siguientes parámetros: el número de haplotipos por población (Nh), las frecuencias haplotípicas y la diversidad genética.

En las tres poblaciones se observaron tres haplotipos. En Arrecife Alacranes se observaron los haplotipos (mt 4, mt 5, y mt 6); en Isla Mujeres los haplotipos (mt 1, mt 2 y mt 7); y en Banco Chinchorro los haplotipos (mt 1, mt 2, mt 3) como se muestra en la Tabla 7.

Tabla 7. Número de haplotipos por población (Nh) para el fragmento 16S rRNA del ADNmt del caracol marino Strombus gigas en tres poblaciones.

Población	N	Nh
Arrecife Alacranes	36	3
Isla Mujeres	41	3
Banco Chinchorro	46	3

Otra forma para la evaluación del polimorfismo genético en RFLP's es estimar la frecuencias con que cada haplotipos se presenta en las poblaciones. En este estudio se calcularon las frecuencias haplotípicas (Tabla 8). Como se observa en esta tabla 8, los únicos haplotipos que fueron compartidos son los haplotipos (mt 1 y mt 2) con Isla Mujeres y Banco Chinchorro. Los haplotipos mt 4, mt 5 y mt 6 fueron exclusivos para el Arrecife Alacranes. Lo que demuestra una clara diferenciación entre la región del Caribe y Golfo de México.

Tabla 8. Frecuencias haplotípicas para RFLP's del fragmento 16S rRNA del ADNmt del caracol marino *Strombus gigas* en las tres poblaciones.

Haplotipos	Arrecife Alacranes	Isla Mujeres	Bancho Chinchorro	Sitios de Restricción
mt 1	0	0.804878	0.782609	011011100011
mt 2	0	0.170732	0.130435	011011100111
mt 3	0	0	0.086957	111011100011
mt 4	0.750000	0	0	110011100011
mt 5	0.222222	0	0	110011100111
mt 6	0.027778	0	0	110111100011
mt 7	0	0.024390	0	011011111000

Al estimar la diversidad genética (Tabla 9). Se observó que las tres poblaciones estuvieron en el mismo rango de índice de diversidad genética, lo cual para este tipo de marcador es definida como la probabilidad que dos haplotipos escogidos al azar sean diferentes en la muestra (Nei 1987).

Tabla 9. Diversidad genética del fragmento 16S rRNA del ADNmt del caracol marino *Strombus gigas* en las tres poblaciones.

Población	Diversidad Genética
Arrecife Alacranes	0.3984 +/- 0.0812
Isla Mujeres	0.3305 +/- 0.0817
Banco Chinchorro	0.3710 +/- 0.0820

Estructuración Genética Poblacional

En el Análisis de Varianza Molecular (AMOVA), se tomaron 2 Regiones. Las poblaciones del Caribe (Isla Mujeres y Banco Chinchorro), se les agrupo en la "Región Caribe" por no presentar diferenciación entre pares de poblaciones y la población del Golfo de México (Arrecife Alacranes), que si presentó diferenciación entre pares de poblaciones con el resto de las poblaciones se le denominó "Región Golfo de México" (Tabla 10).

Tabla 10. Análisis jerárquico anidado de la variación molecular entre las distancias genéticas de los haplotipos del ADNmt del caracol marino Strombus gigas en las poblaciones de la Península de Yucatán.

Componentes variantes	G.L.	Suma de cuadrados	Variancia	Porcentaje de variación
Entre regiones (Caribe vs Golfo de México)	1	48.807	??0.95354	81.56
Entre poblaciones dentro de regiones	1	0.251	<0.00083	<0.07
Dentro de poblaciones	120	25.771	0.21479	18.37
Total	122	74.829	1.16913	100 %

El AMOVA, reveló una mayor variación del ADNmt entre las dos regiones con un 81.56 % y una porción significante de 18.37 % fue atribuido a las diferencias entre las poblaciones, pero la variación entre poblaciones dentro de las regiones fue insignificante con un porcentaje de variación de < 0.07 %.

Distancia Genética y Estimación de Flujo Genético

También con la opción Estructura Genética de Arlequin (Scheneider et al. 2000) se calcularon las distancias genéticas mediante la formula D = -ln (1-FST) de Reynolds et al. (1983). Se observó que ambos valores D de Arrecife Alacranes fueron altamente significativo con respecto a Banco Chinchorro e Isla Mujeres (D = 0.95809, $p < 0.05$; D = 1.01345, $p < 0.05$), Banco Chinchorro con Isla Mujeres presentaron valores no significantes. De esta manera podemos decir que no existe distancia genética entre las dos poblaciones del Caribe (Tabla 11) pero si existe comparándolo con la población de Arrecife Alacranes.

Tabla 11. Distancia genética de (Reynolds 1983) entre las poblaciones en estudio.

	Arrecife Alacranes	Banco Chinchorro
Banco Chinchorro	0.95809	
Isla Mujeres	1.01345	0.00000

Al estimar el flujo genético entre las poblaciones se calculó el número de migrantes absolutos intercambiados entre las poblaciones (Nm) utilizando la forma: M = (1-FST)/(2FST), donde M = Nm para poblaciones haploides (Scheneider, 2000). Al estimar el flujo genético se asume que dos poblaciones de tamaño N intercambian una fracción m de migrantes en cada generación y que el índice de mutación u es despreciable, comparado con el índice de mutación m. Valores bajo de flujo genético (0.311120 y 0.28489) indican que el número de migrantes de *Strombus gigas* entre las poblaciones del Caribe y el Golfo es reducido, y el flujo genético entre las poblaciones de *S. gigas* del Caribe es infinito (Tabla 12).

Tabla 12. Valores de estimación de flujo genético entre las poblaciones en estudio.

	Arrecife Alacranes	Banco Chinchorro
Banco Chinchorro	0.31120	-
Isla Mujeres	0.28489	μ(infinito)

DISCUSIÓN

A continuación se discuten los análisis genéticos obtenidos de los RFLPs del ADNmt del caracol marino *Strombus gigas.*

El nivel de polimorfismo genético intrapoblacional fué igual para las tres poblaciones estudiada ya que todas ellas presentaron tres haplotipos. Isla Mujeres y Banco Chinchorro compartieron los haplotipos (mt 1 y mt 2). La frecuencia de estos haplotipos fue gradual aumentando en dirección Sur-Norte a la largo de Caribe Mexicano según el comportamiento de la Corriente de Caribe.

La diversidad genética es ampliamente conocida como el mecanismo de seguridad que le permite a una especie lidiar con enfermedades, estrés y condiciones ambientales cambiantes. Esta diversidad genética estimada, mostró que la población más diversa es Arrecife Alacranes, seguida por Banco Chinchorro e Isla Mujeres. Los valores de diversidad genética encontrado en *S. gigas* en RFLPs del ADN micondrial es diferente a los reportados para otras especies de moluscos como la ostra americana, *Crassostrea virginica*; He = 0.850 (Reeb y Avise 1990).

La estructura genética encontrada entre las poblaciones sujetas a estudio de *S. gigas* fue una de los aspectos más interesantes del presente trabajo. Como se puede ver en los resultados (Tabla 6, Tabla 10), los parámetros de los FST estimados entre las tres poblaciones mostraron una diferenciación (estructuración) entre la población del Golfo de México (Arrecife Alacranes) con respectos a las dos poblaciones del Caribe mexicano (Isla Mujeres y Banco Chinchorro).

El flujo genético es infinito entre las localidades del Caribe (Isla Mujeres y Banco Chinchorro y el flujo genético entre las localidades de Caribe (Isla Mujeres y Banco Chinchorro) comparado con la localidad del Golfo (Arrecife Alacranes)

es reducido. La existencia de flujo genético tiende a reducir las diferencias genéticas entre poblaciones locales es decir tienden a la homogeneidad (Slakin 1991). Bajo este supuesto, las localidades de Caribe pertenecen a la misma población y la localidad de Arrecife Alacranes a otra población distinta.

Con respecto a las distancias genéticas, los valores más significativos de D se encontraron para Arrecife Alacranes y Banco Chinchorro ($D = 0.95809$, $p < 0.05$); Arrecife Alacranes e Isla Mujeres ($D = 1.01345$, $p < 0.05$) (Tabla 11). Para otras especies donde se utilizó el ADN mitocondrial, como el Huachinango *(Lutjanus campechanus)* donde sus poblaciones se distribuyen a lo largo del Golfo de México, también se encontraron valores de D similares ($D = 0.9140$) (Gold et al. 1997). Esto es debido a la posibilidad de que el Huachinango no presenta una sola población en el Golfo de México al igual que el caracol marino, *Strombus gigas.*

Los resultados encontrados en este estudio, son diferentes a los encontrados por Mitton (1989), quien analizó un amplio rango de sitios en el Atlántico incluyendo la región del Caribe, usando como marcador genético a las isoenzimas, encontrando que las poblaciones del Caribe son unidades homogéneas y solo la población de Bermudas se diferencia de las poblaciones del Caribe.

La estructuración genética encontrada en este estudio con las poblaciones consideradas de las localidades de la Península de Yucatán con esta especie ha sido a una menor escala geográfica, esto es considerando la porción del Golfo de México correspondiente al Estado de Yucatán y el Caribe Mexicano correspondiente al Estado de Quintana Roo. Por esta razón, tratamos de explicar los resultados obtenidos. De esta forma se contó en este estudio con poblaciones que representan únicamente a la Península de Yucatán, México.

La mayoría de las poblaciones de organismos marinos invertebrados y peces viven en un ambiente abierto y sin barreras físicas, donde existe un flujo continuo de larvas y material genético. En muchos casos es importante conocer los patrones de circulación de las corrientes oceánicas y costeras que permiten este transporte larval constante dentro y hacia afuera de la región. Es así, que la dispersión larval a través de corrientes ha sido unos de los parámetros más importantes para establecer la diferenciación genética en las poblaciones marinas.

Tomando en cuenta lo mencionado previamente hay que considerar que la corriente del Caribe se introduce al Golfo de México a través del Canal de Yucatán, esta se dispersa en dos direcciones principalmente. Una corriente principal atraviesa todo el Golfo hasta llegar a las costas de Lousiana y Mississippi en los Estados Unidos y la otra hacia el estrecho de la Florida que se denomina la corriente del Golfo de México y llega hasta el Norte de Europa.

Parte de la corriente del Caribe llega a la localidad de Banco Chinchorro y predomina esta misma corriente del Caribe, en la localidad de Isla Mujeres. En Arrecife Alacranes la corriente del lazo del Golfo de México y la corriente de Yucatán llegan con menor intensidad. Esta separación de corrientes entre el Caribe y Golfo de México podría estar provocando la separación del caracol marino *Strombus gigas* en dos poblaciones. Los caracoles muestreado en Banco Chinchorro e Isla Mujeres corresponden a la misma población, esto puede ser

debido a que la corriente del Caribe al ser ascendente hacia el norte y al unirse a la corriente de Yucatán en el primer punto que es Isla Mujeres lo cual estarían propiciando la dispersión de larvas de *S. gigas* dando como resultados la homogenización de estas dos localidades en un sola población.

Con respecto a los caracoles colectados en Arrecife Alacranes corresponden a una misma población debido a los altos valores de distancia genética, esto puede atribuirse a que es la localidad más distante y al comportamiento de las corriente en la zona; en esta localidad por su situación geográfica y geología marina la corriente de Yucatán llega con escasa intensidad, por consiguiente el aporte de larvas es menor.

En esta región, claramente se observó que el flujo genético no estuvo definida exclusivamente por las corrientes superficiales principales que operan en la región, y podría esperarse que procesos locales hayan permitido el asentamiento de larvas y su posterior aislamiento que a final de cuentas nos dé la pauta para establecer la diferenciación y valores de distancia de esta población con las otras analizadas en las otras localidades. Esto ha ocasionado que las costa de los Estados de Campeche y Yucatán no exista la pesquería de ninguna población de *S. gigas* y solamente para Yucatán se encuentre en la Localidad de Arrecife Alacranes.

CONCLUSIONES

El aporte científico que se obtuvo de la presente investigación es:

i) La variabilidad genética intrapoblacional y la diferenciación genética entre poblaciones del caracol marino Strombus gigas en la Península de Yucatán estimados a partir de haplotipos de RFLP's de ADN mitocondrial, permitieron diferenciar dos poblaciones, la población de Arrecife Alacranes en el Golfo de México y las localidades de Isla Mujeres y Banco Chinchorro como una sola población en el Caribe mexicano.

ii) Desde una base científica de genética de poblaciones permite a las autoridades pesqueras considerar en sus planes de manejo de este recurso como dos poblaciones separadas para la Península de Yucatán.

iii) Con relación a la diversidad genética, la población que mostró más diversidad genética fue la de Arrecife Alacranes. Esto permite recomendar a esta población para la práctica de la maricultura en todas sus etapas.

El flujo genético y la distancia genética también permitieron establecer la diferencia entre la poblaciones de Arrecife Alacranes y las del Caribe mexicano (Isla mujeres y Banco Chinchorro).

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Variación Isoenzimática en Poblaciones del Molusco Marino *Strombus gigas* (L.) en las Costas de Quintana Roo

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RESUMEN

El desconocimiento de la estructura poblacional puede jugar un importante papel en el colapso de las pesquerías, pues las diferencias en las historias de la vida de las subpoblaciones frecuentemente propician la sobrestimación del tamaño de las unidades pesqueras o "*stocks*" y la consecuente sobrepesca. La inexperiencia de la medida en que los factores genéticos contribuyen a la formación de "*stocks*" es relevante para la planificación de la explotación del recurso, ya que su reconocimiento como unidades de pesca independientes puede lograr evitar la pérdida de características poblacionales importantes y la conservación de su patrimonio genético. El presente trabajo se analiza la variación isoenzimática del caracol reina *Strombus gigas* (L) en las costas de Quintana Roo con el propósito de establecer las posibles diferencias genéticas entre poblaciones. Cincuenta organismos fueron capturados en cada uno de los tres sitios de colecta (Isla Mujeres, zona Norte; Punta Allen, zona Centro y Banco Chinchorro, zona Sur) mediante buceo autónomo, sin considerar tamaño, sexo o peso. Se seccionaron segmentos de tejido muscular y gónada, para ser utilizados como elementos de estudio El soporte de electroforesis consistió en un gel homogéneo de poliacrilamida al 7.5 %. La electroforesis se realizó en medio nativo, en una cámara horizontal colocada en frío a una temperatura de 4°C. El gel se corrió a 150 V y 68 mAmp durante 5 horas. De los tres sistemas isoenzimáticos utilizados, AAT, IDH y OPDH en las tres localidades, solo la OPDH-2 resultó ser polimórfica. La variabilidad genética intrapoblacional y la diferenciación genética interpoblacional del caracol reina *S. gigas* en las costas de Quintana Roo, estimados a partir de los tres sistemas isoenzimáticos, permitieron establecer una sola población en el Caribe Mexicano. Es necesario destacar que la población localizada en Punta Allen mostró más diversidad genética que las otras dos poblaciones; en cuanto al flujo y a la distancia genética también permitieron establecer la diferencia entre esta población (Punta Allen) con las de Isla Mujeres y Banco Chinchorro, sin embargo, cabe mencionar que los resultados obtenidos de esta población no son lo suficientemente significativos como para pensar que esta sea una población aislada o alopátrica.

PALABRAS CLAVES: Electroforesis, Isoenzimas, *Strombus gigas*.

INTRODUCCION

Desde los inicios de la Ciencia Pesquera en la segunda mitad del siglo pasado hasta nuestros días, el concepto de *"stock"* ha sufrido cambios sustanciales, de una manera más simple, los recursos pesqueros o *stocks* podían definirse en una base geográfica, dependiendo del radio de acción de la flota o la distribución geográfica del recurso, o bien de acuerdo a la vulnerabilidad para cierto tipo de arte de pesca (Gauldie 1991). Sin embargo, estas formas de definir a los stocks representaban formas muy generales y dejaban fuera todos los aspectos que implican una identidad con un sentido más biológico. Aunque todavía existen quienes consideran a los *stocks* como simples unidades de explotación (Royce 1984).

Ihssen et al. (1981) definen "stock" como un grupo intraespecífico de individuos que se reproducen al azar con integridad espacial y temporal, desde un punto de vista pesquero, esta integridad se refiere a una homogeneidad en las tasas de reclutamiento, crecimiento y mortalidad (Cushing 1968). Desde el punto de vista genético, la integridad implica un acervo genético en común que debe mantenerse diferenciado de otros "stocks" (Kutkuhn 1981). Es importante mencionar que términos como deme, raza y subpoblaciones se han utilizado para describir unidades poblacionales equivalentes a stock (Horrall 1981).

En la conceptualización moderna de "stock", la genética es importante ya que la identificación por otros métodos, como el análisis de parámetros poblacionales, marcado-recaptura, fisiología y comportamiento, morfometría, merística, estructuras calcificadas y citogenética tienen dificultades implícitas que les restan confiabilidad (Ihssen et al. 1981). Una de estas dificultades es que, en la variación fenotípica, el medio ambiente ejerce una influencia que en la gran mayoría de los casos es imposible de cuantificar (Ihssen et al. 1981, Allendorf et al. 1987).

Los estudios de genética de poblaciones han encontrado eco en el estudio de las pesquerías, ya que en algunos casos la separación entre poblaciones o "stocks" de una especie no es muy evidente. A partir de los años cincuenta los métodos bioquímicos empiezan a incursionar dentro de la problemática de diferenciación de poblaciones, primero como estudios complementarios hasta ocupar hoy en día un lugar preponderante como herramienta de trabajo (Utter 1991) y se ha demostrado la gama de problemas específicos que se pueden resolver (Wirgin y Waldman 1994). Sin embargo, todavía en la década de los ochentas se reconocía una deficiencia en la interacción genética-recursos pesqueros (MacLean y Evans 1981, Allendorf et al., 1987). Aunque se insistía que una buena administración de los recursos y los exitosos programas de conservación no debían de dejar aun lado los aspectos genéticos (Ryman 1981, Allendorf et al. 1987), parecía ser que esto sólo lo sabían los genetistas poblacionales. Afortunadamente esta mentalidad esta cambiando, a medida que se van desarrollando técnicas bioquímicas con mayor resolución en la identificación de genotipos, aunado con el interés en el manejo adecuado y la conservación de los recursos pesqueros (Grijalva 1995).

El desarrollo de la genética, con sus diferentes aportes técnicos ha permitido el análisis de una serie de productos biológicos en los organismos cuya actividad es fundamental para la vida de los mismos; con esto nos estamos refiriendo a las

isoenzimas, este término se ha utilizado para designar las múltiples formas de una enzima codificadas por genes diferentes (Kirpichnikov 1981, Ayala 1983, Tello, 1986).

Los patrones de tejidos y el desarrollo de la expresión de loci enzimáticos en diferentes tejidos y durante el desarrollo son frecuentemente característicos de una especie, género o taxón superior y de esta manera son fácilmente utilizados para el estudio evolutivo, la regulación de genes y la genética de poblaciones (Ferris y Whitt 1979). Estos patrones son similares en especies relativamente cercanas y poco parecidos en las que se encuentran muy distantes.

En general estas proteínas son productos de la expresión de un gene y de acuerdo a la genética mendeliana pueden tener dos o más alternativas de expresarse. Debido a los aportes técnicos de la genética molecular, teóricamente existe la posibilidad de poder detectar entre un 20 % a un 50 % de la información genética presente en un organismo (Ayala 1983).

La caracterización de la estructura genética poblacional es vital para especies de importancia comercial y ecológica ya que ésta nos indica la heterogeneidad u homogeneidad de poblaciones sobre grandes regiones geográficas. Esta heterogeneidad, como establecen McMillen et al. (1994) han demostrado que es reflejo de la variación genética de los individuos que componen la población, ya que la variación genética es uno de los parámetros fundamentales en el proceso evolutivo.

Los estudios realizados con isoenzimas se han llevado a cabo en numerosas especies, tanto animales como vegetales, terrestres y acuáticos con diferentes propósitos y por investigadores de múltiples disciplinas (Hamrick, 1989; Lu y Willians 1994, Towsend y Shing 1984, Haylor et al. 1984, Trujillo et al. 1995, Willians y Benzie 1996).

Los caracoles marinos no son la excepción a esta situación y dentro del contexto global, la dificultad de establecer la estructura genética poblacional de los organismos y la variación genética de los mismos es otro ejemplo característico del problema. Estos tipos de organismos, presentan además características propias al ser organismos de poco movimiento y tener desarrollo larval en cierta etapa de su ciclo vida lo cual dificulta y amplia la problemática de determinar el nivel de la variación genética.

Un caso de sumo interés por resolver en pesquerías y que concierne a México es el recurso del caracol marino, *Strombus gigas*. Este caracol es una de las seis especies de Strombidos, que habitan la Península de Yucatán, además de ser utilizados como alimento en el consumo humano, también son empleados como materia prima para la fabricación de artesanías, adornos o joyerías (Solís 1994, Rodríguez 1994).

S. gigas, es un recurso pesquero de elevado interés económico y en algunas áreas donde se le encuentra representa sino la única, una de las más importantes pesquerías en el Caribe Mexicano. En México, *S. gigas* se encuentra únicamente en la Península de Yucatán y específicamente en las costas de Yucatán y Quintana Roo (Rodríguez 1994), en esta superficie de aproximadamente 700 km, un reducido

número de zonas de captura han sido tradicionalmente explotadas y las mayores congregaciones de caracol se encuentran en estos lugares y poca o nula presencia en otras áreas, existiendo un gradiente de población de Norte a Sur de la Península de Yucatán (Quijano 1988).

El recurso caracol, particularmente *Strombus gigas*, muestra síntomas evidentes de sobreexplotación en toda su área de distribución, lo cual es el caso de la mayoría de los países del Caribe, situación que ha obligado a algunos de los países del Atlántico Centro-Occidental, a declarar la veda permanente del recurso (Rodríguez 1994, Solís 1994).

Es base a lo anterior y considerando las características de *S. gigas* en la Península de Yucatán, como son: su desconocimiento genético poblacional, su elevada importancia económica y el alto nivel de explotación a la que se encuentra sometida la pesquería, se hace necesario realizar este trabajo cuyo objetivo es determinar la variación la variación isoenzimática del caracol reina *S. gigas* (L) en las costas de Quintana Roo con el propósito de establecer las posibles diferencias genéticas intra e Inter. poblacionales en función de su análisis genético.

MATERIALES Y METODOS

El estudio sobre el análisis genético poblacional y muy en particular de la variación isoenzimática en las poblaciones del molusco marino *S. gigas* requiere de una metodología relativamente estandarizada por otros autores (Berg et al. 1986; Sobel, et al. 1988, Mitton, et al. 1989 y Campton, et al. 1992). Las particularidades de las técnicas se describen más adelante pero a continuación se muestra un diagrama de flujo que resume los principales pasos del estudio (Figura1).

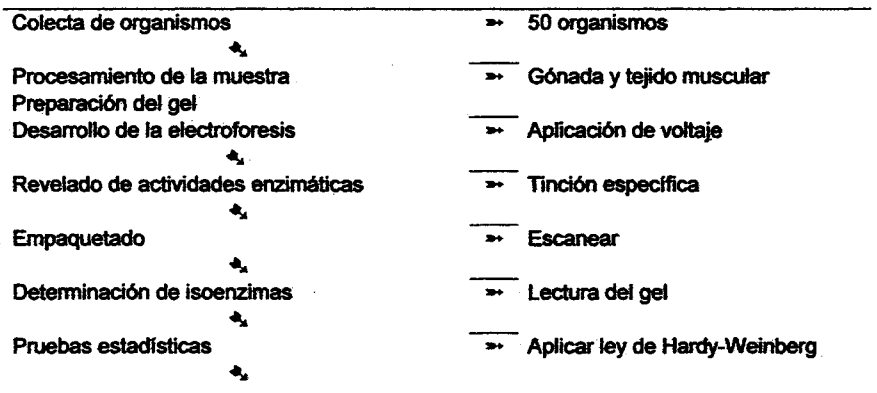

Figura 1. Diagrama de flujo del proceso de electroforésis enzimática en gel de poliacrilamida.

Area de Colecta

En tres sitios de las costas del estado de Quintana Roo, México: Isla Mujeres, Punta Allen y Banco Chinchorro (Figura 2), se efectuó la colecta de 50 organismos por cada sitio de la especie *Strombus gigas*. Los organismos se obtuvieron a profundidades entre 3 y 25 m mediante buceo autónomo con ayuda de pescadores de la región. El substrato predominante fue de arena fangosa y pasto marino constituido por *Siringodium filiforme* y *Thalassia testudinum*. Estos sitios fueron elegidos en función de ser considerados sitios tradicionales de captura de la especie, además de su ubicación geográfica en el estado.

Isla Mujeres— es una pequeña isla enclavada en la parte Noroeste del Estado de Quintana Roo (Figura 2) y se localiza entre los 21°11' y 21°15' latitud Norte y los 86°41' y 86°45' longitud Oeste en donde se encuentra agregaciones de caracoles marinos pero ya muy diezmados debido a la gran presión de pesca y a la elevada actividad turística de la zona, esto ha propiciado que los organismos se encuentren a profundidades superiores a los veinte metros. En esta zona, la Secretaría de Pesca desde 1991 decretó la veda del recurso (Rodríguez 1994).

Punta Allen — (Figura 2) en donde existe una comunidad dedicada por entero a la captura del caracol rosado y langosta espinosa, se encuentra en las costas del Estado de Quintana Roo en las coordenadas 19°47' latitud Norte y 87°28' longitud Oeste. Aquí las agregaciones de caracol se encuentran bien representadas en cuanto a tallas y sexos debido sobre todo a que existe una regulación y vigilancia por parte de los mismos pescadores que como cosa curiosa han lotificado el mar para poder tener en cada área privada sus propias artes de pesca. La veda del recurso en este sitio esta impuesta desde 1991 por la Secretaría de Pesca (Rodríguez 1994).

Banco Chinchorro — se encuentra en la zona Sur del estado de Quintana Roo (Figura 4), esta localizado en los 18°47' y 18°23' latitud Norte y 87°14' y 87°27' longitud Oeste, es un complejo arrecifal frente a la costa sureste del estado de Quintana Roo, entre las poblaciones del Río Indio y Xcalac. Se encuentra separado casi 30 km del continente por un gran canal con profundidades que alcanzan hasta los 1000 m (Jordán y Martín 1987). Tres zonas bien definidas se encuentran en este arrecife: Cayo Lobos, Cayo Norte y Cayo Centro, los cuales son el sitio de campamento de los pescadores y en cuyas inmediaciones se capturaron los organismos. Es la única zona del Caribe Mexicano en donde existen las mayores agregaciones de *Strombus gigas* y en donde hasta ahora se permite la captura por cuota del caracol rosado (Rodríguez 1994).

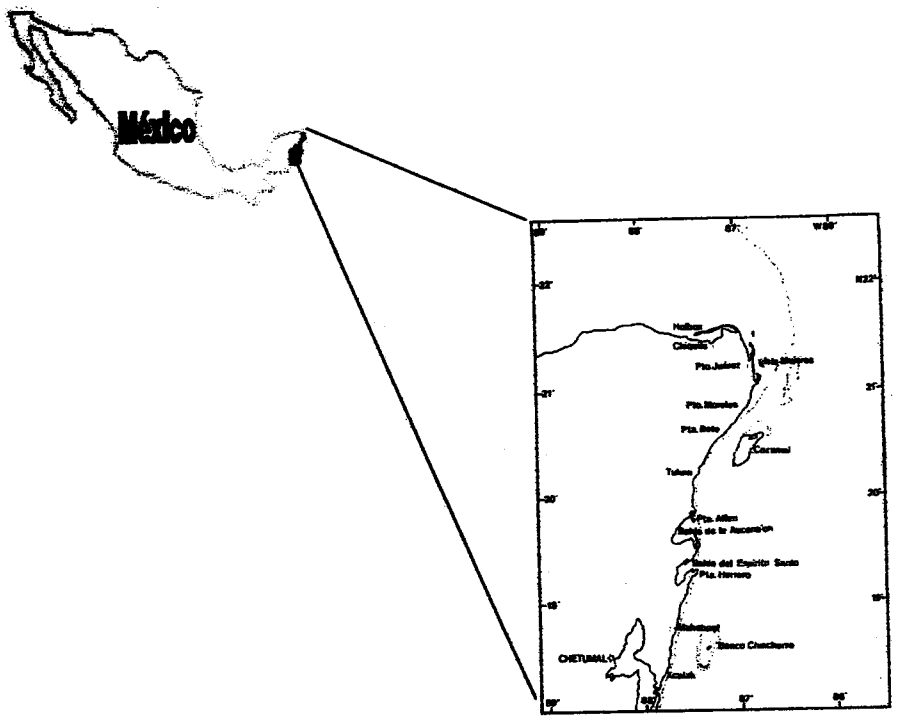

Figura 2. Area de colecta del caracol rosado, *Strombus gigas* (L) en el Caribe Mexicano.

MANEJO DE LAS MUESTRAS

Los organismos fueron sacrificados mediante el "desconcheo", se tomaron medidas de longitud de la concha (cm), peso del organismo desconchado (g) y determinación del sexo. Con la ayuda de un bisturí se seccionaron segmentos de gónada y tejido muscular para ser utilizados como elementos de estudio. Las muestras se colocaron en viales criogénicos de 4.5 ml, se depositaron en un contenedor marca Taylor-Wharton (10 LD) el cual contenía nitrógeno líquido y se trasladaron al laboratorio de recursos marinos del Instituto Tecnológico de Mérida, en donde se almacenaron en un congelador marca REVCO a –40°C.

Secciones de 1 g de gónada y tejido muscular fueron homogenizadas con un buffer de extracción nativo pH 7 o buffer de muestra pH 7, en una relación p/v de 1:2 en un mortero y pistilo de porcelana. El homogenizado se centrifugó a 8000 rpm por 10 minutos a 7°C en una centrífuga refrigerada marca Beckman, usando el rotor F2402H Speed con capacidad para 24 tubos. El sobrenadante fue transferido a tubos Eppendorf de 2 ml y almacenados a -40°C, para su posterior análisis isoenzimático (Tello 1986).

Electroforesis

La electroforesis se realizó en un medio nativo, en donde se utilizaron condiciones no desnaturalizantes. En ésta técnica, la integridad estructural de las proteínas es mantenida y las enzimas pueden ser identificadas al ser hechas reaccionar con un substrato específico y la posterior tinción histoquímicas del producto resultante. El soporte de electroforesis consistió en un gel homogéneo de poliacrilamida al 7.5 %, la solución se vertió entre dos placas (12.5 x 26 cm) de vidrio, separadas por un espacio de 0.2 cm. (Hames y Rickwood 1986).

El corrido electroforético se efectuó en una cámara horizontal modelo: A 3-1 (Owl Scientific, Inc.Woburn, USA) dotada de un generador de corriente con un máximo de 2500 V, 250 mAmp y 100 W.

La cámara de electroforesis horizontal fue llenada con el buffer del electrodo antes de colocar en ella el gel; el puente eléctrico entre el gel y el buffer del electrodo se efectúo mediante una tela altamente absorbente para asegurar la adecuada conectividad. El gel fue equilibrado sin la muestra (precorrido o pre-electroforesis) durante 30 minutos a 120 V y 35 mAmp. Efectuado el precorrido electroforético, se procedió a realizar la electroforesis colocando en cada una de las celdillas volúmenes de muestra de 18 ml, se adicionó a una muestra una gota de azul de bromofenol para visualizar el corrido de la muestra a través del gel; durante 5 horas a 150 V y 68 mAmp.

Los métodos de tinción o revelado para los geles, fueron los propuestos por diversos autores (Brewer 1970, Shaw y Prasad 1970, Brewer, et al. 1974, Shaklee y Keenan 1986). Tres sistemas isoenzimáticos fueron utilizados durante este estudio: aspartato aminotransferasa (ATT), isocitrato deshidrogenasa (IDH) y octopino deshidrogenasa (OPDH). Para una mejor manipulación de los zimogramas y almacenamiento por largos periodos de tiempo el gel fue empaquetado.

Actividades Isoenzimáticas

El número de isoenzimas presentes en el genóma de cada tejido, se determinó en función de la migración de las fracciones reveladas y la fracción de esta en el gel. Posteriormente se procedió a determinar el número de alelos correspondientes.

Las fracciones fueron designadas y númeradas, basándose en su movilidad relativa (Rf), arbitrariamente del cátodo(-) al ánodo(+). Se codificó como 100 el alelo más común y a partir de éste, valores mayores o menores dependiendo de las Rf calculadas (Allendorf y Utter 1979).

Pruebas Estadísticas

Se utilizó el programa denominada TFPGA (Tools for Population Genetic Analyses), el cual es un programa en ambiente Windows que es utilizado, para efectuar el análisis de datos genéticos de alozimas de poblaciones (Miller, 2000) en su versión 1.3.

Este programa fue alimentado con los datos de las expresiones fenotípicas de los organismos muestreados en forma binaria y que se consideraban sean polimórficos de acuerdo al criterio establecido para este fin, los diversos parámetros

determinados se expresan a continuación.

Estadística Descriptiva

Se obtiene información con respecto al número de alelos, frecuencia de heterocigotos, la heterocigosis estimada y las estimaciones del porciento de loci polimórficos a un nivel de jerarquía previamente establecido y un criterio de 95 %. Se proporcionan estimaciones de heterocigosidad directa u observada, la esperada bajo el criterio de Hardy-Weinberg y la estimada por Nei (Weir 1990).

Estadística de FST de Wright

Se aplican los métodos de la estadística FST desarrollada por Wright (Sokal y Rohlf 1995, Weir 1990). La medida de variación entre individuos dentro de las poblaciones, f = FIS o media de fijación y la medida de variación entre poblaciones, Θ = FST o coeficiente de coancestridad.

Se utilizaron las alternativas de remuestreo conocidas como Jacknifing y Bootstrapping, para con ellas remover el posible sesgo obtenido con el muestreo y establecer estimadores más confiables a la hora de efectuar el análisis estadístico. Se estimaron los resultados para cada locus y para cada alelo a un nivel de confianza del 95 %, con unas 1000 repeticiones para el Bootstrapping sobre todos los loci.

Distancias Genéticas

Las medidas de similitud utilizadas por este programa son dadas para las opciones de: La distancia original de Nei, 1972 y la insesgada de Nei (1978) así como las de identidad respectiva.

Las distancias mínimas e identidades de Nei (1972) y la inseagada de Nei (1978). La distancia de Wright (1978) modificada de la de Rogers (1972). La distancia y coancestridad de Reynolds et al., (1983). Todos estos parámetros dados por Weir, 1990.

Pruebas de Robustez para Hardy-Weinberg

En estas pruebas se utilizan dos alternativas para probar el equilibrio de la ley de Hardy-Weinberg, las pruebas de bondad de ajuste de chi-cuadrada (c2), y las pruebas exactas de Haldane (Miller, 2000), considerando la alternativa de agrupar el análisis del genotipo en las categorías de homocigotos y heterocigotos para el alelo más común.

Aunque se presentan los resultados obtenidos por las tres alternativas se ha considerado que para los casos en los que solo existan agrupaciones en sitios de dos alelos, la prueba exacta de Haldane es la que produce la verdadera probabilidad.

Se utilizaron los algoritmos de la cadena de Markov y el método convencional de Monte Carlo con el llamado algoritmo de Metrópolis, con el propósito de establecer una aproximación entre los datos originales y nuevos juegos de datos elaborados al azar.

UPGMA

Se utilizó este método por medio del análisis de Bootstrapping para obtener dendogramas de los resultados de las distancias genéticas y de ellos efectuar inferencias de las relaciones posibles entre los sitios analizados (Sokal y Rohlf, 1995).

RESULTADOS

Los resultados obtenidos durante el desarrollo de la electroforesis de los sistemas enzimáticos utilizados, aspartato aminotransferasa (AAT), isocitrato deshidrogenasa (IDH) y octopino deshidrogenasa (OPDH) en tejidos de músculo y gónada de las localidades: Isla Mujeres, Punta Allen y Banco Chinchorro, se pueden observar en la Tabla I. El signo (√) indica la presencia o el revelado de la isoenzima en los tejidos estudiados de las tres localidades.

Tabla 1. Relación de los sistemas enzimáticos utilizados y detectados en las poblaciones del caracol reina *Strombus gigas* (L) de las costas de Quintana Roo, México.

Sistemas Enzimaticos						
Enzimas	Localidades					
	Isla Mujeres		Punta Allen		Banco Chinchorro	
	Tejidos					
	Músculo	Gónada	Músculo	Gónada	Músculo	Gónada
Aspartato aminotransferasa AAT (EC 2.6.1.1)	√	√	√	√	√	√
Isocitrato deshidrogenasa IDH (EC 1.1.1.42)	√	√	√	√	√	√
Octopino deshidrogenasa OPDH (EC 1.5.1.15)	√	√	√	√	√	√

Los resultados de las frecuencias génicas obtenidas de los sistemas enzimáticos en *S. gigas* se observan en la Tabla 2. Y los patrones electroforéticos de estas isoenzimas en los tejidos de músculo y gónada al parecer resultan de la expresión de seis loci, cinco monomórficos: AAT 1, AAT 2, IDH, OPDH 1 y OPDH 3 y uno polimórfico: OPDH 2, de acuerdo al criterio establecido de que si la frecuencia del alelo más común era menor o igual al 95 %. Los seis loci fueron utilizados para el análisis poblacional, independientemente de que si los loci eran o no polimórficos.

Tabla 2. Relación de las frecuencias génicas de los sistemas enzimáticos revelados en *Strombus gigas* (L)

Frecuencias Genicas de los Sistemas Enzimaticos Revelados en Strombus gigas (l)

		Localidades					
		Isla Mujeres		Punta Allen		Banco Chinchorro	
		Tejidos					
LOCUS	ALELO	M	G	M	G	M	G
AAT 1 MONOMERO	100	1	1	1	1	1	1
AAT 2 MONOMERO	100	1	1	0	0	1	1
IDH MONOMERO	100	1	0	0	0	1	1
OPDH 1 MONOMERO	100	1	1	1	1	1	1
OPDH 2	100	27	1	41	39	14	39
MONOMERO	100/90	14		7	9	17	11
	90	9		2	2	11	0
OPDH 3 MONOMERO	100	0	0	0	1	0	1

M =músculo y G = gónada

Los resultados obtenidos en gónada del análisis estadístico descriptivo poblacional para cada uno de los tres sitios analizados, teniéndose un total de seis loci para cada una de las diferentes localidades: Isla Mujeres, Punta Allen y Banco Chinchorro se observan en las Tablas 3-5.

Los resultados de heteocigosis, heterocigosis insesgada y heterocigosis directa fueron mayores para OPDH 2 con 0.2262, 0.2285 y 0.1800 respectivamente mientras que los valores de cero los presentaron los locus AAT 1, AAT 2, IDH, OPDH 1 y OPDH 3 (Tabla. 4).

Tabla 3. Estadística descriptiva poblacional para gónada de *Strombus gigas* en Isla Mujeres

Locus	Alelo	Observaciones	Frecuencia Alélica
AAT 1	1	100	1.0000
AAT 2	1	100	1.0000
IDH	0	0	0.0000
OPDH 1	1	100	1.0000
OPDH 2	1	100	1.0000
	2	0	0.0000
OPDH 3	0	0	0.0000

Nota: Los valores de Heterocigosis fueron de cero para todos los loci

Tabla 4. Estadística descriptiva poblacional para gónada de *Strombus gigas* en Punta Allen.

Locus	Alelo	Observaciones	Frecuencia Alélica	No. de Heterocigotos	Frecuencia Heterocigotos
AAT 1	1	100	1.0000	0	0.0000
AAT 2	1	100	1.0000	0	0.0000
IDH	1	100	1.0000	0	0.0000
OPDH 1	1	100	1.0000	0	0.0000
OPDH 2	1	87	0.8700	9	01800
	2	13	0.1300	9	0.1800
OPDH 3	1	100	1.0000	0	0.0000

Tabla 5. Estadística descriptiva poblacional para gónada de *Strombus gigas* en Banco Chinchorro.

Locus	Alelo	Observaciones	Frecuencia Alélica	No. de Heterocigotos	Frecuencia Heterocigotos
AAT 1	1	100	1.0000	0	0.0000
AAT 2	1	100	1.0000	0	0.0000
IDH	I	100	1.0000	0	0.0000
OPDH 1	1	100	1.0000	0	0.0000
OPDH 2	1	89	0.8900	11	0.2200
	2	11	0.1100	11	0.2200
OPDH 3	1	100	1.0000	0	0.0000

Los resultados de heterocigosis para Banco Chinchorro revelándose que la OPDH 2 con 0.1958, 0.1978 y 0.2200 presenta los mayores valores y los valores de cero para todos los demás locus.

El análisis global de la estadística descriptiva poblacional de todos los loci que presentaron variación en todas las poblaciones se presenta en la Tabla 6, en donde la OPDH 2 presentó los mayores valores de heterocigosis con 0.1472, heterocigosis insesgada con 0.1477 y de heterocigosis directa con 0.1333, mientras que los menores valores de heterocigosis con cero se presentaron en los demás loci restantes.

Los resultados promedio de los valores de heterocigosis, así como los de polimorfismo en sus tres formas diferentes y los valores globales se presentan en la Tabla 7. El valor de heterocigosis global para las tres poblaciones estudiadas fue de 0.0245.

Los valores de polimorfismo (Tabla 7) con el criterio del 95 %, nos indican valores de 0.0000 para Isla Mujeres, Punta Allen 16.66 %, Banco Chinchorro, 16.66 % y un valor global del 16.66 % en todas las poblaciones.

Tabla 6. Estadística descriptiva poblacional para gónada de *Strombus gigas* en todas las poblaciones sobre los loci.

Locus	Alelo	Observaciones	Frecuencia Alélica	No. de Heterocigotos	Frecuencia Heterocigotos
AAT 1	1	300	1.0000	0	0.0000
AAT 2	1	300	1.0000	0	0.0000
IDH	1	200	1.0000	0	0.0000
OPDH 1	1	300	1.0000	0	0.0000
OPDH 2	1	276	0.9200	20	01333
	2	24	0.0800	20	0.1333
OPDH 3	1	200	1.0000	0	0.0000

Las desviaciones de los valores de Equilibrio de la Ley de Hardy-Weinberg se probaron mediante dos métodos conocidos como Pruebas de Bondad de Ajuste de Chi-Cuadrada (χ^2). Los resultados de la Prueba de Chi-Cuadrada para Isla Mujeres se encontró que todos los locus presentaron significancia en sus resultados, mientras que para Punta Allen los loci AAT 1, AAT 2, IDH, OPDH 1 y OPDH 3, se apartaron del equilibrio. En tanto que en Banco Chinchorro los locus AAT 1, AAT 2, IDH, OPDH 1 y OPDH 3 son los únicos que se apartaron del equilibrio, es decir que presentan significancia al comparar los resultados de los valores de los organismos observados contra los esperados. Los loci que presentaron significancia en la mayoría de las poblaciones o bien se apartan del equilibrio resultaron ser AAT 1, AAT 2, IDH, OPDH 1 y
OPDH 3 .

Tabla 7. Resultados de la estadística descriptiva para todas las poblaciones de *Strombus gigas*.

Parametro	Banco Chinchorro	Isla Mujeres	Punta Allen	Global
Tamaño Promedio de Muestra	50	50	50	133.3333
Heterocigosis Promedio	0.0326	0.0000	0.0377	0.0245
Heterocigosis Promedio Insesgada	0.0330	0.0000	0.0381	0.0246
Heterocigosis Promedio Directa	0.0367	0.0000	0.0300	0.0222
% Loci Polimorfitos sin Criterio	16.6667	0.0000	16.6667	16.6667
% Loci Polimorficos 99%	16.6667	0.0000	16.6667	16.6667
% Loci Polimorficos 95%	16.6667	0.0000	16.6667	16.6667

Una medida promedio de la posible deficiencia de heterocigotos a través de los seis loci, es con la prueba de Fst de Wright o mejor conocida como coeficiente de entrecruzamiento o consanguinidad entre cada población, se presenta en la Tabla 8 como f y nos indica que existe una dispersión o heterogeneidad en sus resultados dentro de las poblaciones al presentar valores que van desde 0.0622 para OPDH 2 hasta los no registrados en AAT 1, AAT 2, IDH, OPDH 1 y OPDH 3, y un valor promedio de 0.0622, considerando que los valores positivos de Fst de Writh indican una deficiencia de heterocigotos.

El índice de fijación, Fst (Φ) o también conocido como medida de variación entre las poblaciones (Tabla 8), nos presenta un valor promedio de 0.0551. Este valor de fijación se puede considerar bajo, pero según Hartl (1980) cae dentro del rango de valores de 0.05 a 0.15 para poder considerar a las poblaciones con un nivel de diferenciación bajo.

Con los resultados anteriores se estableció un nivel de flujo de genes al poder estimar en función de la ecuación de Reynolds et al., (Slatkin 1985) Nm = (1/Fst-1)/4 y el índice de fijación, Fst, el número de migrantes por generación, que en este caso fue de 4.29.

La divergencia genética se analizó utilizando modelos, tanto de distancia como de identidad, y cuyos resultados se expresan en la Tabla 9. Todas las poblaciones son comparadas de manera pareada. De los valores obtenidos de distancia, los establecidos por el modelo original de Nei (1972) resultaron ser los más bajos en todas las poblaciones y los de distancia establecida con el modelo de Rogers modificado por Wright los mayores.

Tabla 8. Resultados de estadístico Fst de Wright para gónada de *Strombus gigas*.

Loci	Alelo	F	F	f
AAT 1	1	*****	*****	*****
	Alelos totales	*****	*****	*****
AAT 2	1	*****	*****	*****
	Alelos totales	*****	*****	*****
IDH	1	*****	*****	*****
	Alelos totales	*****	*****	*****
OPDH 1	1	*****	*****	*****
	Alelos totales	*****	*****	*****
OPDH 2	1	0.1139	0.0551	0.0622
	2	0.1139	0.0551	0.0622
	Alelos totales	0.1139	0.0551	0.0622
OPDH 3	1	*****	*****	*****
	Alelos totales	*****	*****	*****
TODOS LOS LOCI		0.1139	0.0551	0.0622

***** No hubieron valores

Tabla 9. Distancia e identidades de gónada en *Strombus gigas*.

Fuente	Relacion De Poblaciones		
	1-2	1-3	2-3
Distancia Original de Nei 1972	0.0028	0.0001	0.0039
Identidad Original de Nei 1972	0.9972	0.9999	0.9961
Distancia Insesgada de Nei 1978	0.0025	-.0003	0.0036
Identidad Insesgada de Nei 1978	0.9975	1.0003	0.9964
Distancia Original de Roger 1972	0.0275	0.0033	0.0325
Distancia de Roger Modificada por Wright	0.0550	0.0082	0.0650

POBLACIONES: 1. Isla Mujeres, 2. Punta Allen y 3. Banco Chinchorro

Las relaciones jerárquicas entre todas las poblaciones basadas en los diferentes modelos de determinación de distancias genéticas se efectuaron mediante un sencillo análisis de Cluster UPGMA o Dendograma (Ward y Andrews 1995).

En la Figura 3, se observa el Dendograma obtenido del análisis de Cluster, utilizando el modelo de distancia original de Nei 1972 (Tabla 10) en el cual el máximo valor de distancia fue de 0.0034 presentándolo el nodo que relaciona a las poblaciones de Punta Allen-Isla Mujeres-Banco Chinchorro y el menor valor lo presentó el nodo de Isla Mujeres-Banco Chinchorro con 0.0001.

Tabla 10. UPGMA Cluster de gónada en *Strombus gigas* usando la distancia original de Nei (1972).

Nodo	Distancia	Poblaciones
		1 2 3
1	0.0001	1 3
2	0.00034	1 2 3

Nodo	Proporción de réplicas similares
1	0.6690
2	1.0000

Nodo	Número de Loci soportando el nodo	Porciento del Loci soportando el nodo	Porciento del Loci usables soportando el nodo
1	1	16.67%	25.00%
2	4	66.67%	100.00%

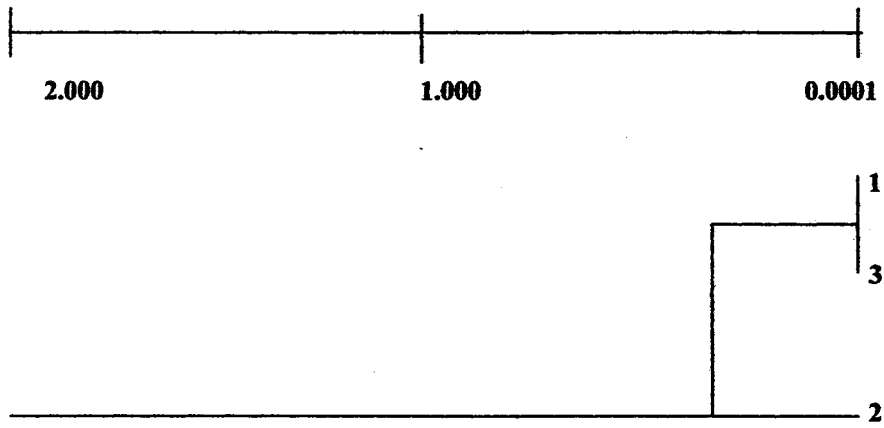

Figura 3. UPGMA Dendograma de afinidad genética entre las poblaciones del caracol reina *Strombus gigas* en las localidades de: Isla Mujeres (1), Punta Allen (2) y Banco Chinchorro (3), basado en las frecuencias alélicas de AAT 1, AAT 2, IDH, OPDH 1, OPDH2 y OPDH 3.

Los resultados provenientes de los extractos de tejido muscular no aportaron datos suficientes que puedan ser utilizados como marcadores genéticos diferenciales de las tres poblaciones estudiadas en las costas de Quintana Roo.

DISCUSIÓN

Strombus gigas es un molusco gasterópodo de significativa importancia económica en el área del mar Caribe y cuya fase de vida planctónica le permite tener un gran rango de dispersión en esta región, lo cual al mismo tiempo implica un gran

problema a la hora de determinar la posición geográfica de sus poblaciones, el origen y patrón de dispersión de las mismas (Campton, et al. 1992).

Los resultados obtenidos en este estudio, son muy similares a los reportados por Berg et al.(1986), quienes analizaron amplios rangos de localidades en el Atlántico incluyendo la región del Caribe, utilizando como marcador genético a las isoenzimas, encontraron que las poblaciones del Caribe son poblaciones homogéneas y solo la población de Bermudas se diferencia de las demás poblaciones del Caribe.

Las tres poblaciones de Strombus gigas analizadas en las costas de Quintana Roo presentan una baja variabilidad y poca diferenciación geográfica entre ellas; el porciento de polimorfismo global en gónada es relativamente bajo 16.66 %, sí se compara con el 58 % en promedio para invertebrados marinos (Saavedra et al. 1993).

Estos bajos niveles de variabilidad pueden tener diversos orígenes o causas desde el poder considerar que sea una causa intrínseca de la especie o bien deberse a historia de vida de los organismos y a niveles de explotación de las poblaciones en el área, así como a un posible bajo número del tamaño de muestra utilizado o bien a errores de interpretación en la resolución o conteo de las frecuencias génicas expresadas en los geles (Heist et al. 1995).

Los valores de heterocigosis promedio para la gónada (0.0245), aunque se puede considerar bajo cae dentro de los típicamente esperados para especies de invertebrados marinos en general ya que la deficiencia de heterocigotos es una característica común encontrada en estudios de invertebrados marinos (Mamuris et al. 1998, Boisselier-Dubayl et al. 1999) aunque las características reproductoras de muchas de esas especies reflejen el clásico modelo panmictíco de las poblaciones genéticas (Bierley et al. 1996) y que pudiendo concluir que los bajos niveles de heterocigotos pueden ser debidos a: una mezcla de poblaciones (Efecto Wahalund), varios tipos de selección, la presencia de alelos nulos o la pérdida de cromosomas causando estimaciones incorrectas de las fracciones fenotípicas (Creasey et al., 1996), fuerzas estocásticas y deterministas que conllevan a la configuración génica de cada población, tal es el caso de los procesos de mutación, migración, selección natural y deriva génica o a otros factores, tales como que cada muestra haya incluido individuos provenientes de sólo algunas fracciones de la población, favorecidas en las primeras etapas de vida por la oportunidad de factores ambientales que les hayan permitido mayor supervivencia. El grado de participación de cada una de ellas puede ser diferente, ya que es función de la biología de la especie, su posible origen geográfico o, sus preferencias térmicas (Trujillo et al. 1995). En el caso de *Strombus gigas* los bajos valores de Fst entre las poblaciones nos indica que no se puede considerar el efecto Wahalund como la causa de este fenómeno, aunque se mantiene la idea de que existe la entrada de migrantes en las poblaciones (4.29).

Las larvas de *S. gigas*, según estudios efectuados acerca de su permanencia en el plancton y su consecuente dispersión, pueden permanecer hasta veintiocho días en la columna del agua (Campton, et al. 1992) sí encuentran las condiciones adecuadas para lograr su proceso de metamorfosis, lo cual les permite ser transportadas a lo largo de todo el mar Caribe y que en función del número de

migrantes obtenidos en este estudio se puede pensar en el proceso de flujo de genes a través del Caribe y sugiriendo con esto que las larvas de *S. gigas* al tener ese amplio rango de dispersión se propicia que la estructura poblacional, y las poblaciones que se encuentran en el área de influencia, sea relativamente común y se tenga una esperada variación genética entre las poblaciones, que va de acuerdo a los resultados de trabajos efectuados en la zona con este organismo (Mitton et al. 1989, Campton et al. 1992).

Los resultados obtenidos del flujo de genes, mediante el análisis de Chi-cuadrada (χ^2) y la prueba de Haldane nos indica que sólo un mínimo de loci son significativamente diferentes.

Los valores de distancia e identidad para *S. gigas* en gónada nos indican que son valores típicos para especies o poblaciones que se encuentran bien mezcladas. Los altos valores de identidad, así como los similares y bajos de distancia genética son comunes para especies con vida planctónica de gran dispersión, similares a S. gigas.

El análisis de agrupamiento o UPGMA Cluster de gónada en *Strombus gigas* usando la distancia original de Nei, muestra una ligera separación, no tan significativa entre los fenotipos encontrados en las poblaciones de Punta Allen con las de Isla Mujeres y Banco Chinchorro. El cambio se tiene al efectuar el análisis en tejidos diferentes; los resultados provenientes de los extractos de tejido muscular no aportaron datos suficientes que puedan ser utilizados para diferenciar poblaciones de *S. gigas*, en gónada la población que presenta una baja separación o distancia respecto a las otras es Punta Allen. Esta baja separación de las poblaciones aparentemente no tienen lógica ya que la corriente del mar Caribe al ser ascendente hacia el norte y pasar por el canal de Yucatán debe de propagar la dispersión de las larvas de *S. gigas* presentes en la columna de agua, lo que se esperaría que las poblaciones sean homogeneas y no considerar a la población de Punta Allen como una población separada o alopátrica.

No obstante, variaciones estocásticas en la corriente de agua, los vientos de superficie, eventos metereológicos, disponibilidad de alimento, temperatura, concentración de oxígeno y aún remolinos localizados podrían afectar la dispersión de las larvas y modificar el reclutamiento de estas en localidades particulares, Bucklin et al. (1989) corroborarón y concluyeron que tales eventos pueden mantener el estado de discreción de las poblaciones en forma espacial o temporalmente, lo que a final de cuentas evita la homogenización del plancton durante el transporte y si consideramos el hecho de que en Punta Allen se tiene la presencia de la bahía de la Ascensión, lo que representa un hábitat restringido a cuerpos de agua semicerrados, permitiendo el asentamiento de larvas y su posterior aislamiento que a fin de cuentas nos de la pauta para establecer la diferenciación y valores de distancia de esta población con las otras analizadas.

Se considera necesario realizar un estudio más amplio, en el que se ensaye con mayor número de poblaciones (localidades) y loci de *Strombus gigas*, para tener un panorama más completo de la estructura y variabilidad genética de tales poblaciones.

CONCLUSIONES

La variabilidad genética intrapoblacional y la diferenciación genética interpoblacional del caracol reina Strombus gigas en las costas de Quintana Roo (Punta Allen, Isla Mujeres y Banco Chinchorro) estimados a partir del número de isoenzimas presentes en el genoma de cada tejido, permitieron establecer una sola población en el Caribe Mexicano.

La baja heterocigocidad detectada y la poca diversidad genética encontrada dentro de las poblaciones puede ser atribuida a limitaciones en el tamaño efectivo de la población y a otros factores como los ambientales y oceanográficos.

Punta Allen mostró más diversidad genética que las otras dos poblaciones; en cuanto al flujo y a la distancia genética también permitieron establecer la diferencia entre esta población con las de Isla Mujeres y Banco Chinchorro, sin embargo, cabe mencionar que los resultados obtenidos de esta población no son lo suficientemente significativos como para pensar que esta sea una población aislada o alopátrica.

Los resultados obtenidos de las isoenzimas provenientes de los extractos de tejido muscular no aportaron datos suficientes que puedan ser utilizados como marcadores diferenciales de la especie *S. gigas* en las tres poblaciones estudiadas de las costas de Quintana Roo.

La poca diferencia existente entre las poblaciones de Punta Allen con las de Isla Mujeres y Banco Chinchorro, apoyada en los 6 loci examinados fue baja, en función de los valores de Fst de Wright y de la distancia genética. Esta baja o nula diferenciación entre las poblaciones se debe en muchas ocasiones a la dirección de las corrientes marinas provenientes del Mar Caribe que se introducen al Golfo de México a través del Canal de Yucatán.

Es probable que este patrón de flujo de agua mantenga las frecuencias alélicas y genotípicas similares o muy cercanas entre sí.

Las corrientes han sido uno de los parámetros más importantes para establecer la diferenciación genética en las poblaciones marinas, en el caso de las poblaciones de Strombus gigas analizadas en el presente trabajo, el número de migrantes en las poblaciones aunque resultó ser muy bajo, nos indica que sí existe un flujo de genes y que las poblaciones se encuentran relativamente homogéneas.

Se concluye que tanto los procesos estocásticos como de selección natural son posiblemente los que más contribuyen a la homogenización o diferenciación entre las poblaciones de *S. gigas* analizadas en el presente trabajo, permitiendo a las autoridades pesqueras, considerar en sus planes de lineamientos y estrategias de manejo a dicho recurso, como una sola población para el Caribe Mexicano; así como contribuir a resolver problemas de maricultura: en el manejo, cosecha y repoblación de esta especie.

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Especies de Strombus Potenciales para su Cultivo en las Costas e Islas de la Peninsula de Yucatán, Mexico

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RESUMEN

El desarrollo del turismo y la alta demanda han contribuido a la sobreexplotación de poblaciones naturales del caracol (*Strombus* spp.), los cuales han mostrado declinaciones drásticas en el Caribe. México no es ninguna excepción, y los recursos del caracol han disminuido dramáticamente desde 1982. El género *Strombus* es representado por seis especies en el Golfo y Caribe, *Strombus gigas* L., *S. costatus* Gmelin, *S. raninus* Gmelin, *S. pugilis* L., *S. alatus* Gmelin, *S. gallus* L. En la Península de Yucatán, México, hay seis especies de gastrópodos comercialmente importantes. Todos han declinado debido a la sobrepesca y *S. gigas*, *S. costatus* y *S. pugilis* son las especies que han sido más explotadas por ser las especies de más alto valor comercial. Debido a la sobrepesca y ante el peligro creciente de la extinción del caracol, el gobierno mexicano prohibió en 1987 la pesca del caracol en el estado de Yucatán y en Quintana Roo existe veda total permanente en la Zona Norte y Centro y solo se permite la pesca en la Zona Sur regulado por: cuotas de pesca, veda estacional, tamaño y arte de pesca . Sin embargo, los pescadores continúan capturando adultos y juveniles, poniendo a las poblaciones del caracol en niveles críticos de supervivencia. Pero a pesar de la captura indiscriminada por la pesca ilegal, como ejemplo , en el caso de Arrecife de Alacranes algunos pescadores son capturados con 500 kg de peso blando capturada de dos o tres días; lo que hace suponer que el aporte viene de poblaciones de aguas profundas. Esto hecho ocurre ha pesar de haberse impuesto una veda permanente por 15 años y este es una de las razones no se han recobrado poblaciones como se esperaba (Comunicación personal con el CRIP en Yucalpetén, Yucatán, y el CRIP de Puerto Morelos, Quintana Roo, Enero de 1999). En la actualidad existe una fuerte presión social por parte de los pescadores para que se reabra de nuevo la pesquería y el gobierno de México ante esta situación a convocado por medio del fondo sectorial de SAGARPA-CONACYT al establecimiento del cultivo como una alternativa al problema. Ante esta situación, el presente trabajo analiza que especies son potencialmente recomendadas para su cultivo en cada sitio de la costa de la Península de Yucatán e islas tomando en cuanta varios aspectos como: biológicos, la región, el consumidor, factibilidad técnica y económica del cultivo intensivo, impacto social y sectores que promuevan

la investigación, producción y comercialización.

A pesar de que la regulación pesquera es uno de los medios de recuperar las poblaciones explotadas, la maricultura es una alternativa muy fuerte que debe considerarse y dentro de esta práctica también se consideran en este trabajo las disciplinas que se han generado en la región y que apoyan su cultivo.

PALABRAS CLAVES: Maricultura, *Strombus gigas, S. costatus, S. pugilis*

Potential Species of Strombus for its Cultivion in the Coasts and Islands of the Mexico, Yucatan Peninsula

The development of the tourism and the high demand have contributed to the overexploitation of natural populations of the snail (*Strombus* spp.), which have shown drastic declines in the Caribbean. Mexico is no exception, and the resources of the snail have diminished dramatically from 1982. The *Strombus* genus is represented by six species in the Gulf and the Caribbean, *Strombus gigas* L., *S. costatus* Gmelin, *S. raninus* Gmelin, *S. pugilis* L., *S. alatus* Gmelin, *S. gallus* L. In the Yucatan Peninsula, Mexico, are six species of commercially important gastrópodos. All have declined due to overfishing and *S. gigas*, *S. costatus* and *S. pugilis* is the species that more have been operated being the species of more high commercial value. Due to the overfishing and before the increasing danger of the extinction of the snail, the Mexican government prohibited in 1987 the fishing of the snail in the state of Yucatan and in Quintana Roo permanent total prohibition in the North Zone exists and single Center and allows the fishing in the South Zone regulated by: quotas of fishing, seasonal, so large prohibition and art of fishing. Nevertheless, the fishermen continue capturing adult and youthful, putting to the populations of the snail in critical levels of survival. But in spite of the indiscriminate capture by the illegal fishing, like example, in the case of Reef of Scorpions some fishermen are captured with 500 kg of captured soft weight of two or three days; what makes suppose that the contribution comes from deep water populations. This fact happens has to weigh to have imposed a permanent prohibition by 15 years and this is one of the reasons have not recovered populations as it were expected (personal Communication with the CRIP in Yucalpetén, Yucatan, and the CRIP of Port Morelos, Quintana Roo, January of 1999). At the present time a strong social pressure on the part of the fishermen so that pesquería reopens again and the government of Mexico exists before this summoned situation to by means of the sectorial bottom of SAGARPA-CONACYT to the establishment of the culture like an alternative to the problem. Before this situation, the present work analyzes that species potentially are recommended for their culture in each site of the coast of the Yucatan Peninsula and island taking in whichever several aspects like: biological, the region, the consumer, technical and economic feasibility of the intensive culture, social impact and sectors that promote the investigation, production, and commercialization.

Although the fishing regulation is one of means to recover the operated populations, the maricultura is an alternative very hard that must be considered and within this practice also the disciplines are considered in this work that have been generated in the region and which they support his culture.

KEY WORDS: Maricultura, *Strombus gigas*, *S.costatus*, *S. pugilis*

INTRODUCCIÓN

El desarrollo del turismo y la alta demanda han contribuido a la sobreexplotación de poblaciones naturales del caracol del Género *Strombus*, los cuales han mostrado declinaciones drásticas en el Caribe. México no es ninguna excepción, y los recursos del caracol han disminuido dramáticamente desde 1982.

El género *Strombus* es representado por seis especies en el Golfo y Caribe, *Strombus gigas* L., *S. costa*tus Gmelin, *S. pugilus* L., *S. raninus* Gmelin *S. alatus* Gmelin, *S. gallus* L.(Rodríguez 1994).

La distribución geográfica abarca prácticamente toda el área del Caribe , desde Florida hasta Venezuela (Brownell y Stevely, 1981). En México se localiza en las Costas de la Península de Yucatán (Rodríguez, 1994).

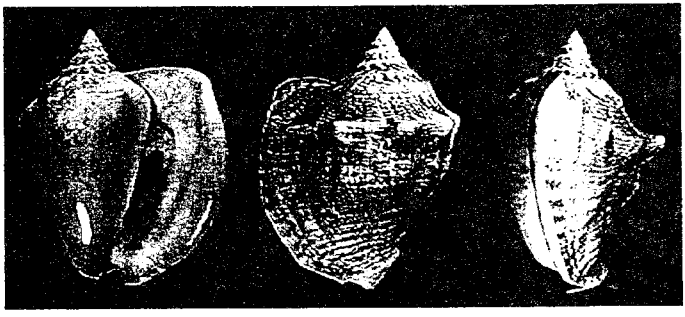
En la Península de Yucatán, México, hay seis especies de gastrópodos comercialmente importantes. Todos han declinado debido a la sobrepesca y *S. gigas, S. costatus* y *S. pugilis* (Figuras 1, 2 y 3) son las especies que han sido más explotadas por ser las especies de más alto valor comercial (Rodríguez et al. 2000)

Las poblaciones de caracol rosado *S. gigas*, *S. costatus* y *S. pugilis* a igual que las otras especies de *Strombus* están disminuyendo a través de todo el Caribe, debido en parte a la pesca intensa, pérdida de hábitat y degradación de la calidad del agua. Las características naturales de estas especies, como movimiento lento, agregaciones, dependencia a lugares poco profundos, hacen de estos caracoles muy vulnerable a la sobre-explotación. Las reducciones en abundancia de estos caracoles han sido bien documentadas en todo el Atlántico occidental tropical (Gibson et al. 1983, Goodwin 1983, Appeldoorn y Sanders 1984).

El recurso caracol de la región que comprende los estados de Campeche, Quintana Roo y Yucatán, ha registrado variaciones en su abundancia a nivel de zonas, por lo que, la Secretaria de Pesca estableció medidas de regulación que consideran variaciones regionales y locales (Rodríguez 1994). Aproximadamente el 96 - 98 % de las capturas totales de este recurso están compuestas por caracol marino *S. gigas*, que alcanza su talla de primera madurez a partir de los 20 cm de longitud de concha, por lo que es necesario establecer regulaciones de talla mínima para garantizar el adecuado aprovechamiento de esta especie (Rodríguez 1994).

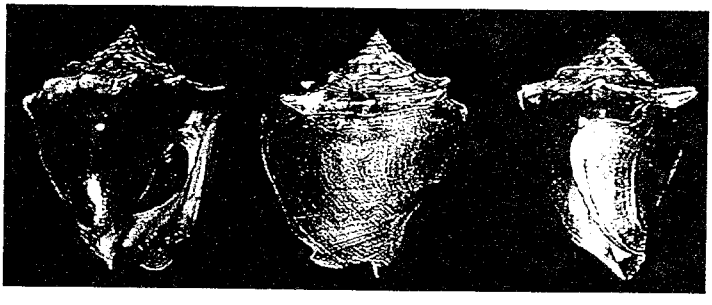
A B

Figura 1. Morfología externa del caracol reina *Strombus gigas* (L). Vistas: ventral (A) y dorsal (B).



A B C

Figura 2. Morfología externa del caracol lechoso *Strombus costatus* Gmelin Vistas: ventral (A) , dorsal (B) y lateral (C).



A B C

Figura 3. Morfología externa del caracol canelo *Strombus pugilis* (L) Vistas: ventral (A), dorsal (B) y lateral (C).

Es así, que la Secretaría de Pesca ha ordenado el no acceso a esta pesquería para el Estado de Yucatán desde el año de 1987 (SEPESCA 1987), y en el Norte de Estado de Quintana Roo en Isla Mujeres y Cozumel en 1990 (SEPESCA 1988). Posteriormente mediante los estudio de dinámica poblacional se realizaron evaluaciones del recurso para Isla Mujeres y Cozumel notando una recuperación de las poblaciones en función de estas evaluaciones y se reabrió esta pesquería para Cozumel en 1997 (SEPESCA1998). Actualmente la captura comercial se limita al Sur de Quintana Roo y para la Isla de Cozumel.

En Banco Chinchorro ubicado al Sur de Q. Roo, se extrae este producto, bajo una cuota de 45 toneladas, en el banco de Cozumel la cuota de extracción es de 12 toneladas con una temporada de captura del 1 de mayo al 31 de octubre, en Isla Mujeres permanece en veda al igual que en los Arrecifes los Alacranes (SEPESCA1998, Diario oficial 2000).

Sin embargo, los pescadores continúan capturando adultos y juveniles, poniendo a las poblaciones del caracol en niveles críticos de supervivencia.

Actualmente en el Estado de Yucatán existen cinco reservas, tres federales que incluye la Reserva de Ría de Celestún, la de Ría Lagartos, e Isla Alacranes y dos estatales el Palmar y Dzilam de Bravo. En Quintana Roo Especial interés son: Isla Holbox, Isla Contoy, Isla Mujeres, Cozumel, Banco Chinchorro, Puerto Morelos, Mahahual, Punta Allen. Pero a pesar de haberse impuesto una veda por quince años las poblaciones no se han recobrado como se esperaba (Comunicación personal con el CRIP en Yucalpetén, Yucatán, y el CRIP de Puerto Morelos, Quintana Roo, 2002.

A pesar de que la regulación pesquera es uno de los medios de recuperar las poblaciones explotadas, la maricultura es una alternativa muy fuerte que debe considerarse aunada a la regulación pesquera y dentro de esta práctica esta el apoyo y las facilidades que las autoridades deben proporcionar para recuperar este recurso ante la fuerte demanda de recuperar este recurso por varios sectores de la sociedad, pero principalmente de los pescadores y de la (Secretaria de recursos pesqueros y alimentación (SAGARPA) quien en este año de 2002 emitió una convocatoria con fondos Sectoriales SAGARPA-CONACYT para el cultivo del caracol rosado *Strombus gigas* (L.). Ante esta situación el propósito de este trabajo es de dar a conocer que especies son potencialmente recomendadas para su cultivo en cada sitio de la costa de la Península de Yucatán e islas tomando en cuanta varios aspectos como: biológicos, la región, el consumidor, factibilidad técnica y económica del cultivo intensivo, impacto social y sectores que promuevan la investigación, producción y comercialización.

METODOS

Para el desarrollo de maricultura es necesario tomar en cuenta varios aspectos como: el ciclo biológico de la especie, la región y el sitio donde se instalará el "hatchery" y las demás etapas del cultivo, así como la factibilidad técnica y económica del cultivo, impacto social y sectores que promuevan la investigación,

producción y comercialización. Por lo que, fue necesario seguir una estrategia de búsqueda de información en la literatura citada, encuestas a pescadores, visita a los sitios de la costa de la península de Yucatán para el reconocimiento de la infraestructura con que se cuenta así como las facilidades de Apoyo e incentivos del Gobierno Federal, Estatal y Municipal para el desarrollo del cultivo con dos propósitos bien definidos: el de repoblación y con fines comerciales.

Con lo que respecta al ciclo biológico de las especies potenciales para cultivo, las que se proponen como *Strombus gigas*, *S. costatus* y *S. pugilis* han sido bien documentadas por varios autores (Davis 1994, Hahan 1989, Rodríguez 1990, Rodríguez 1994, Rodríguez 1995, Rodríguez 1995a, Rodríguez et al. 2000) y recomendadas para su cultivo, siempre y cuando se cultiven en las condiciones adecuadas.

Con respecto a la región y el sitio juegan un papel importante su elección, pues de ello va a depender que especie se pueda cultivar con éxito. Por lo que, a continuación se mencionan ciertos criterios.

Para la región de las costas de Yucatán y Campeche en estas regiones se encuentran caracoles de desarrollo indirecto del Genéro *Strombus* como: la lanceta *Strombus costatus.*, *S. pugilus*, *S. raninus*, *S. alatus*, *S. gallus*. Los dos primeros son de consumo alimentario para la gente de la región y las conchas se utilizan para trabajos de artesanía. Los tres últimos no los consumen para alimento y no están regulados por la Norma Oficial Mexicana NOM-013-1994). Para esta región no se encuentra la especie *Strombus gigas.*

Para la región de la costa de Quintana Roo e islas y bancos la principal especie es *Strombus gigas* que aporta de un 96 - 98 % del total de este recurso. Para la región del Banco e Campeche donde quedan incluidas las islas que le pertenecen al estado de Campeche y Yucatán se encuentra también *S. gigas* como la especie que mayor aporta seguida de *S. costatus y S. pugilus* de interés comercial (NOM-013-1994).

Con respecto al sitio hay que tomar en cuenta que especies se encuentran, la calidad del agua, la infraestructura, los servicios y facilidades del gobierno para establecer el cultivo.

En relación a la factibilidad técnica y económica hay que establecer un plan de negocios que deberán incluir los aspectos que más puedan incidir en el éxito de un proyecto en este sentido se recomienda que se consideré lo siguiente:

i) Resumen ejecutivo,
ii) Análisis de mercado,
iii) Análisis de la posición estratégica de la empresa,
iv) Estrategia para el desarrollo de ventajas competitivas únicas y sostenibles,
v) Factores de riesgo,
vi) Plan de mercadotecnia,
vii) Recursos humanos y estructura organizacional,
viii) Factibilidad técnica,
ix) Factibilidad financiera,
x) Análisis de sensibilidad,

xi) Dirección y gerencia,

xii) Conclusiones y anexos.

En referencia impacto económico y/o social. En la actualidad existe una veda total para la pesca de este caracol, una de las formas de contribuir a la recuperación y preservación de este recurso es por medio de su cultivo, lo cual contribuirá a que los pescadores tengan un ingreso económico y beneficio social. Al mismo tiempo que el pescador aprenda la tecnología para su cultivo y de como puede mejorar la producción para preservar esta especie en peligro de extinción. Para la cual el proyecto del cultivo debe involucrar a los sectores público, social y privado para su impulso.

RESULTADOS

Uno de los principales problemas de la maricultura respecto al cultivo de los caracoles del Género *Strombus* es la falta de disponibilidad de las puestas de masas de huevos, pero esto queda resuelto con la construcción de encierros que funciones únicamente en la época de desove para cada especie. Para *Strombus* gigas se recomienda 2 machos : 15 hembras, para un área de 40 m^2 con suficiente alimento, para *Strombus* costatus la misma proporción de 2 machos y 15 hembras para 20 m^2 , para *Strombus* pugilus de 2 machos y cinco hembras en condiciones de laboratorio (Rodríguez et al. 2000).

Con relación a la región y sitios de cultivo en la Península de Yucatán la sección de arrecifes, cayos, bancos e islas una parte se encuentran en el banco de Campeche y otras en el Caribe Mexicano. Se divide para el estado de Campeche en: Cayo Arcas es un conjunto de 3 pequeñas islas entre los Estados de Yucatan y Campeche. Triángulos sur, este, oeste, y Cayo Nuevo. Para el Estado de Yucatán en : Arrecife Alacranes, Cayo Arenas, Arrecife de Sisal, Arrecife de al Serpiente, y Arrecife de Madagascar. Para el Estado de Quintana, Roo en: Isla Holbox, Isla Contoy, Isla Mujeres, Isla Cancún, Isla Mujeres, Isla Cozumel y Banco Chinchorro.

Con relación al Estado de Campeche por la situación geográfica de sus cayos y la poca cobertura y la nula infraestructura y servicio es muy difícil por las condiciones actuales llevar a cabo el cultivo de las tres especies de *Strombus* recomendadas. La única comunicación es por medio de los barcos de la Secretaria de Marina y de la Secretaria de Comunicaciones y Transportes que se efectúa cada mes por el cambio de guardia. Sin embargo, si se toma en cuanta la costa del Estado de Campeche, se recomienda por las condiciones geográficas los sitios de Isla Arenas para los cultivos de *Strombus costatus* y *S. pugilis*, para *S. gigas no* se recomienda, por que no se presentan condiciones adecuadas para su cultivo.

Con relación al Estado de Yucatán para las islas solamente Arrecife de Alacranes reúne las condiciones y de las cinco Islas que se presentan en este Arrecife solamente Isla Pérez se recomienda por presentar condiciones de calidad de agua, vigilancia, permanencia constante del personal de la Secretaría de Marina y personal de la Secretaría de transporte. En cuanto a los servicios se cuenta con un helio-puerto, luz y las instalaciones de la Secretaria de Comunicaciones. Las demás arrecifes no tienen parte terrestre y en Cayo Arenas no hay servicios y la cobertura

de su superficie terrestre es muy pequeña.

El Parque Nacional Arrecife Alacranes al Norte de la Península de Yucatán, esta situado aproximadamente 72 millas (130 km) de la costa del Norte de la Península de Yucatán entre los 22°37' y 22°22' Latitud Norte y los 89°33' y 89°48' Latitud Oeste. Hay seis islas en fila, la isla principal es Isla Pérez, donde se localiza el faro, las otras son: Desterrada, Chica, Pájaros, Muertos y Desaparecida, estas últimas islas son una batería de arena que aparece durante mareas bajas, y su altura sobre el nivel del mar es dada por el sedimento que fluye. En este sitio existen agregaciones de *Strombus. gigas*, *S. costatus* y *S. pugilis* pero sobre las cuales desde 1987 la Secretaría de Pesca decreto la veda permanente como medida de protección del recurso (Rodríguez 1994).

Tomando en cuenta la costa del Estado de Yucatán se recomiendan los siguientes puertos: Sisal, Celestún, Santa Clara, Dzilam de Bravo, San Felipe y El Cuyo Puestos que presentan los servicios y la calidad de agua para el cultivo de *Strombus costatus* y *S. pugilis* , pero no se recomienda para *S. gigas.*

Con relación al Estado de Quintana Roo para las islas de: Contoy, de Mujeres y Cozumel se recomiendan para el cultivo de *Strombus gigas* por su calidad de agua y los sitios que presentan servicios e infraestructura para su cultivo.

Isla Contoy por la importancia y la diversidad de su fauna, es por decreto presidencial desde febrero de 1961 Zona de Refugio Nacional. Esta isla refugio de aves marinas, es la más importante del Caribe Mexicano donde estas aves encuentran un sitio seguro, suficiente alimento, lugares para anidar y poca alteración humana. Se encuentra localizada en el Estado de Quintana Roo, a 30 Km al Norte de Isla Mujeres, aproximadamente a 12.5 Km de la Costa Noreste de la Península de Yucatán. Políticamente pertenece al municipio de Isla Mujeres. Sus coordenadas geográficas son: 21° 27'40" y 21° 32'10" Latitud Norte 86° 48'25" y 86° 49'05" Longitud Oeste.

La Isla presenta una longitud de 6.17 km y es de forma alargada e irregular, la costa oriental es fundamentalmente rocosa con playas arenosas más extensas cerca de la punta norte. La costa occidental es rocosa y arenosa encontrándose por la boca de tres lagunas, playas como lxmapoit, Tortugas, Pájaros y Cocos. La isla presenta numerosas lagunas internas de gran importancia ya que sirven de criadero a numerosos organismos acuáticos y en sus márgenes se encuentran situadas los principales sitios de anidación de aves marinas y palustres, la temperatura media anual es de 27.7°C la media más alta se presenta en los meses de julio y la más baja en enero, la precipitación anual es de 1400 mm aproximadamente siendo septiembre el más lluvioso.

Isla Mujeres, es una pequeña isla enclavada en la parte Noroeste del Estado de Quintana Roo y se localiza entre los 21°11' y 21°15' latitud Norte y los 86°41' y 86°45' longitud Oeste en donde se encuentra agregaciones de caracoles marinos pero ya muy diezmados debido a la gran presión de pesca y a la elevada actividad turística de la zona, esto ha propiciado que los organismos se encuentren a profundidades superiores a los veinte metros. En esta zona, la Secretaría de Pesca desde 1991 decretó la veda del recurso (Rodríguez 1994).

Cozumel es la Isla mas grande del Caribe Mexicano con una extension de 45 kms de largo y 10.5 kms de ancho, separada 18 kms de la Peninsula de Yucatán .

Isla Holbox ubicada al noreste de la Península de Yucatán se recomienda para el cultivo de *Strombus* costatus y pugilis, pero no para *S. gigas*, porque, la calidad de agua es diferente tiende hacer similar a las aguas del Golfo de México en la línea de costa. Isla Cancún no se recomienda por su desarrollo turístico y porque en un momento determinado se puede contaminar el cultivo por estar cerca de un desarrollo urbano que esta creciendo. Con relación a Banco Chinchorro es un lugar ideal por su calidad de agua , pero los servicios, el transporte y los servicios no son los adecuados hasta este momento.

Banco Chinchorro se encuentra en la zona Sur del estado de Quintana Roo esta localizado en los 18°47' y 18°23' latitud Norte y 87°14' y 87°27' longitud Oeste, es un complejo arrecifal frente a la costa sureste del estado de Quintana Roo, entre las poblaciones del Río Indio y Xcalac. Se encuentra separado casi 30 km del continente por un gran canal con profundidades que alcanzan hasta los 1000 m (Jordán y Martín, 1987). Tres zonas bien definidas se encuentran en este arrecife: Cayo Lobos, Cayo Norte y Cayo Centro, los cuales son el sitio de campamento de los pescadores y en cuyas inmediaciones se capturaron los organismos. Es la única zona del Caribe Mexicano en donde existen las mayores agregaciones de *S. gigas* y en donde hasta mayo de 1997 se permitía la captura por cuota del caracol rosado (Rodríguez 1994).

Sin embargo, hay que considerar tres puertos interesantes en la costa de Q. Roo el de Puerto Morelos quien tiene los servicios y toda la infraestructura para desarrollar el cultivo como son las instalaciones del Centro Regional de Investigación pesquera de Quintana Roo (CRIPQR). Un puerto también muy interesante es Punta Allen y Mahahual que ahora ambos presentan los servicios y la infraestructura necesaria para desarrollar un proyecto para cultivo de *Strombus* gigas, teniendo en cuenta que el proveedor más grande de puestas de masas de huevos para el cultivo se tiene a dos horas (Banco Chinchorro) usando lanchas de 25 pies y motor de 60 Hp.

CONCLUSIONES

Las especies potenciales de interés comercial, las regiones y los sitios para su cultivo en la Península de Yucatán son:

i) *Para el Estado de Campeche* — a pesar de tener Islas y Cayos con condiciones propicias en cuanto a la calidad de agua estas no presentan los servicios y la infraestructura necesaria actualmente para poder desarrollar el cultivo de cualquiera de las tres especies de *Strombus* recomendadas (*Strombus gigas*, *S. costatus* y *S. pugilis*. Sin embargo, en la costa de este estado Isla Arenas es un lugar propicio para el cultivo de *S. costatus* y *S. pugilis*.

ii) *Para el Estado de Yucatán* — a pesar de tener varios arrecifes uno es el que presenta las condiciones para el cultivo de las tres especies recomendadas y es Isla Pérez que se encuentra ubicado en el Parque

Nacional de arrecife de Alacranes. Pero en la costa de este estado hay varios puertos interesantes como: Celestún, Sisal, Santa Clara, Dzilam de Bravo, San Felipe, Rio Lagartos y el Cuyo que se recomiendan para el cultivo de dos especies de *Strombus* (S. costatus y *S. pugilis*) pues dichos puertos presentan los servicios y la infraestructura necesaria para el desarrollo de sus cultivos.

iii) *Para el Estado de Quintana Roo* — este representa en comparación con los otros dos estados de la Península una ventaja en cuanto a que tiene mucho más sitios con mejores condiciones de calidad de agua e infraestructura y servicios para el cultivo de las tres especies de *Strombus* propuestas para su cultivo. Para *Strombus gigas* se recomiendan las siguientes Islas. Contoy, Mujeres, Cozumel y Banco Chinchorro. Para *S. costatus* y *S. pugilis* Isla Contoy se recomienda. Puerto Morelos, Punta Allen y Mahahual se recomiendan también para el cultivo de *S. gigas*.

Estos son algunas regiones y sitios que se recomiendan pero hay que tomar en cuenta que es necesario desarrollar un plan de negocios que incluya la factibilidad técnica, económica y estudio de mercado si se quiere comercializar aunado a la repoblación. De esta manera la maricultura es una fuerte herramienta que las autoridades deben promover para la recuperación del recurso aunado al manejo pesquero.

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Abundance, Size Frequency, and Spatial Distribution of Queen Conch, *Strombus gigas*, in Xel-há Park, Mexico

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ABSTRACT

Since November 2001 abundance, size frequency, and spatial distribution of queen conch, *Strombus gigas* have been monitored in Xel-Há Park, in the Caribbean Sea of Mexico. Xel-Há Park showed different bottom sites and different condition of salinity and temperature, because this park has the spring water. Site one, has a moderate seagrass benthic coverage (30%), in this site queen conch population was formed from juveniles (40 mm, of shell length) to adults (320 mm, of shell length). Site two, is only sand bottom, without seagrass coverage. In this site, were observed principally juveniles, with an average shell length of 90 mm formed the queen conch population. Site two, showed scarcely small juveniles (low of 50 mm shell length) and adults. The purpose of this study that was to determine abundance, size frequency and spatial distribution in Xel-Há Park showed differences between the sites.

KEY WORDS: Queen conch, *Strombus gigas*, population parameters

Abundancia, Frecuencia de Tallas y Distribución Espacial del Caracol Reina, *Strombus gigas*, en el Parque de Xel-Ha, México

A partir de noviembre 2001 la abundancia, frecuencia de tallas y distribución espacial de la población de *Strombus gigas* en el parque de Xel-Há en el caribe mexicano fueron monitoreadas. El parque de Xel-Há muestra diferentes tipos de fondos, con diferencias también en la temperatura y en la salinidad, dado que este parque presenta surgimientos subterráneos de agua dulce. El sitio uno, cercano al mar, se caracterizó por tener una mayor salinidad y presentar fondos de arena y *Thalassia* con una cobertura de un 30%. En Este sitio se encontraron juveniles desde 40 mm hasta adultos en perfectas condiciones con una longitud de concha de 320 mm. El sitio 2, se caracterizó por ser un fondo de arena un poco con fango, sin ninguna cobertura vegetal y con menor salinidad. En este sitio, la población de *Strombus gigas*, fue principalmente de juveniles pero de mayor talla, con un promedio en 90 mm de longitud sifonal de la concha. No se encontraron juveniles por abajo de 50 mm, ni tampoco adultos. Así, la abundancia, frecuencia de tallas y distribución espacial de la población de *Strombus gigas* en el parque de Xel-Há,

mostró diferencias en función del hábitat.

PALABRAS Claves: Caracol rosado, *Strombus gigas*, parámetros poblacionales

Strombus galeatus: Descripciones Biológicas de un Caracol en Riesgo

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RESUMEN

El *Strombus galeatus* es un gasterópodo marino habitante de la costa Pacífica tropical. Constituye una especie de importancia económica, dado su consumo generalizado y]creciente extracción tanto de poblaciones naturales como de áreas protegidas, lo que la convierte en una especie en riesgo y de interés para la acuicultura. Se ha desarrollado los primeros estudios tendientes a la descripción de las poblaciones en algunas áreas protegidas y públicas marinas del Pacífico de Costa Rica. Se ha utilizado el método de buceo libre y con tanques para efectuar observaciones biológicas, y con el método de marcado-recaptura se ha procedido a hacer descripciones biométricas y de biología poblacional en cada uno de los sitios visitados. Se ha logrado conocer parte de su biología ecológica y de describir preliminarmente la estructura poblacional de esta especie por edades y sexos. Paralelamente se ha efectuado ensayos para el cultivo de larvas en el laboratorio. De las observaciones obtenidas en zonas no protegidas y por las crecientes incursiones en las protegidas, se hace indispensable sugerir el mantenimiento y aumento de las zonas costeras protegidas existentes, por representar áreas con poblaciones relativamente sanas y reproductivas, así como el desarrollo de investigación tendiente a la optimización de tecnologías del cultivo y de repoblación, para mitigar la presión sobre las zonas establecidas bajo sistemas estatales de protección.

PALABRAS Claves: *Strombus galeatus*, descrípciones biológicas

Strombus galeatus: Biological Descriptions of a Conch in Risk

The *Strombus galeatus* is a marine gastropod inhabitant of the Pacific tropical coast. It is a species of high economic value because of its generalized consumption and increasing extraction from natural and protected areas, that make it a species in risk and of aquaculture interest. The first studies for this species have been developed in order to describe natural populations in protected and public areas of

the Pacific coast of Costa Rica. Snorkel and scuba diving have been used for biological observations,. and the mark-recapture method for biometric and population biology studies in each of the visited sites. Descriptions for its ecologic biology and population structure by size and sexes have been obtained from each one of the areas. At the same time, some attempts for larval culture in the laboratory have been made. From the observations taken in public and protected coastal zones and after the most common invasion in protected ones, the maintenance and increase of marine protected areas is very important, because of the existence of relatively healthful and reproductive populations for this and other species. Besides, the development of new research to improve larval culture technologies and repopulation methodologies for this species is indispensable to mitigate social pressures under protected areas.

KEY WORDS: *Strombus galeatus*, biological discription

Histología del Manto de *Strombus gigas* (Mesogastropoda: Strombidae) Linnaeus, 1758

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RESUMEN

El Caracol Pala *Strombus gigas* ha sido estudiado desde los 60 en su biología básica por ser un recurso marino de importancia económica en todo el Mar Caribe, sin embargo, se ha detecto la ausencia de conocimiento en su histología básica. El manto es una importante estructura de la anatomía de los gasterópodos, responsable de fabricar la concha, de interactuar química y físicamente con el ambiente, de secretar mucus, entre otras. Además, el desarrollo de la acuacultura y la protección de las poblaciones naturales de *Strombus gigas* es cada día más vulnerables a enfermedades y contaminación por la disminución de su diversidad genética requiriendo el conocimiento de las características histológicas, que permitan el diagnóstico de daños causados por enfermedades, parásitos, contaminación y

depredación.

En esta investigación se analizan tres machos y tres hembras del Arrecife Alacranes, Yucatán, México, con una longitud de la concha de 228 mm (± 20) y un grosor del labio de 16 mm (± 1,8). Cada animal fue removido de su concha y muestras de 1 cm^3 del manto fueron fijadas en Solución Davidson A.F.A. por cuatro días, lavados en alcohol al 70 %, deshidratadas en alcoholes del 70 %, 96 % y 10 0%, clarificadas en Benceno y embebidas en Parafina Paraplast. Secciones de 6 im fueron hechas con un microtomo rotatorio y fueron montadas sobre placas con albúmina de Meyer. Para la tinción se uso Hematoxilina de Harris - Eosina Amarillenta "HHE_2", método regresivo. Se describe a magnificaciones de 100x, 400x y 1000x la anatomía microscópica de cinco zonas que forman el manto desde su parte externa (adyacente a la concha) hasta su parte interna (próxima a la cavidad del manto) y está constituido de la siguiente forma:

i) Franja constituida por epitelio escamoso;
ii) Franja de fibras colágeno;
iii) Zona intermedia de tejido conectivo;
iv) Zona de tejido muscular; 5) epitelio transicional. Como característica particular se observa que el citoplasma de las cinco zonas que estructuran el manto es de colágeno.

PALABRAS CLAVES: *Strombus gigas* , histología del manto

Histology of the Mantle of *Strombus gigas* (Mesogastropoda: Strombidae) Linnaeus, 1758

The basic biology of the Queen Conch has been studied from the 1960s because is an economical importance marine resource in all Caribbean Sea; however, an absence on the knowledge of basic histology has been detected. The mantle is a very important structure of gastropod anatomy, it is responsible of shell formation, to interacting both chemically and physically with the environment, to secrete mucus, and so on. Moreover, the Aquaculture development and the conservation of the natural stock the Queen Conch everyday are more vulnerable a maladies and contamination by lessening of its genetic diversity, requiring the knowledge of its histological characteristic that is necessary to establish diagnostics of damage caused by diseases, parasites, contamination and depredation.

In this investigations three males and three females were sampled from Alacranes reef, 22°22"96'N 89°41"3'W, North of Yucatan Peninsula, Mexico. They had a shell length of 228 mm (± 20) and a lip thickness of 16 mm (± 1.8 mm). Each individual were remove from the shell and a 1-cm^3 section of the mantle were fixed in Davidson's A. F. A. solution for four days, rinsed in alcohol at 70 %, dehydrated in alcohol at 70 %, 96 %, 100 %, clarified in Benzene, and inclusion in Aparaplast@ synthetic paraffin. Six microns sections were made with rotary microtome and were mounted on glass slides with Meyer's albumin. For staining was used Harris Hematoxiline B Yellow Eosine (HHE_2), regressive method. Under 100x, 400x and

1000x magnifications the microscopy anatomy of five layer that form the mantle from outside (shell adjacent) until inside (cavity of mantle) were described as follow:

i) A squamous epithelium layer;
ii) A collagen fibers layer;
iii) A middle layer of connective tissue;
iv) Layer of muscular tissue; and
v) Transitional epithelium.

As particular characteristic, it was observed that collagen form the cytoplasm of all the five layers that structure the mantle.

KEY WORDS: *Strombus gigas*, histology of the mantle

Microscopic Anatomy of Tegument of the Foot the Queen Conch *Strombus gigas* (Mesogastropoda: Strombidae) Linnaeus, 1758

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ABSTRACT

The histology of healthy tissues has to be known in detail if the damage caused by diseases, pollution and maladies is to be identified. *Strombus gigas* Linnaeus, 1758 (Prosobranchia, Mesogastropoda, Strombacea, Strombidae) is a species under severe stress, caused by the reduction of its populations and pollution of coastal waters where it inhabits. Epithelia are important structures of gastropod anatomy, aiding in locomotion, physical and chemical interaction with the environment, respiration among others. In this investigations three males and three females were sampled from Alacranes reef, 22°22'96"N 89°41'03"W, North of Yucatan Peninsula, Mexico. They had a shell length of 228 mm (± 20) and a lip thickness of 16 mm (± 1.8 mm). Each individual were remove from the shell and a 1 cm^3 section of the mantle were fixed in Davidson's A. F. A. solution for four days, rinsed in alcohol at 70 %, dehydrated in alcohol at 70 %, 96%, 100%, clarified in Benzene, and

inclusion in "Paraplast" synthetic paraffin (Avila 2001). Six microns sections were made with rotary microtome and were mounted on glass slides with Meyer's albumin. For staining was used Harris Hematoxiline B Yellow Eosine (HHE_2), regressive method (Howard and Smith 1983).

Were described the different epithelia found on the side and sole of the foot. Side epithelia present two different characteristics: 1) Glandular cylindric ciliated epithelia that forms tubular folds and 2) Cylindrical pseudo-stratified epithelia forming irregular sinuosities. The epithelia of the sole presents two different type of cells: 1). The cells contiguous to the foot side are cylindrical, and 2) the sole presents pseudo-stratified cylindrical ciliated epithelia, forming twinned low rigs. The glandular structure of the foot side has a lubricating function, evidenced by secretion granules and mucus, while the rigs on the sole aid on a caterpillar sort of locomotion, characteristics that are present through the Gastropod class, but have a different degree of development in the diverse families and modes of life.

KEY WORDS *Strombus gigas*, anatomy, histology, foot, tegument

Anatomía Microscópica del Tegumento del Pie del Caracol Pala *Strombus gigas* (Mesogastropoda: Strombidae) Linnaeus, 1758

La histología de los tejidos sanos seria conocida en detalle si los daños causados por enfermedades y polución son identificados. *Strombus gigas* Linnaeus, 1758 (Prosobranchia, Mesogastropoda, Strombacea, Strombidae) es una especie bajo muchos strees, causado por la reducción de su población y por la polución de las aguas donde hábitat. El epitelio es una importante estructura de la anatomía de los gasterópodos, que ayuda en la locomoción, en la interacción física y química con el ambiente, en la respiración ,entre otras. En esta investigación tres machos y tres hembras fueron muestreados del Arrecife Alacranes, Yucatán, Estados Unidos Mexicanos, con una longitud de la concha de 228 mm (± 20) y un grosor del labio de 16 mm (± 1,8). Cada animal fue removido de su concha y muestras de 1 cm^3 de la parte anterior del pie fueron fijadas en Solución Davidson A.F.A. por cuatro días, lavados en alcohol al 70 %, deshidratadas a través de una serie de alcoholes del 70 %, 96 % y 100%, clarificadas con Benceno y embebidas en Parafina Paraplast (Avila, 2001). Secciones de 6 µm de espesor fueron hechas con un micrótomo rotatorio y fueron montadas sobre placas con albúmina de Meyer. La tinción se realizo con Hematoxilina de Harris - Eosina Amarillenta $AHHE_2$@ (Howard and Smith, 1983).

Fueron descritas las diferencias epiteliales encontradas en el lado del pie y la suela del pie. El epitelio del *lado del pie* presenta dos orientaciones diferentes: (1) Epitelio cilíndrico glandular ciliado (glándula pedal) formando pliegues tubulares y (2) epitelio cilíndrico seudo-estratificado ciliado contiguo a la suela del pie formando sinuosidades pareadas con aristas angulares. La *suela del pie* presenta dos epitelios

diferentes: (1) un epitelio cilíndrico con disposición lineal en la parte contigua al lado del pie, y (2) un epitelio cilíndrico seudo-estratificado con disposición lobulada y pareada en la parte de la suela del pie que se apoya en el lecho marino. Con esta investigación se demuestra que hay una especialización al nivel de tejidos entre el lado y la suela del pie de *S. gigas*. Se sugiere que esta diferencia anatomía es debida a la forma de movimiento y al tipo de hábitat.

PALABRAS CLAVES: *Strombus gigas* , histología del pie, tegument

Mexican Marine Parks as a Fishery Management Tool for the Queen Conch *Strombus gigas*

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ABSTRACT

Strombus gigas is a species of primary economic importance to all Caribbean countries. Its importance comes from the high exploitation levels ought to local demand for inner consumption, tourist market and international trade. Given its limited distribution range and accessibility, in low energy grass and algal beds, its populations have been depleted in many areas and seriously diminished in others, where exploitation is still taking place. This is the primary reason why it has been placed as a commercially threatened species under CITES (Appendix II). Different measures have been taken to regulate exploitation, which include minimum size, based on shell length, weight and lip thickness, catch quotas, temporal and permanent fishing bans, and marine parks as a measure to preserve reproductive stocks. The level of protection in the different parks of Mexico ranges from a total fishing ban with high reinforcement, to controlled exploitation with little to no reinforcement. The impact of the marine parks on the populations of *S. gigas* is as variable as the number of parks. The density of populations within the parks is critical for the recovery of the populations to its original levels. Evidence shows that the anticipated larval export outside the parks for the restoration of populations seems not to be significant. Marine parks are of practical use for the conservation of reproductive stocks and as a source of juveniles and adults for the rehabilitation of areas under commercial exploitation.

KEY WORDS: Queen conch, *Strombus gigas*, marine parks

Parques Marinos Mexicanos como Herramienta de Manejo de la Pesquería del Caracol Reina *Strombus gigas*

Strombus gigas es una especie de importancia económica en el Caribe, debido al alto grado de explotación, demanda de mercados locales e internacional y al turismo. Dado su área de distribución limitado y lo accesible que es su captura en pastizales y fondos arenosos, sus poblaciones están colapsadas o diezmadas en aquellas, donde existe aún explotación. Por lo anterior, se encuentra en el Apéndice II del CITES. Diferentes medidas han sido implementadas para regular la explotación de este recurso: Desde una talla mínima de captura (longitud de la concha y grosor del labio), rara vez se considera el peso de la carne, cuotas de captura, vedas temporales y permanentes y la creación de parques marinos, para preservar el stock reproductivo. El nivel de protección en los diferentes parques de México va de veda total y permanente con buena vigilancia o con poca. El impacto de los parques marinos sobre las poblaciones de *S. gigas* es tan variable como el propio numero de parques. La densidad de sus poblaciones dentro de los parques es un factor critico para la recuperación de las poblaciones a su nivel original. Evidencias muestran que por sí solo la exportación de larvas esperadas fuera del parque para la recuperación de las poblaciones no es significa. Los parques marinos son de uso practico en la conservación de los stocks reproductivos y como una fuente de juveniles y adultos para la rehabilitación de áreas sometidas a explotación comercial

PALABRAS CLAVES: Caracol rosado, *Strombus gigas*, parques marinos

Larviculture of Queen Conch *Strombus gigas* from Reserve of Biosphere Banco Chinchorro, under Laboratory Conditions

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ABSTRACT

In this work are presented the results obtained in larvicultures of *Strombus* gigas, under laboratory conditions in CINVESTAV-IPN. The sampling was realized during the reproduction season In the Reserve of Biosphere Banco Chinchorro, Quintana Roo. Nine cultures were realized from hatching to settlement, to evaluate the development, growth and survival.

For all cultures the same methodology has been used: density of 200 larvae by litter, feeding with *Tetraselmis suecica* at a concentration of 1,000 algal cells/ml, temperature of 29° ± 1° C and natural photoperiod. The time of hatching varied

between 92 and 95 hours with a average of 94 ± 1.06 hours after the ovoposition. The shell length at hatching was of 296 ± 10.23 μm (n = 210 larvae) and the larvae showed two velar lobes and 1.5 shell whorls.

Larvae reached metamorphosis at 30 days and developed a shell length between 980 and 988 μm, with a average of 983 ± 3.55 μm. The best survival was obtained in July (42 %) and the low survival in September, with only 13 %. The results obtained in the cultures shows that is possible realize the incubation of egg masses from natural ovoposition period and obtain good results in development, growth but not in survival, under laboratory conditions.

KEY WORDS: *Strombus gigas*, culture, laboratory conditions

Cultivo del Caracol Rosado *Strombus gigas* de la Reserva de la Biosfera Banco Chinchorro, Bajo Condiciones de Laboratorio

En éste trabajo se presentan los resultados obtenidos en cultivos de *Strombus gigas*, bajo condiciones de laboratorio en el CINVESTAV-IPN. Los muestreos fueron realizados durante la temporada de reproducción en la Reserva de la Biosfera Banco Chinchorro, Quintana Roo. Nueve cultivos fueron realizados de la eclosión al asentamiento, para evaluar el desarrollo, crecimiento y sobrevivencia. Para todos los cultivos la misma metodología ha sido empleada: densidad de 200 larvas por litro, alimentación con *Tetraselmis suecica* a una concentración de 1,000 células algales por ml, temperatura de 29°± 1° y foto período natural.

El tiempo de eclosión varió entre 92 y 95 horas con un promedio de 94 ± 1.06 horas después de la ovoposición. La longitud sifonal al momento de la eclosión fue de 296 ± 10.23μm (n = 210 larvas) y las larvas presentaron dos lóbulos del velum y 1.5 vueltas de espira de la concha. Las larvas alcanzaron la metamorfosis a los 30 días y desarrollaron una longitud sifonal entre 980 y 988 μ m, con un promedio de 983 ± 3.55 μm. La mejor sobrevivencia fue obtenida en Julio (42 %) y la más baja en Septiembre con 13%.

Los resultados obtenidos en los cultivos, muestran que es posible realizar la incubación de masas de huevos provenientes del medio natural y obtener buenos resultados en desarrollo, crecimiento pero no en sobrevivencia, bajo condiciones de laboratorio.

PALABRAS CLAVES: *Strombus gigas*, cultivo, condiciones de laboratorio

Catch and Effort in Queen Conch *Strombus gigas* (Mesogasteropoda: Strombidae) Fishery in the Archipielago of San Andres, Providencia and Santa Catalina, Colombia

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ABSTRACT

In Colombia, commercial extraction of Queen conch is done at Península de la Guajira and Departamento Archipiélago de San Andrés, Providencia y Santa Catalina, region which has reported the greatest numbers of captures. In recent years, interest upon this fishery has grown, and several management strategies have been implemented, such as: catch quotas, protected areas, closed seasons, and minimum catch weight. This paper presents the results obtained from the fishery monitoring between 2000 and 2002, done by the Secretaría de Agricultura y Pesca of the Departamento Archipiélago. In the Archipiélago, the fishery is done at artisanal and industrial scales, depending upon the type of boat used; however, the extraction method is similar in both scales, manual recollection by skin diving. Industrial activity has its action range mainly at Banco Serrana, and exceptionally at Bancos Serranilla and Roncador. Artisanal fishery has lost importance and its captures are generally done at Bajo Quitasueño, Providencia island and Cayo Bolívar. Catch ranges around 100 Tons per year, represented in greatest proportion by the industrial fishery, exerted by 10 - 12 boats, mainly foreigners.

The highest catches are obtained at Cayo Serrana, in coincidence with higher resource densities in this platform, when compared with the other sites. Catch effort has been practically constant, and it is highly influenced by resource abundance and the established ordering. The catch per unity of effort is not significantly different between fishing areas. Besides this, catch volume behavior for the last 30 years is analyzed, observing a strong tendency to the fishery collapse.

KEY WORDS: Queen conch, *Strombus gigas*, catch effort, Colombia

Captura y Esfuerzo en la Pesquería de Caracol Pala *Strombus gigas* (Mesogasteropoda: Strombidae) en el Archipiélago de San Andrés, Providencia y Santa Catalina, Caribe Occidental

En Colombia, la extracción comercial de caracol pala se realiza en la Península de la Guajira y en el Departamento Archipiélago de San Andrés, Providencia y Santa Catalina, región que ha aportado históricamente la mayor parte de las capturas. En los último años se ha despertado un gran interés por esta pesquería y se han

implementado diferentes estrategias de manejo, tales como: cuotas de pesca, áreas de reserva, épocas de veda y pesos mínimos de captura. En este artículo se presentan los resultados obtenidos del monitoreo de la pesquería entre los años 2000 - 2002, adelantado por la Secretaría de Agricultura y Pesca del Departamento Archipiélago.

En las islas se desarrolla la actividad a escala artesanal e industrial, basándose ésta clasificación en las características de la embarcación, sin embargo el método de extracción es similar, recolección manual mediante buceo libre a pulmón. La actividad industrial tiene su radio de acción principalmente en la plataforma del Banco Serrana y excepcionalmente en los bancos Serranilla y Roncador. La pesca artesanal ha perdido importancia y sus capturas se realizan por lo general en el bajo Quitasueño, la isla de Providencia y Cayo Bolívar. Las capturas se encuentra alrededor de 100 toneladas año, representadas en mayor proporción por la actividad industrial, la cual es ejercida por 10 - 12 embarcaciones en su mayoría extranjeras. Las mayores capturas se presentan en el cayo Serrana coincidiendo con mayores densidades del recurso en su plataforma, comparativamente con las otras áreas de pesca. El esfuerzo pesquero se mantuvo prácticamente constante durante el periodo evaluado y estuvo altamente influenciado por la abundancia del recurso y las medidas de ordenamiento establecidas. La captura por unidad de esfuerzo no mostró diferencias significativas entre las áreas de pesca. Adicionalmente, se analizó el comportamiento de los volúmenes de capturas en los últimos 30 años, observando una fuerte tendencia hacia el colapso de la pesquería.

PALABRAS CLAVES: Caracol pala, *Strombus gigas*, esfuerzo pesquero, Colombia

Distribución Vertical y Morfología de la Concha de *Strombus gigas* en el Cayo dos Mosquises Sur, Archipiélago de Los Roques, Venezuela

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RESUMEN

La forma de la concha de individuos adultos viejos, adultos "piedra" o "stunted" (en Inglés) de *Strombus gigas* y su distribución vertical, han sugerido hipótesis que postulan su pertenencia a una especie o grupo poblacional diferente al del que pertenecen los de aguas someras. Por el contrario, otras hipótesis sugieren que la distribución de estos individuos en aguas profundas responde a presiones de pesca

o a migraciones. Motivados por esta controversia, en este trabajo estudiamos la distribución vertical de diferentes estadios de desarrollo de *Strombus gigas* en el Cayo Dos Mosquises Sur. En esta localidad, la distribución vertical de los botutos es principalmente el resultado de factores no antropogénicos, dado que su pesquería ha sido controlada por el personal de la Estación de Biología Marina de Dos Mosquises. Diez variables obtenidas *in situ* de cada concha (N = 553) fueron estudiadas utilizando un análisis de componentes principales. Los individuos fueron identificados como juvenil, pre-adulto, adulto y adulto viejo a partir de la apariencia de la concha y *a priori* de los análisis morfológicos. Los intervalos de profundidades fueron agrupados en dos categorías: aguas someras (menos de 4 m) y aguas profundas (~ 28 m). Los resultados del análisis demuestran que las formas de las conchas se sobreponen en varias de las categorías, lo que sugiere que las variables seleccionadas no capturan toda la variabilidad necesaria para discriminar entre los diferentes estados de desarrollo. Sin embargo, las conchas identificadas como adultos y adultos viejos se distribuyen tanto en aguas someras como profundas en esta localidad, mientras que juveniles y pre-adultos se distribuyen principalmente en aguas someras. Estos resultados sugieren que la distribución diferencial en las localidades reportadas en la literatura puede ser consecuencia de una intensidad pesquera más acentuada en las zonas someras.

PALABRAS CLAVES: *Strombus gigas*, distribución vertical, morfología de la concha

Vertical Distribution and Shell Morphology of *Strombus gigas* in Cayo Dos Mosquises Sur, Archipiélago De Los Roques, Venezuela

The shell morphology of old, "stunted", or "piedra@" adults (in Venezuelan) of *Strombus gigas* and their vertical distribution have lead researchers to suggest that these individuals belong to populations or species different from those inhabiting shallow waters. On the other hand, alternative hypotheses point to differential migration rates and fishing effort as the cause of their distribution. Encouraged by this controversy, in this paper we study the vertical distribution of different growth stages of *Strombus gigas* in Cayo Dos Mosquises Sur. In this locality, fisheries of *Strombus gigas* have been under control by personnel from the Marine Biology Station at Dos Mosquises. Consequently, the vertical distribution of this species is expected to be similar to that from a non-exploited, natural population. We used a principal component analysis to study 10 variables, measured *in situ* from each collected individuals (n = 553). Before this analysis was carried out, each individual was identified as juvenile, pre-adult, adult or old adult, according to the morphology of its shell as a whole. Depth intervals were grouped in two categories: shallow waters (less than 4 m) and deep waters (~ 28 m). Results demonstrate that some growth stages overlap in shell morphology, suggesting that these variables not

always discriminate among growth stages. Adults and old adults are found inhabiting shallow and deep waters, whereas juveniles and pre-adults are mostly found in shallow waters. These results suggest that the deep distribution of old adults reported in the literature may be the consequence of the inexorable exploitation of *Strombus gigas* inhabiting shallow waters.

KEY WORDS: Queen conch, vertical distribution, shell morphology, *Strombus gigas*

Evaluaciones Poblacionales y Manejo Pesquero Sostenible del Caracol Reina (*Strombus gigas*) en las Principales Areas de Pesca de la Plataforma Cubana

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RESUMEN

Desde 1999 se ejecuta un Proyecto de Investigación por el Centro de Investigaciones Pesqueras dirigido al recurso *Strombus gigas* en al plataforma insular cubana. El objetivo principal es conocer el estado actual de la abundancia poblacional en las principales áreas de pesca, siguiendo las regulaciones de CITES en su explotación y comercialización. Se tienen los resultados de las evaluaciones y monitoreos efectuados durante los últimos tres años en las áreas tradicionales de pesca. Los aspectos biológicos que se tratan en los trabajos se limitan a las características poblacionales como talla, peso, edad, desembarques y composición por sexos. Toda la pesca se realiza por buceo libre en "apnea". En el 2002 se inician estudios biológicos complementarios para establecer las vedas y las posibilidades reales del maricultivo. Las zonas estudiadas han sido objeto de explotación (hasta 1997, cuando se declara la moratoria a nivel nacional) por diferentes empresas pesqueras estatales del país. Por los resultados de las densidades de individuos como índice de la abundancia y la estructura poblacional encontrada, como se puede presentar, se han propuesto cuotas de captura anuales bajo licencia, que alcanzan un total de 1,250 t (peso entero), como suele reportarse en Cuba, que equivalen a unas 88 t de carne limpia al 100% (foot weight). Además, se definen las estrategias de manejo pesquero para el uso sostenible de Strombus gigas en la pesquería del recurso en Cuba, teniendo en cuenta su conservación, el ambiente y la biodiversidad de las zonas costeras, como reclama CITES y las autoridades del Medio Ambiente.

PALABRAS CLAVES: Caracol reina, *Strombus gigas*, abundancia poblacional

Population Assessment and Fishery Sustainable Management of Queen Conch (*Strombus gigas*) in the Main Fishing Grounds of the Cuban Shelf

From 1999 the Fisheries Research Center of Cuba is working on a Project aim to evaluate the population abundance and fishery stock assessment on Queen Conch Strombus gigas in the main fishing areas of the Cuban shelf. Investigations were developed according to know present status of the resource in our waters. We are working under CITES regulations on Conch for exploitation and trading. The objective is to evaluate the abundance and population composition (juveniles, adults and seniles). There are available the results of abundance indexes and monitoring for the last 3 years for the whole country fisheries, as we can present. Until now, results are given sizes, weight, conversions, ages, landings, and sex ratios. Fishing operation is always by free diving. Aqualungs and compressors are not allowed. At present, year 2002, we started to do some biological studies in order to determine the closing season for our populations and the possibilities for conch mariculture. All Cuban areas were fished until 1997, when conch exploitation was closed by CITES rules. Densities and population structure are showing that it is possible to propose year quotas under licences up to 1250 metric tons (living weight) as reported in Cuba, that means 88 tons of 100% clean meat (foot weight). Furthermore, the fishery management was established for a sustainable use of Strombus gigas in the Cuban shelf, according to its protection, the environmental conditions and the biodiversity of the coastal areas. CITES claims for that, and the environmental authorities.

KEY WORDS: Queen conch, *Strombus gigas*, population abundance

Education to Rescue *Strombus gigas* in Guadaloupe: Success for Failure?

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ABSTRACT

Efforts to minimize the fishing pressure on *Strombus gigas* in Guadeloupe, since more than 15 years associate various regulations, education, and repression. Successive regulations aim to protect the juveniles, to lower the fishing pressure on

deep areas, and to leave sanctuaries free of any fishing. It has been extended this year from January to September. To enforce such various regulations is a heavy task which is very partially fulfilled. For example, it is possible to find *S. gigas*, sold in the market at week ends during the closed season and as well illegal size *S. gigas* without any reaction of the competent authorities. People have always a good reason to explaing why they do not comply with the regulation as they are not convinced of its usefulness and are not threatened by seizure and fines except on very special occasions.
Efforts to offer simple, reliable biological information as well to fishermen as to consumers have been developed for a good understanding of the scientific reason of legal constraints. Biological documents on the life of *S. gigas* are published and used for educational purposes. Several initiatives aim to educate the children between 10 and 14 yeasrs as they appear as the most receptive ones for environmental education. Amplification using television and radio broadcasting as well as local newspapers is used as frequently as possible, but it is difficult to evaluate the impact of such campaigns. All the efforts do not appear to lower the actual illegal fishing pressure on *S. gigas*, and it is necessary to develop a rather harsh campaign to keep *S. gigas* alive for the next generation, which may be more conscious of the importance of endangered species and nature conservation.

KEY WORDS: Queen conch, *Strombus gigas*, education, conservation

Assessing Populations of Queen Conch from the Mexican Caribbean: Maximum Sustainable Yield Levels and Stage-classified Demographic Models

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The queen conch, *Strombus gigas*, is a large marine gastropod that is widely distributed in sea grasses and on sandy bottoms throughout the Caribbean Sea. For centuries it has been one of the most valuable fisheries resources in the region, resulting in heavy stock exploitation. A variety of methods have been used to assess stock status relative to fishing pressure, however there are only a few studies that incorporate conch life-history and fishery parameters to guide the management of the species.

Queen conch vital rates and size/age structure depend on growth rate and body size, and to some extent on sex ratio. Queen conchs grow in shell length only until the onset of sexual maturity; adults do not grow in shell length but in shell lip thickness. Furthermore, individuals of the same age differ considerably in size; thus age and length alone do not provide sufficient information on fecundity or natural mortality, which are important elements used in the design of management strategies. Size increments (in length and lip thickness) from 458 marked and recaptured individuals were used in this study to develop a stage-classified demographic model to project different scenarios of mortality, fecundity and stage-structured (size-age) harvest; and to test the sensitivity of the rate of population increase (R_0) to changes in those parameters.

KEY WORDS: Queen conch, *Strombus gigas*, maximum sustainable yields, demographic models

Evaluacion de las Poblaciones del Caracol Rosado del Caribe Mejicano: Maximos Niveles de Producion Sostenibles y Modelos demograficos Stage-classified

El caracol rosado, *Strombus gigas*, es un gastrópodo marina grande que se distribuye extensamente en hierbas del mar y en fondos arenosos a través del mar del Caribe. Por siglos ha sido uno de los recursos más valiosos de las industrias pesqueras de la región, dando por resultado la explotación común pesada. Una variedad de métodos se ha utilizado para determinar la presión en relación con de la pesca del estado común, no obstante hay solamente algunos estudios que incorporan parámetros de la vida-historia y de la industria pesquera del conch para dirigir la gerencia de la especie. Las tarifas vitales del conch de la reina y la estructura de size/age dependen de tarifa de crecimiento y de tamaño de cuerpo, y a un cierto grado de cociente del sexo. Los conchs de la reina crecen en longitud de la cáscara solamente hasta el inicio de la madurez sexual; los adultos no crecen en longitud de la cáscara sino en grueso del labio de la cáscara. Además, los individuos de la misma edad diferencian considerablemente de tamaño; así la edad y la longitud solamente no proporcionan la suficiente información en fecundidad o la mortalidad natural, que son elementos importantes usados en el diseño de las estrategias de la gerencia. Los incrementos del tamaño (en grueso de la longitud y del labio) a partir del 458 marcada y de los individuos recobrados fueron utilizados en este estudio para desarrollar un modelo demográfico etapa-clasificado para proyectar diversos panoramas de la mortalidad, de la fecundidad y de la cosecha etapa-estructurada (de la tamaño-edad); y para probar la sensibilidad del índice del aumento de la población (R0) a los cambios en esos parámetros.

PALABRAS CLAVES: El caracol rosado, *Strombus gigas*,, producciones sostenibles máximas, modelos demográficos

Physical Properties of the Queen Conch *Strombus gigas* (Mollusca Gastropoda) and its Consequences on the Shell Growth Development

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ABSTRACT

The thermal, thermoelastic, mechanical and structural properties of the shell of the Queen conch (*Strombus gigas*) is presented. The evolution of these properties as a function of the shell growth in mollusks. Thermal properties show a typical high conductivity behavior of the aragonite materials, thermoelastic properties show the interaction of the organic with the inorganic matrix, mechanical properties show the high toughness of the aragonite biogenic material and X-ray diffraction study is used to monitor the texturization.

The consequences of our results on the development and susceptibility to thermal and mechanical stress is discussed and proposed an adequate rapport: Shell size *versus* different properties of the conch shells (thermal properties, thermoelastic properties, mechanical properties and texturization) in order to propose an adequate size for the rehabilitation programs

KEY WORDS: Queen conch, *Strombus gigas*, shell growth

Características Físicas del Caracol Rosado *Strombus gigas* (moluscos Gastropoda) y su Cosequencias en el Desarrollo y en el Crecimiento de la Concha

Las características termales, thermoelastic, mecánicas y estructurales de la cáscara del conch de la reina (gigas de Strombus) se presentan. La evolución de estas características en función del crecimiento de la cáscara en moluscos. Las características termales demuestran un alto comportamiento típico de los materiales del aragonite, demostración thermoelastic de la conductividad de las características la interacción del orgánico con la matriz inorgánica, demostración mecánica de las características la alta dureza del material biogénico del aragonite y el estudio de la difracción de la radiografía se utiliza para supervisar la textura. Las consecuencias de nuestros resultados en el desarrollo y la susceptibilidad a la tensión termal y mecánica se discuten y propusieron una simpatía adecuada: Descasque el tamaño

contra diversas características de las cáscaras del conch (características termales, características thermoelastic, características mecánicas y textura) para proponer un tamaño adecuado para las programas de la rehabilitación.

PALABRAS CLAVES: Caracol rosado *Strombus gigas,* desarrollo y crecimiento de la concha

Queen Conch (*Strombus gigas*), Genetics Analysis: Preliminary Results

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ABSTRACT

The queen conch (*Strombus gigas*) is a western Atlantic Gastropod and one of the Caribbean species in the family Strombidae. It is the most important.mollusk in the area. Due to the artisanal fisheries that the conch has .supported for centuries in the Caribbean Sea increased fishing pressures led .to the decline of the stock. Since the 1970s several private and public efforts are being made to recover the species from commercial exploitation, .but to date queen conch are still considered a "commercially threatened .species". My hypothesis is that queen conch populations throughout the Caribbean are interconnected due to larval transport resulting gene flow.among populations in different locations effectively creating a metapopulation .of queen conch in the Intra-Americas Sea. . If this is the case, international.efforts would need to be coordinated to ensure recovery of the species throughout the Intra-Americas Sea. In a preliminary analysis queen conch samples were collected, preserved, followed by DNA extraction and amplification with PCR methods, and surveyed for amplified fragment length polymorphisms (AFLP), a multi-locus DNA fingerprint technique. Results suggest a relatively genetic uniform species-specific fingerprint pattern in Strombus gigas from Andros Island, Bahamas and the possibility of
working with conch genomic DNA, which are important steps in future genetic studies of queen conch.

KEY WORDS: Queen conch, *Strombus gigas*, genetic analysis

Análisis de la Genética del Caracol Rosado *Strombus gigas:* Resultados Preliminares

El caracol rosado (*Strombus gigas*) es un gastrópodo y atlántico occidental de la especie del Caribe en la familia Strombidae. Es la mayoría del important.mollusk en el área. debido a las industrias pesqueras del artisanal que el conch tiene el supported por siglos en el mar del Caribe aumentó el to conducido las presiones de la pesca la declinación de la acción. Desde los años 70 se están haciendo varios esfuerzos privados y públicos de recuperar la especie de la explotación comercial, reina del but hasta la fecha que el conch todavía se considera "los species comercialmente amenazados". Mi hipótesis es que las poblaciones del conch de la reina a través del Caribe son interconectado debido a las poblaciones del gene flow.among del transporte que resultan larval en diversas localizaciones que crean con eficacia un conch de la reina del of del metapopulation en el mar de Intra-Ame'ricas. Si éste es el caso, international.efforts necesitaría ser coordinado para asegurar la recuperación de la especie a través del mar de Intra-Ame'ricas. En un conch de la reina del análisis del preliminar las muestras fueron recogidas, preservadas, seguidas por la extracción de DNA y la amplificación con métodos de PCR, y examinadas para los polimorfismos amplificados de la longitud del fragmento (AFLP), una técnica de la huella digital de la DNA del multi-lugar geome'trico. Los resultados sugieren un patrón species-specific uniforme relativamente genético de la huella digital en los gigas de Strombus de la isla de Andros, de Bahamas y de la posibilidad de trabajo con DNA genomic del conch, que son pasos importantes en los estudios genéticos futuros del caracol rosado.

PALABRAS CLAVES: Caracol rosado, *Strombus gigas*, análisis genético

Distribution and Abundance of Hawk Wing Conch (*Strombus raninus*, Gmelin, 1791) Larvae in the Florida Keys

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ABSTRACT

We examined the spatial and temporal distribution of larvae of the hawk wing conch (*Strombus raninus*), by conducting plankton samples in four sites in the Florida Keys from April 2000 to June 2002. Larvae were collected using a conical

plankton net (0.50 m diameter and 202 ìm mesh). At each site, duplicate 15 minutes surface plankton tows were made. Two stations were sampled at each site: one was over the back reef, (approximate 3 m water depth) and the other was approximate 1.5 km offshore (approximate 35 m water depth). In the laboratory, samples were sorted for *S. raninus*, larvae were counted, measured and classified as early (<500 ìm, mid (500-900 ìm) and late-stage (>900 ìm). A total of 305 larvae were collected during the sampled period. With exception of Molasses Reef, there were always more larvae offshore than nearshore. Looe Key had the highest percentage of larvae (58%), followed by Sombrero Reef (20%), Molasses Reef (11.5%) and Sand Key (10.5%). Late-stage larvae represented the 99.34%, whereas mid-stage represented 0.66%. No early stage larvae were found. Even when there was not a definite pattern, a higher larvae percentage occurred between April and August, with a highest percentage in April 2000 (29.4%), in 2001, the largest number of larvae was found in August (18.6%), whereas in 2002 the highest number occurred in May (7.2%). Based upon the larvae size, two recruitment periods could be possible for the species, one in May and another in September. The lack of early larvae stages may indicate low local larval production. Furthermore, the large numbers of late-stage larvae suggest that *S. raninus* larvae might originate in remote locations. Further research should examine these hypotheses.

KEY WORDS: Conch, Florida Keys, hawk wing, larvae, *Strombus raninus*

Distribución y Abundancia de Larvas del Caracol ala de Halcón (*Strombus Raninus*, Gmelin, 1791) en los Cayos de Florida

Nosotros examinamos la distribución espacio temporal de las larvas del caracol ala de halcón (*Strombus raninus*), mediante muestras plancton colectadas en cuatro sitios de los Cayos de Florida, de abril de 2000 a Junio de 2002. Las larvas se colectaron con una red cónica de plancton (0.50 m de diámetro y 202 ìm de luz de malla). En cada sitio se realizaron arrastres superficiales de 15 minutos de duracion por duplicado. Dos estaciones fueron muestreadas en cada sitio: una sobre el arrecife anterior (aproximadamente 3 m de profundidad) y la otra, aproximadamente a 1.5 km del arrecife (aproximadamente 35 m de profundidad). En el laboratorio las larvas de *S. raninus* se separaron, se contaron, y se midieron, clasificandose en tres estadíos: temprano (< 500 µm), medio (500-900 ìm) y final (>900 ìm). Se colectaron un total de 305 larvas durante todo el periodo de muestreo. Con excepción de Molasses Reef, siempre hubo mayor cantidad de larvas en las estaciones fuera de la costa que cerca de la costa. Loee Key fue el sitio con mayor porcentaje de larvas (58%), seguido por Sombrero Reef (20%), Molasses Reef (11.5%) y Sand Key (10.5%). El 99.34% de las larvas correspondió al último estadío de desarrollo, mientras que el estadío medio representó el 0.66%. No se encontraron larvas de estadío temprano. Aunque no hubo un patron definido, el mayor porcentaje de larvas

se presentó entre abril y agosto, con un mayor porcentaje en abril del 2000 (29.4%), en el 2001 el mayor porcentaje ocurrió en agosto (18.6%) y en 2002 la mayor cantidad de larvas se encontró en Mayo (7.2%). Considerando el tama?o de las larvas, puede afirmarse que existen dos periodos de reclutamiento importantes de la especie, uno en mayo y otro en septiembre. La ausencia de larvas de estadíos tempranos podría indicar una baja produccion local de larvas. Además, el gran número de larvas del último estadío sugiere que las larvas de *S. raninus* podrían originarse en sitios remotos. Investigaciones adicionales deberían examinar esas hipótesis.

PALABRAS CLAVES: Caracol ala de halcon, *Strombus raninus*, Cayos de Florida, larvas

Proyecto sobre Maricultivo del Caracol Rosado en la Península de Yucatán

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RESUMEN

El caracol rosado *Strombus gigas* es uno de los principales recursos pesqueros en el Caribe mexicano. Sin embargo, la pesquería de este molusco se encuentra en serio deterioro, debido a una sobre-explotación por la pesca ilegal. Recientemente, se ha planteado la necesidad de cerrar esta pesquería a través de una veda por tiempo indefinido en todo el estado de Quintana Roo, promovida por el propio sector pesquero. Ante tal problemática, el CRIP Puerto Morelos del INP, pretende retomar su experiencia previa en el cultivo del caracol rosado, para perfeccionar e implementar técnicas de larvicultivo, manejo de post-larvas y engorda de juveniles hasta alcanzar la talla comercial, con la finalidad de que los pescadores puedan cultivar juveniles en corrales marinos. Otros estudios han enfocado sus esfuerzos en liberar pequeños juveniles al medio natural para restaurar poblaciones dañadas, sin embargo este beneficio resulta en una competencia entre pescadores legales, pescadores furtivos y los propios depredadores naturales. La ventaja de la aproximación planteada aquí es que se garantiza un beneficio directo para los pescadores legales; contribuyendo de esta manera a la recuperación de las poblaciones naturales. La primera etapa de esta investigación es cultivo a escala menor, con larvicultivo en 200 lts, comparando la eficiencia de 2 técnicas: flujo continuo y filtración biológica, la engorda de 200 juveniles silvestres en un corral marino de 50 m^2. La segunda fase corresponde a un cultivo a gran escala, con

larvicultivo de 1,000 lts y engorda de juveniles producidos en cultivo; así como una fase de entrenamiento en la que las cooperativas de pescadores se adiestrarán en la técnica de engorda de juveniles en corrales. La Dra. Dalila Aldana, CINVESTAV, colaborará evaluando aspectos de la ecofisiología larval y la elaboración de una dieta artificial óptima para engorda de juveniles. Los resultados de este estudio serán el sustento técnico para plantear la transferencia de tecnología a los pescadores, y establecer en el CRIP Puerto Morelos un Centro de abastecimiento de semilla de caracol para los acuacultores de la región.

PALABRAS CLAVES: Caracol rosado, *Strombus gigas*, maricultura

A Project for the Mariculture of the Queen Conch in the Yucatán Peninsula

The queen conch, *Strombus gigas* is one of the principal fisheries resources in the Mexican Caribbean. However, the catch of this mollusc is in serious decline due to the over-exploitation as a result of illegal fishing. Recently, an indefinite closure of this fishery has been proposed for the whole state of Quintana Roo, based on suggestion from the fishermen, themselves. Faced with this issue, CRIP Puerto Morelos of INP, aims to use its previous experience in culturing the queen conch, to refine and implement techniques of larval culture, to maintain post larval stages and to raise juveniles until they reach legal catch size, with the goal to fishermen can culture juveniles in cages. Another studies have been based on small juveniles are released into the wild to grow to legal size, however this benefit results in a competition between legal fisherman with illegal fisherman and natural predators. The advantage of the approach outlined here is that it guarantees a direct benefit to the legal fishermen, thereby contributing significantly to the recovery of the natural populations. The first stage of this research is small-scale larval culture in 200 L tanks, comparing the efficiency of two techniques: continuous flow and biological filtration. The raising of 200 wild juveniles would be done in 50 m^2 cages in the sea. The second phase is on a big scale using 1,000 L tanks for larval and juvenile culture; as well as a training phase, where the fisheries co-operatives are taught how to raise the juveniles in cages. Dr. Dalila Aldana, CINVESTAV, will collaborate in evaluating aspects of larval ecophysiology and the development of an optimal artificial diet for raising juveniles. The results of this study will be the development of techniques, which can be passed on to the fishermen, and to establish CRIP Puerto Morelos as a center for the distribution of larval stages of queen conch to aquaculturists at the region.

KEY WORDS: Mariculture, queen conch, *Strombus gigas*

Estudio Comparativo de la Dinámica Alimenticia de Larvas de *S. gigas*, en Función de la Edad y de la Dieta

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RESUMEN

Se presenta un análisis comparativo de la dinámica de alimentación de larvas velígeras de *Strombus gigas* de 1, 10 y 18 días de edad alimentadas con cinco diferentes dietas microalgales: *T. suecica, T. tetrathele, C keslleri, Chlorella sp. y C. cerastoporum.* La dinámica alimenticia fue estudiada mediante la observación directa de la ingestión de alimento y su subsecuente digestión, utilizando la técnica de microscopía de epifluorescencia. La evolución de los procesos de ingestión y digestión fue observada a cada hora durante 8 horas, y a 24 horas después administrado el alimento. Se trabajo a una densidad larval de 100 larvas/L y a una temperatura de 28°C. Todas las observaciones fueron realizadas con larvas vivas. Para comparar el comportamiento alimenticio entre las dietas microalgales y edad larval se utilizaron dos índices: índice absoluto de ingestión (I.A.I.) , e índice absoluto de digestión (I.A.D.). Para cada estadio larval, también fue posible realizar un análisis cualitativo del llenado del estómago, en función de la dieta utilizada.

Para las tres edades estudiadas, el grado de ingestibilidad y digestibilidad fue mayor en las larvas alimentadas con *T. suecica y T. tetrathele*. En las larvas de 1 día alimentadas con *Chlorella* sp. y *C. cerastoporum* no se observó ingestión, ni digestión. Con estas dietas, las larvas de 10 días presentaron un I.A.I. de 25 %, y un I.A.D. de cero. A 18 días, *C. cerastoporum* fue ingerida y digerida, sin embargo; el I.A.I. fue de 6 5% y el I.A.D. de 40 %. De acuerdo con estos resultados, se confirma *T. suecica* como dieta adecuada para el cultivo larval de *S. gigas* y se sugiere el uso de *T. tetrathele* como alimento potencial. Asimismo, no se recomienda el uso de *C. cerastoporum* y *Chlorella* sp. sobre todo en las primeras etapas de desarrollo larval.

PALABRAS CLAVES: Molusco, larva, *S. gigas*, ingestión-digestión, microalga

Comparative Study of Feeding Dynamics of *S. gigas* Larvae as a Function of Age and Diet

This study was a comparative analysis of feeding dynamic of 1, 10 and 18 days-old *Strombus gigas* veliger larvae fed five different algae diets: *T. suecica, T. tetrathele, C keslleri, Chlorella sp. y C. cerastoporum.* Feeding dynamic was studied by direct observation of ingestion and digestion process with epifluorescences

microscopy. The evolution of ingestion and digestion process was observed each hour during 8 hours, and 24 hours after feeding supply. Density was 100 larvae?l^{-1} and temperature was kept at 28 °C. All observations were done with alive larvae. To compare feeding behavior between the different algae diets and larval age, two indices were used: absolute ingestion index (A.I.I.) and absolute digestion index (A.D.I.). A qualitative analysis of the stomach filling was done to each larval stage according to the different diets used.

For the three larval ages, ingestibility and digestibility were larger in larvae fed *T. suecica y T. tetrathele*. It was not observed both ingestion and digestion on one day-old larvae fed *Chlorella* sp. y *C. cerastoporum*. Ten days-old larvae fed these diets showed an A.I.I. of 25% and A.D.I. of cero. At 18 days-old *C. cerastoporum* was ingested and digested; however the A.I.I. was 65% and the A.D.I. 40%. According to these results, it is confirmed the use of *T. suecica* as a suitable diet to rear *S. gigas* larvae, and it is suggested *T. tetrathele* as a potential feeding. It is not recommended the used of *C. cerastoporum* y *Chlorella* sp. mainly in the first stages of larval development.

KEY WORDS: Mollusk, larvae, *S. gigas*, ingestion-digestion, microalgae

Abundance of *Strombus gigas* Larvae in the North of the Yucatan Peninsula

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ABSTRACT

An abundance study of *Strombus gigas* larvae was realized at north of Yucatan Peninsula, between Caribe Sea and the Alacranes reef, into isobaths of 5 m and 50 m. This study was at july and october of 2001 and march of 2002 in 27 sites. Plankton tows were made for 15 minutes at 1 m/s with a bongo net that had a 0.5 m diameter opening and 202 μm mesh size. Plankton samples were preserved in a 10% neutral formaldehyde-seawater mixture. In the laboratory, the entire volume of each plankton sample was sorted for *Strombus* veligers following the descriptions of Davis et al. (1993). The *Strombus* populations at north of Yucatan Peninsula are

included *Strombus gigas* (Arrecife Alacranes) and *Strombus costatus* (all north coast of Peninsula de Yucatan). The high abundance of *Strombus* larvae (600 larvae/tows) were collected for july, at NW study area into Alacranes reef. At NE of Yucatan Peninsula we found a density of 4 larvae/tows. At N of study area we do not found *Strombus* larvae. With the results we concluded that Alacranes reef is an important area for larval supply to *Strombus gigas* nurseries in the north of Yucatan Peninsula.

KEY WORDS: *Strombus gigas*, abundance, larvae, Alacranes reef

Abundancia de Larvas del Género Strombus en la Costa Norte de la Península de Yucatán

Se realizó un estudio de abundancia larvaria del género Strombus en el Norte de la Península de Yucatán, entre el Mar Caribe y el Arrecife Alacranes, dentro de las isóbatas de los 5 m y los 50 m. El trabajo se efectuó durante los meses de julio y octubre del 2001 y en marzo del 2002, en 27 sitios de muestreo. Los arrastres se realizaron de forma superficial con una red tipo Bongo, durante 15 minutos a una velocidad de 1 metro por segundo. Las muestras obtenidas fueron fijadas en formaldehido en agua de mar al 10% y neutralizadas con Borato de Sodio. Las larvas de Strombus fueron separadas del resto de los gasterópodos tomando como referencia la guía de Davis *et al.* (1993). Las poblaciones de adultos de Strombus en el Norte de Yucatán incluyen las especies de *Strombus gigas* (Arrecife Alacranes) y *Strombus costatus* (Total de la costa Norte de Yucatán). La mayor abundancia de larvas de Strombus (600 larvas por arrastre) fue encontrada en el mes de julio, al NW del área de estudio dentro de la laguna del Arrecife Alacranes. Al NE de la Península de Yucatán, se encontró una densidad de 4 larvas por arrastre. Al Norte del área de trabajo, no se observaron larvas de Strombus. Los resultados indican que el Arrecife Alacranes es un sitio fundamental de existencia de larvas de Strombus lo cual lo ubica como sitio CLAVES para el mantenimiento de las poblaciones de Strombus en el Norte de la Península de Yucatán.

PALABRAS CLAVES: *Strombus gigas*, abundance, larvae, Alacranes reef

Improving the Culture Conditions of Juvenile Queen Conch (*Strombus gigas* Linné) for Restocking Purposes

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ABSTRACT

Overfished queen conch stocks in the Caribbean and Florida may be replenished with the release of hatchery-reared juveniles. In past wild stock enhancement studies, it was found that the thin shells of the hatchery-reared juvenile queen conch caused a large number of mortalities. Two factors determined to play a role in the shell morphology of the juvenile conch include stocking density and tank substrate. Experiments were designed to test differences in growth rate, shell weight to meat weight ratio, shell strength, survival, and burying of juvenile queen conch between different densities and substrates. Stocking densities were 20, 50, 75, 200, and 400 conch/m^2 and the tank substrates included crushed coral aragonite, aragonite chips, and plastic liner. Consistent with previous research, juvenile conch grown in lower stocking densities statistically grew faster in shell length and animal weight than conch grown in higher densities. However, there were no statistical differences in growth rates between conch grown in 200 and 400 conch/m^2. Conch grown on crushed coral aragonite grew significantly faster than conch grown on plastic liner but at similar rates to conch grown on aragonite chips. Preliminary data suggests that there are no significant differences in shell weight to meat weight ratios or shell strength between conch grown in different densities. Survival was lowest in conch grown in high stocking densities and on plastic liner. Burying occurred more frequently with conch stocked at high densities. In order to increase growth rate, to lower hatchery costs, and increase shell strength to enhance the chance of survival after release into the wild, it is recommended that juvenile queen conch be grown at a stocking density of 75 conch/m^2 on crushed coral aragonite.

KEY WORDS: Queen conch, *Strombus gigas*, mariculture

Mejorarando las Condiciones ce la Cultura de la Reina Juvenil Concha (*Strombus gigas* Linné) para Propósitos que Vuelven a Surtir

La pesca excesiva de la concha de la reina en el Caribe y la Florida se puede

rellenar con la siembra de juveniles criadero-alzados. En últimos estudios fue encontrado que el caparazón fino de juveniles de concha causaron una gran cantidad de mortalidades. Dos factores que determinarón desempeñar un papel en la morfología de la caparazón de los juveniles de concha incluyen, densidad de siembra y el substrato del tanque. Los experimentos fueron diseñados para probar diferencias en incrementos proporcional del crecimiento, peso del caparazon al cociente del peso de la carne, fortaleza del caparazon, supervivencia, y el enterraminto de juveniles de concha reino entre diversas densidades y los substratos. Las densidades de la media eran 20, 50, 75, 200, y 400 concha/m^2 y el aragonite coralino machacado incluido los substratos del tanque, las virutas del aragonite, y el trazador de líneas plásticas. Pievias investigación anterior en concha juvenil crecido en densidades más bajas de la media creció estadístico más rápidamente en longitud del caparazón y peso del animal que la concha crecida en densidades más altas. Sin embargo, no había diferencias estadísticas en incrementos proporcional concha crecida en 200 y 400 concha/m^2. La concha crecida en aragonite coralino machacado creció perceptiblemente más rápido que concha crecida en trazador de líneas plásticas pero en las tarifas similares de concha crecido en virutas del aragonite. Los datos preliminares sugieren que no hay diferencias significativas en peso de la cáscara a los cocientes del peso de la carne o fuerza de la cáscara entre concha crecido en diversas densidades. La supervivencia fue más baja en la concha crecida en altas densidades de la media y en trazador de líneas plásticas. Enterramiento ocurrió más con frecuencia con la concha sambrada en las altas densidades. Para aumentar tarifa de crecimiento, reducir los costos de los criadero, y aumentar la fortaleza del caparazón para realzar la ocasión de la supervivencia después del lanzamiento en el salvaje, se recomienda que los juveniles de concha reina esten a una densidad de la media de 75 concha/m^2 en aragonite coralino machacado.

PALABRAS CLAVES: Conch de la reina, *Strombus gigas*, maricultura

Determinación de la Tasa de Crecimiento, Estudio Fisiológico, Energético y Gonadal en el Genero *Strombus* (Mesogastropoda: Strombidae)

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En Panamá se han realizado escasos reportes que informen sobre el peligro que afronta el genero *Strombus*, ni como dicha riqueza pueda ser protegida y cultivada, como lo han hecho en diversos países que están trabajando en la repoblación de

varias especies de la Familia Strombidae (Aranda & Suárez 1998, Brownell, W. N. 1977, Davis & Stoner 1994). Este trabajo es un proyecto complejo, el cual presenta datos morfológicos, fisiológicos y bioquímicos para estudiar la relación de dichos parámetros con el desarrollo gonadal del gasterópodo *Strombus raninus* Gmelin. Además se realiza una comparación del crecimiento y la fisiología de *S. raninus* con *S. gracilior*. En este proyecto se colectaron 82 individuos de la especie *S. raninus* en la Costa de Colón, Mar Caribe y 28 individuos de *S. gracilior* en Playa Chumical, Océano Pacifico. Se eligieron al azar 30 animales de *S. raninus* para determinar el porcentaje de carbohidratos, lípidos y proteínas a diferentes partes del cuerpo, mientras que parte de las gónadas fueron tratadas por métodos histológicos teñidas con hematoxilina B eosina y montadas en placas para su observación. Otros 20 individuos de cada especie de *S. raninus* y *S. gracilior* fueron sometidos a pruebas fisiológicas (consumo de oxígeno y excreción de amonia) cada 15 días por un período de 3 meses. Al finalizar los mismos 20 animales de *S. raninus* fueron sometidos igualmente a pruebas bioquímicas y observación de las gónadas en placas. En este proyecto se espera que los resultados expresen una relación entre el crecimiento, cambios fisiológicos y bioquímicos con respectos al estado de madurez gonadal y determinar diferencias fisiológicas entre especies de ambos mares.

PALABRAS CLAVES: *Strombus*, datos morfológicos, fisiológicos y bioquímicos, tasa de crecimiento

Determination of the Growth Rate, Physiology, Energy and Gonad Studies within Genus *Strombus*

There have been few reports in Panama that informs about the risk that faces the genus *Strombus* and how can it be protected and cultivated, like it has been done in other countries that are working in the repopulation of various species of the Strombidae (Aranda and Suarez 1998, Brownell, W.N. 1977, Davis and Stoner 1994).

This project is very complex, in which morphology, physiology, and biochemical data is presented to study the relation between the data presented and the gonad development of gastropod *Strombus raninus* Gmelin. Furthermore a comparison of the growth and physiology between the *S. raninus* and the *S. gracilior* is also made. In this project 82 individuals from the specie *S. raninus* were collected in the Coast of Colon, in the Caribbean Sea and 28 individuals of the *S. gracilior* were collected in Playa Chumical, in the Pacific Ocean. Thirty animals were random selected of *S. raninus* to determined the percentage of carbohydrates, lipids and proteins of different parts of the body, also parts of the gonads were treated on histological methods, dyed with hematoxiline - eosine and mounted in slides for observation. Another 20 individuals of each species of S. *raninus* and *S. gracilior* where submitted to physiological test (consumption of oxygen and ammonia excretion) every 15 days during a 3 months period. Next the same 20 animals of *S. raninus* where submitted to biochemical test and observation of the gonads in slides.

In this project is expected that the results express a relation between the growth, physiology and biochemical changes within the state of the gonad maturity and determined the physiological differences between the species of both seas.

KEY WORDS: *Strombus*, morphological, physiological and biochemical data, growth rate

Características Físicas del Milk Conch *Strombus costatus* (moluscos Gastropoda) y su Cosequences en el Desarrollo de la Concha

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RESUMEN

Las características termales, thermoelastic, mecánicas y estructurales de la cáscara del conch de la reina (*Strombus gigas*) y se presentan. La evolución de estas características en función del crecimiento de la cáscara en moluscos. Las características termales demuestran un alto comportamiento típico de los materiales del aragonite, demostración thermoelastic de la conductividad de las características la interacción del orgánico con la matriz inorgánica, demostración mecánica de las características la alta dureza del material biogénico del aragonite y el estudio de la difracción de la radiografía se utiliza para supervisar la textura. Las consecuencias de nuestros resultados en el desarrollo y susceptibilidad a la tensión termal y mecánica se discuten y propusieron una simpatía adecuada: Descasque el tamaño contra diversas características de las concha del caracol (características termales, características thermoelastic, características mecánicas y textura) para proponer un tamaño adecuado para los programas de la rehabilitación:

PALABRAS CLAVES: Ordeñe el conch, *Strombus gigas*, características de la concha.

Physical Properties of the Milk Conch *Strombus costatus* (Mollusca Gastropoda) and its Consequences on the Shell Growth Development

The thermal, thermoelastic, mechanical and structural properties of the shell of the Queen conch (*Strombus gigas*) and is presented. The evolution of these properties as a function of the shell growth in mollusks. Thermal properties show a typical high conductivity behavior of the aragonite materials, thermoelastic properties show the interaction of the organic with the inorganic matrix, mechanical properties show the high toughness of the aragonite biogenic material and X-ray diffraction study is used to monitor the texturization.
The consequences of our results on the development and susceptibility to thermal and mechanical stress is discussed and proposed an adequate rapport: Shell size versus different properties of the conch shells (thermal properties, thermoelastic properties, mechanical properties and texturization) in order to propose an adequate size for the rehabilitation programs

KEY WORDS: Milk conch, *Strombus costatus*, shell properties

Potencial para el Transporte y Retención de Larvas de *Strombus gigas* en ll Parque Nacional Archipiélago de Los Roques, Venezuela

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RESUMEN

Se examinó el potencial para transporte y retención de larvas de *Strombus gigas* en el Parque Nacional Archipiélago de Los Roques. Los muestreos se realizaron entre el 22 y el 28 de agosto de 1998. Las muestras se colectaron en 18 estaciones, 10 dentro del archipiélago y 8 en las aguas exteriores a su plataforma (5 y 10 millas, en dirección de cada uno de los puntos cardinales). Las colecciones se hicieron por duplicado y superficiales (2 m), usando mallas de plancton de 202 ?m de abertura. Se detectaron un total de 84 veliger, en 11 de las estaciones evaluadas. Las mayores concentraciones se observaron en las localidades interiores del archipiélago (entre 3.78 y 6.32 ind./100 m^3), encontrándose una importante representación de larvas en estaciones oceánicas ubicadas al este y al suroccidente del archipiélago. Fueron pocas las larvas encontradas al norte de la laguna interna, así como al sur del archipiélago. El 47.6% de los individuos se encontró en el intervalo de talla correspondiente a las larvas recién eclosionadas (entre 150 y 450 μm), ubicándose

la mayoría de estos en aguas interiores, al oeste del archipiélago. Un 34.5 % de las larvas, también en aguas interiores, midió entre 451 y 700 μm, estimándose que las mismas podrían tener aproximadamente 5 días de vida. Las larvas de mayor tamaño, algunas cercanas al reclutamiento se observaron en las estaciones oceánicas. Obviamente, existe un patrón interesante de distribución y abundancia de larvas de *S. gigas* en el archipiélago, el cual debe estar directamente relacionado con la ubicación de los bancos donde se depositan las masas de huevo y los patrones de corrientes y contracorrientes locales, que en definitiva se encargan de dispersar y retener las larvas dentro de la plataforma.

PALABRAS CLAVES: *Strombus gigas*, transporte y retención, Parque Nacional Archipiélago de Los Roques

Potential for *Strombus gigas* Larval Transportation and Retention in the Los Roques Archipelago National Park, Venezuela

The potential for *Strombus gigas* larval transportation and retention was study in the Los Roques Archipelago National Park. Sampling was conducted in august 1998 (22 to 28). Samples were collected at 18 sites, 10 within the archipelago and 8 outside of its platform (5 and 10 nm off, in the direction of each cardinal point). Duplicate and superficial plankton tows were collected using a net with 202 ?m mesh. A total of 84 veligers were detected, in 11 of the evaluated stations. The highest concentrations were observed within the archipelago (between 3.78 and 6.32 ind./100 m^3), being an important representation of larvae in the oceanic stations located to the east and southwest of the archipelago. Few larvae were found to the north of the internal lagoon, nor to the south of the archipelago. A 47.6% of the observed individuals were in the size interval corresponding to recent hatch larvae (between 150 and 450 μm), being most of these located in the internal stations. A 34.5% of the larvae, also within the archipelago, measured between 451 and 700 μm, being considered to be 5 days old. The larger veligers, some of them near to recruitment, were observed in the oceanic stations. Obviously, an interesting pattern exists for the distribution and abundance of *S. gigas* in the archipelago, which should be directly related with the location were egg masses are being layed, and the patterns of currents and countercurrents that are responsible to disperse or retain the larvae within the platform.

KEY WORDS: *Strombus gigas*, larval transportation and retention, Los Roques Archipelago National Park

Evaluacion Bio-ecologica y Historico-cultural de los Concheros de Botuto (*Strombus gigas*) en el Parque Nacional Archipielago de Los Roques, Venezuela

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RESUMEN

El presente proyecto de investigación tiene como objetivo el rescate del valor cognoscitivo que se encuentra asociado a los enormes amontonamientos de conchas de botuto (*Strombus gigas*), dispersos en varios cayos del Archipiélago de Los Roques. La historia de algunos de estos concheros se remonta a más de 3000 años del presente, mientras que otros son de origen reciente. El estudio, financiado a dos años por el Fondo Nacional de Ciencia, Tecnología e Innovación (FONACIT), involucra la reconstrucción histórica de la bio-ecología y pesquería del recurso, a la vez que recupera la valiosa información arqueologica que atesoran los mismos. Uno de los aspectos más interesante de la propuesta es su carácter interdisciplinario, el cual a permitido reunir a biólogos, ecólogos y arqueólogos en una única forma de enfrentar la problemática logística y estructural que representa el trabajar con estos mega-concheros, sin afectar el contexto de una de las disciplinas. La metodología a emplear involucra el trabajo *in situ* con los concheros, lo que permitirá establecer su ubicación exacta, la determinación de su volumen y la estimación del número de conchas acumuladas en los diferentes periodos de explotación. Igualmente, se procederá a datar la edad de los concheros de manera absoluta y relativa mediante el uso de carbono 14. El análisis poblacional de las conchas en cada estrato cronológico facilitará en entendimiento de los diferentes regímenes de pesca a los que se ha visto sometido el recurso, a la vez que permitirá evaluar los periodos de recuperación del mismo. El amplio espectro de la investigación permitirá formular recomendaciones en el orden de manejo pesquero, conservación del recurso, aprovechamiento económico, realce social, rescate histórico-cultural y desarrollo científico.

PALABRAS CLAVES: *Strombus gigas*, conchas de botuto, histórica de la bio-ecología y pesquería

Historico-cultural and Ecological Evaluation of the Queen Conch (*Strombus gigas*) in the National Park Archipelago of Los Roques, Venezuela.

The present investigation has as an objective to determine the cultural value associated with the enormous accumulations of shells of botuto (*Strombus gigas*), dispersed in several keys of the Archipelago of the Roques. The history of some of these conch middens goes back to more than 3000 years of the present, whereas others are of recent origin. The study, financed to two years by the National Foundation of Science, Technology and Innovacion (FONACIT), involves the historical reconstruction of the bio-ecology and fishery of the resource, simultaneously recovering their valuable archeological information. One of the aspects most interesting of the proposal is its interdisciplinary character, which brings together biologists, ecologists and archaeologists share in the logistical and structural challenges that represents working with these conch middens without affecting the context of one of the disciplines. The methodology to use involves the work in situ with the concheros, which will allow to establish its exact location, the determination of its volume and the estimation of the number of accumulated shells in the different periods from operation. Also, it will allow for an accuarate dating of the middents from absolute and relative way by means of the use from carbon 14. The population analysis of the shells in each chronological layer will facilitate understanding of the different regimes of fishing from which has been put under the resource, and to evaluate the periods of recovery. A major aspect of the investigation will allow to formulate recommendations in the order of fishing handling, conservation of the resource, economic advantage, social enhancement, rescues historical-cultural and scientific development.

KEY WORDS: *Strombus gigas*, shells of botuto, historical of the bio-ecology and fishery.

Conch Heritage Network: Preserving Queen Conch for Future Generations

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ABSTRACT

The Conch Heritage Network was established in September 2001 with the goal of working with the communities of South Florida and the Caribbean to help preserve and restore depleted queen conch, *Strombus gigas*, populations. It is comprised of scientists from Harbor Branch Oceanographic Institution (Harbor Branch), Mote Marine Laboratory (MML), and the Florida Fish and Wildlife Conservation Commission (FFWCC).

Restoring overfished queen conch populations will occur with the aid of fisheries management, conservation education, aquaculture, and stock enhancement. Harbor Branch researchers established the first captive-breeding program for queen conch with funding assistance from Project AWARE. Eggs from captive and wild adults are being cultured for juvenile growth and restocking studies. With funds from the Disney Wildlife Conservation Fund, Harbor Branch and MML are determining the optimal culture conditions, such as density and substrate, to improve the shell strength and survival of conch released in the field. The FFWCC has examined variables that limit the survival of hatchery-reared outplants in order to establish queen conch stocking criteria for the Florida Keys. Scientists at FFWCC together with The Nature Conservancy and the U.S. Fish and Wildlife Service are also implementing a transplant program to increase the Florida queen conch spawning stock. They are also examining the origins of larvae recruiting to Florida since any restoration effort must address sources of recruits. The Conch Heritage Network raises awareness of the historical, socio-economic, and environmental value of queen conch as well as the importance of best management practices by conducting lectures and distributing brochures and posters as conservation-education outreach tools. The "Conch in the Classroom" field activity is a favorite hands-on program for students and teachers visiting Harbor Branch's conch hatchery and nursery. An informative website (www.savetheconch.org) documents research, student activities, general life history, and culture information on conch.

With a focus on conservation, research, education, and restoration, the Conch Heritage Network is a successful research and outreach program, and a voice for the legacy of the queen conch.

KEY WORDS: Queen conch, *Strombus gigas*, conservation

Conch Heritage Network: Preservando la Concha Reina para las Generaciones Futuras

La Conch Heritage Network fue establecida en Septiembre de 2001 con la meta del trabajo con las comunidades de la Florida del sur y el Caribe a ayudar a preservar y a restaurar los poblaciones de el conch de la reina, *Strombus gigas*. Se abarca de científicos de HARBOR BRANCH Oceanographic Institution (Harbor Branch), Mote Marine Lab (MML), y la Florida Fish and Wildlife Conservation Commission (FFWCC).

La restauración del conch de la reina que las poblaciones que son pescado excesivo ocurrirán con la ayuda de la gerencia de las industrias pesqueras, la educación de la conservación, la acuacultura, y el realce común. Los investigadores de Harbor Branch establecieron el primer programa de cautivo-crianza para el conch de la reina con ayuda de financiamiento del proyecto AWARE . Los huevos de los adultos cautivo y salvajes, se están cultivando para el crecimiento juvenil y los estudios de rellenar. Con los fondos del Disney Wildlife Conservation Fund, Harbor Branch y MML están determinando las condiciones óptimas de la cultura, tales como densidad y substrato, para mejorar la fuerza de la cáscara y la supervivencia del conch relezar en el campo. El FFWCC ha examinado las variables que limitan la supervivencia de los animales que son criadero-alzados, para establecer los criterios de la media del conch de la reina para los cayos de la Florida. Los científicos en FFWCC junto con la Nature Conserverancy y el U.S. Fish and Wildlife Service también están poniendo un programa del trasplante para aumentar el conch de la reina de la Florida. También están examinando los orígenes de las larvas que reclutan a la Florida, puesto que cualquier esfuerzo de la restauración debe tratar fuentes de reclutas. La Conch Heritage Network, trae a la vanguardia el conocimiento del valor histórico, socioeconómico, y ambiental del conch de la reina tan bien como la importancia de las mejores prácticas de gerencia conduciendo conferencias y distribuyendo folletos y carteles. El "Conch in the Classroom" es un programa preferido para los estudiantes y los profesores que visitan el criadero del conch de Harbor Branch. Un website informativo (www.savetheconch.org) documenta la investigación, actividades del estudiante, historia general de la vida, y la información de la cultura sobre conch. Con un foco en la conservación, la investigación, la educación, y la restauración, la Conch Heritage Network es una voz para la herencia del conch de la reina.

PALABRAS CLAVES: Conch de la reina, *Strombus gigas*, preservar, conservación,

Towards a Holistic Strategy to Managing Florida's Queen Conch (*Strombus gigas*) Population

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ABSTRACT

The Florida Keys once had thriving commercial and recreational queen conch fisheries. In the mid 1980s, all harvest was banned due to concerns over the declining population. On its own, the population was slow to recover; therefore, we began seeking a proactive restoration strategy. After evaluating releases of hatchery juveniles, we adopted a transplantation approach based upon research that demonstrated that non-reproductive conch inhabiting the nearshore zone began reproducing when transplanted offshore into spawning aggregations. Furthermore, the conch found nearshore cannot migrate to breeding aggregations offshore. To maximize the contribution these conch make to the recovery of the local stock, it is critical to transplant them into aggregations where the larvae that are produced there have a high probability of retention in the Keys waters. Therefore, we are also examining the origin of larvae recruiting to the Keys by conducting plankton surveys and combining these results with satellite imagery and hydrological data. All past and current research and the implementation of the transplantation program uses an extensive base of community volunteers. Taken together, an approach that combines transplantation with metapopulation theory and is implemented with the assistance of local volunteers appears to be an effective strategy for restoring Florida's conch population.

KEY WORDS: Queen conch, larvae, restoration, stock assessment, recruitment

Hacia una Strategia Holistica para Restaurar la Población del Caracol reina en la Florida

Los Cayos de Florida tuvieron pesquerías (comercial y recreacional) abundantes para el cobo. En los 1980s toda la pesca fue prohibida debido a preocupaciones por una declinación de la población. La población fue lenta para recuperarse; por lo tanto, comenzamos a buscar una estrategia de restauración activa. Después de evaluar la eficacia de soltar juveniles cultivados, hemos adoptado un estrategia de trasplante basado en una investigación que demostró que cobos que habitan la zona adyacente a la costa nunca se reproducen; toda la reproducción ocurre cerca del arrecife. Además, los cobos que se encuentran en la zona adyacente a la costa no

pueden emigrar a las agregaciones de cría más remotas. Sin embargo, cobos trasplantados de la zona adyacente a la costa en agregaciones criadoras comienzan a reproducirse después de aproximadamente seis meses. Para maximizar la contribución que estos cobos hacen a la recuperación local, es crítico trasplantar cobos en agregaciones con probabilidades altas de que las larvas producidas allí se recluten a los Cayos. Estamos examinando el origen de larvas que reclutan a los Cayos por muestreos de plancton y estamos combinando estos resultados con imágenes de satélite e hidrología. Toda las investigaciónes pasadas, y actuales, y el programa de trasplante usan voluntarios. Tomados juntos, este método que combina el trasplante con la teoría de metapoblaciones y puesto en práctica con la ayuda de voluntarios locales parece ser una estrategia eficaz para restaurar la población de cobo en la Florida.

PALABRAS CLAVES: Caracol reina, larvas, restaurar

Situación de la Pesca del Caracol, *Strombus gigas*, en Nicaragua

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RESUMEN

La pesca del la concha reina *Strombus gigas* está localizada en le región noreste del Caribe nicaragüense. Tradicionalmente este recurso ha sido capturado "incidentalmente" por buzos que se dedican a la captura de langosta. Antes de 1997 los desembarques de concha reina eran reportados junto con los desembarques de otras especies de poco interés comercial. Los desembarques de carne limpia de *S. gigas* se han incrementado de 17 toneladas métricas (tm) en 1997 a 113 tm en 2001, y las exportaciones de 8 tm a 45 tm, respectivamente. Los volúmenes de exportación se rigen por cuotas establecidas de acuerdo con CITES; que en 1997 definió en 20 tm, incrementándose a 45 tm a partir del 2001. Se desconoce el volumen del consumo local. No existen estudios que definan el potencial aprovechable. Sin embargo, de acuerdo a experiencias regionales y a muestreos biológicos locales, se considera que el recurso está subexplotado y se ha sugerido una talla minima de captura (longitud sifonal) de 200 mm. La administración pesquera nacional y la empresa privada hacen esfuerzos para evaluar el recurso y definir una nueva cuota de captura de acuerdo a la capacidad biológica del recurso. El Gobierno carece de recursos y no tiene capacidad para controlar la pesca y el tráfico ilegal por y hacia paises vecinos.

PALABRAS CLAVES: Caracol reina, *Strombus gigas*, pesqueria, Nicaragua

The Status of the Fishery for Queen Conch, *Strombus gigas*, in Nicaragua

The fishing of the snail is located in the northeast region of Nicaraguan Caribbean; traditionally the resource has been captured "incidentally" by divers that dedicate themselves to the lobster catch, reason why the statistics of landings are begun to register as of 1997, since before this date the few landings volumes were registered grouped with other species of little interest. The landings of snail (clean meat) have been increased of 17 ton. in 1997 to 113 ton. in 2001, and the exports of 8 to 45 ton for the same years. The volumes of export are governed by quotas established in agreement with CITES, which were defined from 1997 as 20 tons. and increased to 45 tons in 2001. The volume of local consumption is not known. Studies do not exist that define the usable potential, however, according to regional

experiences and to local biological samplings, it is considered that the resource is subexploded and a minimum length capture (siphonal length) of 200 mm has been suggested. The national fishing administration and private companies differ in their evaluation of the resource and to define a new quota of capture according to the biological capacity of the resource. The state does not have capacity to control the fishing and the illegal traffic by and towards neighboring countries.

KEY WORDS: Queen conch, *Strombus gigas*, fishery, Nicaragua

ABSTRACTS OF POSTER SESSION

55TH GULF AND CARIBBEAN FISHERIES INSTITUTE

A Preliminary Study of the Fisheries Canane (*Ocyurus chrysurus*) in Holbox, Quintana Roo, Mexico

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In this study it was considered in a preliminary way the age and the growth of the yellowtail (*Ocyurus chrysurus*, Bloch 1791) in the Island of Holbox, Quintana Roo during the period March-May of the 2002. The yellowtail is a characteristic tropical fish of the reef areas, belonging to the family Lutjanidae, this species is found distributed from Florida to Brazil being more abundant in the Gulf of Mexico. A total of 871 organism captured by the handmade fleet of community of Holbox were obtained, using the hook and line like fishing art. For the estimate of the age and the populational parameters they used the lenght frequencies of the three worked months. It was observed that the biggest capture incidence is among the sizes 255 and 275 mm FL, with a stocking of 265 mm FL. The populational parameters obtained through the software FiSAT were for ELEFAN Loo= 500.50, k= 0.33 and to= -0.19 and by means of Shepherd´s Loo= 520.05, k= 0.30 and to= -0.22. The intervals of lenght frequency were also used to determine the relationship between lenght and weight with a n= 659 organisms; the result of the regression was $W=0.00004334FL^{2.8105}$. The curve of growth was carried out for the von Bertalanffy equation where $Lt= 500.5\ (1-e^{-0.33(t+0.19)})$ for ELEFAN and $Lt= 520.05\ (1-e^{-0.30(t+0.22)})$ for Shepherd´s. The knowledge of the populational parameters is of supreme importance to guarantee an appropriate handling of this resource, as well as its conservation for the future generations.

KEY WORDS: Yellowtail snapper, *Ocyurus chrysurus*, population parameters

Estudio Preliminar de la Pesqueria de Canane (*Ocyurus chrysurus*) en Holbox, Quintana Roo, México

En este estudio se estimó de manera preliminar la edad y el crecimiento del canane (*Ocyurus chrysurus*, Bloch 1791) en la Isla de Holbox, Quintana Roo durante el periodo Marzo-Mayo del 2002. El canane es un pez tropical característico de las zonas arrecifales, perteneciente a la familia Lutjanidae, esta especie se encuentra distribuida desde Florida hasta Brasil siendo más abundante en el Golfo de México. Se obtuvieron un total de 871 organismos capturados por la flota artesanal de comunidad de Holbox, utilizando la línea como arte de pesca. Para la estimación de la edad y los parámetros poblacionales se utilizaron las frecuencias de longitud de los tres meses trabajados. Se observó que la mayor incidencia de captura se encuentra entre las tallas 255 y 275 mm LF, con una media de 265 mm LF. Los parámetros poblacionales obtenidos a través del software FiSAT fueron para

ELEFAN Loo= 500.50, k= 0.33 y to= -0.19 y por medio de Shepherd's Loo= 520.05, k= 0.30 y to= -0.22. Los intervalos de frecuencia de longitud también fueron utilizados para determinar la relación longitud-peso con una n= 659 organismos; el resultado de la regresión fue $W= 0.00004334LF^{2.8105}$. La curva de crecimiento se realizó por la ecuación de von Bertalanffy donde $Lt= 500.5\ (1-e^{-0.333(t+0.19)})$ para ELEFAN y $Lt= 520.05\ (1-e^{-0.30(t+0.22)})$ para Shepherd's. El conocimiento de los parámetros poblacionales son de suma importancia para garantizar un adecuado manejo de este recurso, así como su conservación para las futuras generaciones.

PALABRAS CLAVES: Canane, *Ocyurus chrysurus*, parámetros poblacionales

Oceanographic Features and Zooplankton Community Structure in Mayagüez Bay, Puerto Rico

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This study was part of a multidisciplinary research effort aimed to establish a characterization of the oceanographic features and the zooplankton community structure that could serve to evaluate the response of marine communities to a water quality restoration initiative. Monthly samplings consisted of conductivity, temperature and depth (CTD) and chlorophyll-a fluorescence profiles. Grab samples for nutrients determination (NO_3/NO_2 organic N, NH_4^+ and PO_4^{-3}) and Secchi transparency. Zooplankton was collected by oblique tows using a 1m5 TuckerTrawl System with three nets of 0.202 mm mesh. Sampling program included twelve cruises from February, 1997 through January, 1998 at six stations. Density profiles at Ocean station showed permanent stratification with well-developed pycnoclines associated with increasing salinity and declines of water temperature with depth. Inshore stations had well-mixed water columns, vertical stratification associated to freshwater lenses at the surface during large rainfall events. Maximum water column chlorophyll-a concentrations were consistently higher at Atuneras and AAA stations. Chlorophyll-a concentration was positively correlated with streamflow at Manchas and Rodríguez, but varied independently from streamflow at the other stations. Organic nitrogen (Org-N) was the nutrient in highest concentration, followed by ammonium-ion (NH_4^+) and nitrate (NO_3-N). Concentrations of orthophosphate (PO_4^{-3}BP) were only detected during April in Añasco. These data suggests that phosphate may be regulating plankton production at stations with good light penetration. Secchi transparency penetrated less than 50 % of the water column at Atuneras and AAA stations.

Total zooplankton abundance varied between 828B2,135 ind/m^3 during the dry season and between 1,365 - 3,040 ind/m^3 during the rainy season. Zooplankton abundance was higher at inshore stations (1,905 - 2,588 ind/m^3) compared to Ocean station (1,097 ind/m^3). Meroplankton represented less than 5% of total zooplankton abundance. Principal component analysis indicated that meroplankton abundance at Ocean station explained 85% of the variation of meroplankton taxonomic groups. Higher abundances of fish larvae from the families Clupeiformes, Pomacentridae, Haemulidae and Holocentridae accounted for the separation of inshore station. Clupeiformes were more abundant during heavy rainfall events and during night-time collections.

KEY WORDS: Oceanographic processes, zooplankton, Puerto Rico

Caracteristicas Oceanograficas de la Estructura de la Comunidad Zooplanctonica en Mayagüez Bay, Puerto Rico

Este estudio fue parte de un esfuerzo de investigación multidisciplinario con el fin de establecer una caracterización básica de los procesos oceanográficos y de la estructura de la comunidad de zooplancton que pueden servir para evaluar las respuestas de las comunidades biológicas marinas a una iniciativa de restauración de la calidad del agua. De los muestreos mensuales se obtuvieron perfiles de conductividad, temperatura, profundidad (CTD) y clorofila-a fluorescente. Además, se colectaron muestras para la determinación de nutrientes ($N0_3/NO_2$, N-Orgánico, NH_4^+ y PO_4^{-3}) y lecturas de transparencia Secchi. El zooplancton se colectó mediante arrastres oblicuos usando un sistema Tucker provisto con tres redes de 0.200 mm. El programa de muestreos incluyó doce cruceros desde febrero 1997 hasta enero, 1998 en seis estaciones. Los perfiles de densidad en la estación oceánica mostraron estratificación permanente con picnoclinas bien formadas asociadas a incrementos de salinidad y a la disminución de la temperatura del agua con la profundidad. Las estaciones internas mostraron columnas de agua bien mezclada, con estratificación vertical asociada a lentes de baja salinidad en la superficie durante los eventos de lluvia fuertes. La concentración máxima de clorofila-a en la columna de agua fue más elevada en las estaciones de Atuneras y AAA. La concentración de clorofila-a estuvo positivamente correlacionada con el flujo de los ríos en las estaciones de Manchas y Rodríguez, pero varió independientemente con el flujo de los ríos en las otras estaciones. El nitrogeno orgánico (N-Org) fué el nutriente de mayor concentración, seguido por el ión amonio (NH_4^+) y el nitrato (NO_3^-). La presencia de ortofosfato (PO_4^{-3}-P) sólo se detectó durante abril en la estación de Añasco. Estos datos sugieren que el ortofosfato puede estar regulando la producción de fitoplancton en las estaciones que tienen una buena penetración de luz.

La abundancia total de zooplancton varió entre 828-2,135 ind/m^3 durante la epoca seca y entre 1,365 - 3,040 ind/m^3 durante la estación de lluvia. La abundancia

de zooplancton fue más alta en las estaciones internas (1,905 - 2,588 ind m^{-3}) comparado con la estación oceánica (1,097 ind/m^3). El meroplancton representó menos de un 5% del total de la abundancia total de zooplancton. El analisis de componentes principales indicó que la estación oceánica explica el 85% de la variación de los grupos taxonómicos de meroplancton. Una abundancia mayor de larvas de peces de las familias Clupeiformes, Pomacentridae, Haemulidae y Holocentridae fué responsable por la separación de las estaciones internas. Los clupeiformes fueron más abundantes durante los eventos de lluvia fuerte y durante colecciones hechas en la noche.

PALABRAS CLAVES: Pprocesos oceanográficos, zooplancton, Puerto Rico

Using Sidescan Sonar to Assess the Impact and Persistence of Natural and Anthropogenic Disturbance to Low-relief Oyster Habitats in Coastal Louisiana

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Traditional methods used to assess oyster reef distribution and condition are only able to provide subjective point information which is often poorly georeferenced. Maps of oyster habitat in shallow waters are therefore typically extremely generalized, giving few details about the true distribution, character and dynamics of reefs. Sidescan sonar offers a significant advantage for oyster reef assessment in the turbid waters of coastal Louisiana. We used sidescan sonar in ultra-shallow (<2m) waters to completely image over 19 000 ha in Louisiana estuaries in advance of an impending freshwater diversion project. We also conducted four years of intense annual surveys in a more restricted area (320 ha) with a diversity of reef types and culture intensity to examine natural and anthropogenic impacts on oyster reef extent and character. Our intensive surveys identified older stable reefs which had not been actively worked. Shell abundance and structure on these reefs were high, but oyster meat productivity was low. Areas of intense oyster culture were characterized by low relief reefs that frequently showed distinct evidence of scarring from dredging and other anthropogenic sources. Smaller scars caused by oyster dredging typically healed through the within time period of our study while larger anthropogenic scarring did not diminish over the four years. We also deployed the sonar towfish over an area immediately before and after both seeding and harvesting to establish a quantitative relationship with sonar reflectance. These relationships can be further used to predict the impact of

harvesting and seeding on the extent oyster habitat. Demographic comparison of red snapper (*Lutjanus campechanus*) from the Atlantic and Gulf of Mexico.

KEY WORDS: Sidescan sonar, oyster habitat, Louisiana

El Uso del Sonar se Sidescan para Determinar el Impacto y la Persistencia de Disturbios Naturales y Anthropogenicos en los Habitat de Poco Relieve en la Costa de Luisiana

Los métodos tradicionales usados para determinar la distribución y la condición del filón de la ostra pueden solamente proporcionar la información subjetiva del punto que está a menudo georeferenced mal. Los mapas del habitat de la ostra en aguas bajas por lo tanto se generalizan típicamente extremadamente, dando pocos detalles sobre la distribución verdadera, el carácter y la dinámica de arrecifes. El sonar de Sidescan ofrece una ventaja significativa para el gravamen del filón de la ostra en las aguas turbias de Luisiana costera. Utilizamos el sonar sidescan en (de los aguas ultra bajas < 2m) totalmente a la imagen sobre 19 000 has en los estuarios de Luisiana por adelantado de un proyecto de agua dulce inminente de la diversión. También condujimos cuatro años de exámenes anuales intensos en un área más restricta (320 has) con una diversidad de los tipos del filón y de la intensidad de la cultura para examinar impactos naturales y anthropogenic en grado y carácter del filón de la ostra. Nuestros exámenes intensivos identificaron arrecifes estables más viejos que no habían sido trabajados activamente. La abundancia y la estructura de la cáscara en estos arrecifes eran altas, pero la productividad de la carne de la ostra era baja. Las áreas de la cultura intensa de la ostra fueron caracterizadas por los arrecifes bajos de la relevación que demostraron con frecuencia la evidencia distinta de marcar con una cicatriz fuentes de dragado y de otras anthropogenic. Las cicatrices más pequeñas causadas por la ostra que dragaba típicamente curaron con dentro el período de nuestro estudio mientras que el marcar con una cicatriz anthropogenic más grande no disminuyó sobre los cuatro años. También desplegamos el towfish del sonar sobre un área inmediatamente antes y después de la sembrar y de cosechar para establecer una relación cuantitativa con la reflexión del sonar. Estas relaciones se pueden utilizar más a fondo para predecir el impacto de cosechar y de la sembradura en el habitat de la ostra del grado. Comparación demográfica del snapper rojo (campechanus de Lutjanus) del Atlántico y del golfo de México.

PALABRAS CLAVES: Sidescan Sonar, habitat de la ostra, Luisiana

Growth and Survival of American Oyster *Crassostrea virginica* on Laguna de las Pilas, Laguna de Términos, Campeche, México: Preliminary Evaluation

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American oysters *Crassostrea virginica* of 2.64 ± 0.57 cm average height were cultured by 70 days in contiguous waters to the Pilas lagoon, in Terminos Lagoon, Campeche. Biweekly, growth and survival were measured and the incorporation of seeds in the box of culture (fixation) was registered. A average growth of 0.84 cm/month was presented, reaching 4.62 ± 0.63 cm of average height after 70 days of cultivation, where 78.75% of oysters fluctuated between 3.8 and 4.8 cm and 17.5% between 5.5 and 5.8 cm of average height. Survival was of 80%. An incorporation of oysters in the culture boxes was registered (fixation), starting from final of October until the end of the experiment, with values between 35 and 55 seeds. Highest fixations were in end of October and earlier November. Temperature stayed between 27 and 30 ºC, while the salinity presents a variation between 18.15 and 29.06 ppt, with maximum values in September and minimum at the end of November. Growth and survival results demonstrate that oyster culture in this Lagoon is feasible biologically.

KEY WORDS: Oyster culture, recruitment, *Crassostrea virginica*, Laguna de Términos, Campeche, México

Evaluación Preliminar del Crecimiento y Sobrevivencia del Ostión *Crassostrea virginica* en la Laguna de las Pilas, Laguna de Términos, Campeche, México.

Ostiones (*Crassostrea virginica*) de 2.64 ± 0.57 cm de altura promedio fueron cultivados en aguas contiguas a la laguna de las Pilas, en la Laguna de Términos, Campeche. Quincenalmente el crecimiento y supervivencia fueron medidos y la incorporación de semillas en las cajas de cultivo (reclutamiento) fue registrada. Se presentó un crecimiento promedio de 0.84 cm/mes, alcanzando 4.62 ± 0.63 cm de altura promedio después de 70 días de cultivo, donde el 78.75 % de los ostiones fluctuaba entre 3.8 y 4.8 cm y el 17.5 % entre 5.5 y 5.8 cm de altura promedio. La supervivencia fue del 80 %. Se registro una incorporación de ostiones en las cajas

de cultivo (reclutamiento) a partir de finales de octubre hasta el fin del experimento, presentándose valores entre 35 y 55. Las mayores fijaciones a finales de octubre y principios de noviembre. La temperatura se mantuvo entre 27 y 30 ºC, mientras que la salinidad presentó una variación entre 18.15 y 29.06 ppm, con valores máximos en septiembre y mínimos a finales de noviembre. Los resultados de crecimiento, sobrevivencia y reclutamiento demuestran que es biológicamente factible el cultivo de ostión en esta Laguna.

PALABRAS CLAVES: Cultivo de ostión, reclutamiento, Crassostrea virginica, Laguna de Términos, Campeche, México

Experimental Culture of Hooked Mussel *Ischadium recurvum* (Rafinesque, 1820) in a Suspended System in the Laguna de Términos, Campeche, México

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The initial growth of hooked mussel *Ischadium recurvum* was evaluated in the Terminos lagoon, Campeche, Mexico, starting from spats of 18.7 ± 4,4 mm. The spats were placed in Nestier boxes suspended in a system located about to 200 m of the coast. Biweekly registry the total height of the shell, to all the individuals, as well as the following physical chemical parameters: temperature, salinity, pH and dissolved oxygen. The growth pattern of the shell maintains a rate of growth continuous (5.73 mm/month), reaching a total height of shell 32.8 ± 4.7 mm and an accumulated mortality of 20 %, after 70 days of culture. The results show an adaptation of spats of I. recurvum to the suspended culture, thus we considered that it is possible to develop his culture until commercial size (50 mm) in six months in the Terminos lagoon.

KEY WORDS: Mussel culture, *Ischadium recurvum*, Terminos Lagoon, Campeche, México

Cultivo Experimental del Mejillón Curvo *Ischadium recurvum* (Rafinesque, 1820) en un Sistema Suspendido en la Laguna de Términos, Campeche, México.

Se evaluó el crecimiento inicial del mejillón curvo *Ischadium recurvum* en la Laguna de Términos, Campeche, México, a partir de semillas de 18.7 ± 4.4 mm. Los juveniles fueron sembrados en cajas Nestier suspendidas en un sistema ubicado a unos 200 m de la costa. Quincenalmente se registro la altura total de la concha, a todos los individuos, así como los siguientes parámetros fisicoquímicos: temperatura, salinidad, pH y oxígeno disuelto. El patrón de crecimiento de la concha mantuvo una tasa de crecimiento continua (5.73 mm/mes), alcanzando una altura total de la concha 32.8 ± 4.7 mm y una mortalidad acumulada del 20 %, después de 70 días de cultivo. Los resultados muestran una adaptación de los juveniles de *I. recurvum* al cultivo suspendido, por lo cual consideramos que es posible desarrollar su cultivo hasta talla comercial (50 mm) en 6 meses en la Laguna de Términos.

PALABRAS CLAVES: Cultivo de mejillón, *Ischadium recurvum*, Laguna de Términos, Campeche, México

Distribution and Abundance of Larvae *Callinectes rathbunae* in Atasta Lagoon, Terminos Lagoon, Campeche, Mexico

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In the last years the crab fishery in the region of the Lagoon of Terms has been increased remarkably. With the purpose of knowing some preliminary aspects the reproductive time and sites of spawning of *Callinectes rathbunae* superficial zooplankton samples were made in 6 stations distributed in the lagoon of Atasta during five campaigns (April, July, September and December of 2001 and February of 2002). The month with greater number of collected zoeas was April with 67.45 larvae/m^3, associated to temperatures between 27,5 and 28,5 1 °C and salinities between 0.9 and 3.7 ‰. The station with greater incidence of larvae was number 2 located in the center of the lagoon, which this influenced by the currents, which can

transport the larval stages towards that place thus influencing in the recruitment.

KEY WORDS: Crab larvae, *Callinectes rathbunae*, Laguna de Atasta, Laguna de Términos, Campeche, México.

Distribución y Abundancia de Larvas de *Callinectes rathbunae* en la Laguna de Atasta, Laguna de Términos, Campeche, México

En los últimos años la pesquería de jaiba en la región de la Laguna de Términos se ha incrementado notablemente. Con la finalidad de conocer algunos aspectos preliminares de la época reproductiva y sitios de desove de la jaiba prieta *Callinectes rathbunae* se realizaron arrastres de zooplancton superficial en 6 estaciones distribuidas en la laguna de Atasta durante cinco campañas (abril, julio, septiembre y diciembre de 2001 y febrero de 2002). El mes con mayor número de zoeas colectadas fue abril con 67.45 larvas/m^3, asociado a temperaturas entre 27.5 y 28.5 1 °C y salinidades entre 0.9 y 3.7 ‰. La estación con mayor incidencia de larvas fue la número 2 situada en el centro de la laguna, la cual esta influenciada por las corrientes las cuales pueden transportar los estadios larvales hacia ese lugar influyendo así en el reclutamiento.

PALABRAS CLAVES: Larvas de jaiba, *Callinectes rathbunae*, Laguna de Atasta, Laguna de Términos, Campeche, México.

Spatial and Temporal Distributions of Larvae *Callinectes rathbunae* in the Pom Lagoon, Terminos Lagoon, Campeche, Mexico

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The crab fishery in the region of the Terminos Lagoon, it has been developed in a considerable way in the last 10 years and it is considered the second resource in single importance after the shrimp, generating employment sources and foreign currencies product of the export of the crab meat. In spite of the above mentioned it is considered that the studies of the biological and fishing aspects of the crab in the

region are limited but necessary to order the fishery. The main objective of the present work was this way to carry out an analysis of the planktonic abundance of the crab *Callinectes rathbunae*, with the purpose of contributing to the knowledge of some preliminary aspects of its reproductive time and the recruitment sites in the Pom Lagoon, to the west of the Terminos Lagoon. They were carried out superficial samples of zooplancton in 6 stations distributed in the lagoon during five campaigns between April of 2001 and February of 2002 (April, July, September, December and February). Simultaneously were obtained the variables: temperature, salinity, dissolved oxygen and pH by means of multi parametric Sonde Hidrolab Datasonde. The stations with smaller larval densities during the five campaigns were 5 and 6 located in the mouth of connection with the Atasta Lagoon, while the maximum densities of zoeae were in the month of July with 166.03 larvae/m^3 and 82.06 larvae/m^3 for stations 3 and 4 respectively, which are located to the end of the lagoon, this due to the currents which influence in the recruitment when transporting the larvae until that place. The parameters physical-chemistry associated to these high densities was: temperature 30 ± 1 °C; pH 8.63; salinity between 0.7 and 1.1 ‰ and oxygen dissolved between 4.17 and 7.4 mg/l.

KEY WORDS: Crab larvae, *Callinectes rathbunae*, Laguna de Pom, Laguna de Términos, Campeche, México

Distribucion Espacial y Temporal de Larvas de *Callinecte rathbunae* en la Laguna de Pom, Laguna de Terminos, Campeche, México

La pesquería de jaibas en la región de la Laguna de Términos, se ha desarrollado de manera considerable en los últimos 10 años y se considera el segundo recurso en importancia solo después del camarón, generando fuentes de empleo y divisas producto de la exportación de la pulpa de jaiba. A pesar de lo anterior se considera que los estudios de los aspectos biológicos y pesqueros de la jaiba en la región son limitados pero necesarios para ordenar la pesquería. Así el principal objetivo del presente trabajo fue realizar un análisis de la abundancia planctónica de la jaiba *Callinectes rathbunae*, con el fin de contribuir al conocimiento de algunos aspectos preliminares de su época reproductiva y los sitios de reclutamiento en la laguna del Pom, al poniente de la Laguna de Términos. Se realizaron arrastres superficiales de zooplancton en 6 estaciones distribuidas en la laguna durante cinco campañas entre abril de 2001 y febrero de 2002 (abril, julio, septiembre, diciembre y febrero). Simultáneo a los arrastres se obtuvieron las variables temperatura, salinidad, oxígeno disuelto y pH mediante una Sonda multiparámetrica Hidrolab Datasonde. Las estaciones con menores densidades larvarias durante las cinco campañas fueron la 5 y 6 situadas en la boca de conexión con la Laguna de Atasta, mientras que las densidades máximas de zoeas se encontraron en el mes de julio con 166.03 larvas/m^3 y 82.06 larvas/m^3 para las estaciones 3 y 4 respectivamente, las cuales están situadas al fondo de la laguna, esto debido a las corrientes las cuales influyen en el

reclutamiento al transportar las larvas hasta ese lugar. Los parámetros físico-químico asociados a estas altas densidades fueron: temperatura 30 ± 1 °C; pH 8.63; salinidad entre 0.7 y 1.1 ‰ y oxígeno disuelto entre 4.17 y 7.4 mg/l.

PALABRAS CLAVES: Larvas de jaiba, *Callinectes rathbunae*, Laguna de Atasta, Laguna de Términos, Campeche, México

The Sea Urchin Fishery of Saint Lucia, West Indies: A Challenge to Management Authorities

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Sea urchins, a once popular resource, declined considerably in the early 1980=s due to over harvesting. A 3-year ban imposed by the Department of Fisheries and regular monitoring of stocks by this Department in collaboration with Caribbean Natural resource Institute and resource harvesters allowed stocks to recuperate. In addition, a community approach to management was implemented. This approach offered considerable potential since it placed much of the responsibility for resource conservation on the harvesters themselves. In the 1990s, this type of management proved quite successful in this fishery, as harvesters came forward on a number of occasions to give information on the status of the stock in their respective areas. However, in 1993 - 1999 unknown factors, not believed to be associated with harvesting activities, caused a markedly low recruitment of juveniles.

After this period of low recruitment into the sea urchin fishery, ongoing monitoring revealed that during the period November, 2000 to February, 2001 there was a high level of recruitment. The adult populations were also relatively high as compared to previous years. As such, the Department of Fisheries, along with some of the more active harvesters, agreed that the numbers were high enough to withstand a harvest period.

However, since the harvest period in mid-September, 2001, illegal harvesting has continued to such an extent that post harvest sea urchin surveys reveal that the fishery has been decimated in most areas.

The paper discusses how factors such as, manpower constraints within key agencies, weak collaborative arrangements among key institutions, large number of harvestable areas, and poor memory of pasts events, can affect the effectiveness of management authorities.

KEY WORDS: Sea urchin, community based management

La Industria Pesquera del Erizo de Mar de Santa Lucia, West Indias: Un Desafío a las Autoridades Encargadas de su Manejo

El erizo de mar, una vez que recurso popular, declinado considerablemente en el 1980s temprano debido a cosechar del excedente. Una interdicción de tres años impuso por el departamento de industrias pesqueras y la supervisión regular de la acción por este departamento en la colaboración con el instituto del recurso natural y las máquinas segadores del Caribe del recurso permitió que la acción recuperara. Además, un acercamiento de la comunidad a la gerencia fue puesto en ejecucio'n. Este acercamiento ofreció potencial considerable puesto que puso mucha de la responsabilidad de la conservación del recurso en las máquinas segadores ellos mismos. En los años 90, este tipo de gerencia probó absolutamente acertado en esta industria pesquera, pues las máquinas segadores vinieron adelante en un número de ocasiones dar la información sobre el estado de la acción en sus áreas respectivas. Sin embargo, en 1993 - 1999 factores el desconocido, no creídos ser asociado a cosechar las actividades, causadas un reclutamiento marcado bajo de juveniles. Después de este período del reclutamiento bajo en la industria pesquera del pilluelo de mar, la supervisión en curso revelada eso durante el período noviembre de 2000 a febrero de 2001 allí era un alto nivel del reclutamiento. Las poblaciones del adulto eran también relativamente altas con respecto a años anteriores. Como tal, el departamento de industrias pesqueras, junto con algunas de las máquinas segadores más activas, convino que los números eran arriba bastante soportar un período de la cosecha. Sin embargo, desde el período de la cosecha en septiembre mediados de de 2001, el cosechar ilegal ha continuado hasta tal punto que las encuestas sobre pilluelo de mar de la cosecha del poste revelan que la industria pesquera se ha diezmado en la mayoría de las áreas. El papel discute tales como cómo los factores, los apremios de la mano de obra dentro de las agencias dominantes, los arreglos de colaboración débiles entre las instituciones dominantes, el número grande de áreas harvestable, y la memoria pobre de los acontecimientos de los pasts, pueden afectar la eficacia de las autoridades de la gerencia.

PALABRAS CLAVES: El pilluelo de mar, comunidad basó a gerencia

Use of Biochemical and Molecular Genetics Techniques to Distinguish Two Closely Related and Morphologically Similar Carcharinid Shark Species- *Carcharhinus brevipinna* and *Carcharhinus limbatus*

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Species identification for closely related, morphologically similar shark species is difficult under field conditions or when using processed samples. Various molecular markers have been utilized to distinguish among easily misidentified sharks. Current research at Perry R. Bass Marine Fisheries Research Station has required the examination of blacktip shark fin clips obtained from diverse localities. Some samples were collected by local fishermen. Due to the possibility of confusing blacktip sharks with spinner sharks the utility of various protein and DNA markers have been explored to distinguish between these species. Isoelectric focusing (IEF) and sequencing of PCR amplified nuclear fragments were investigated.

KEY WORDS: Carcharinid sharks, biochemical and molecular genetic techniques

La identificación de especies de tiburón que son morfologicamente similares es difícil en muestras procesadas colectadas en mercados. En este estudio se utilizaron varios marcadores bioquímicos y moleculares (DNA) para la identificación correcta de tiburones que pueden confundirse fácilmente como *C. limbatus* y *C. bevipinna.* En la actualidad la Estación de Investigación de Pesquería Costera Perry R. Bass está conduciendo un estudio en genética de poblaciones de tiburones punta negra collectadas por pescadores en diferentes localidades. Dada la posibilidad de tiburones punta negra pueden ser confundidos con tiburones spinner las muestras fueron analizadas con isoelectroforesis de proteínas y sequenciación de fragmentos de ADN nuclear amplificados con PCR reaccion en cadena de polimerasa

PALABRAS CLAVES: Tiburones, biochemica y geneticas

Aspects of the Reproduction of Large Pelagic Fishes in the Northern Gulf of Mexico

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Information on the reproduction of large pelagic fishes in the northern Gulf of Mexico is almost non-existent. Species such as blue marlin (*Makaira nigricans*), yellowfin tuna (*Thunnus albacares*) and bluefin tuna (*T. thynnus*) are captured by both commercial and recreational fishers in the northern Gulf. Blue marlin are taken during the summer (May - September), bluefin tuna are found from January through June and yellowfin tuna are captured almost year-round. Histological examination of gonads of blue marlin captured during June 2000, 2001 and 2002 (n = 5) showed ovaries were in the regressed or early maturation classes. Collections of istiophorid larvae in the northern Gulf indicated that spawning by billfish was at a low level in May and increased during the summer months. Collections of female bluefin tuna during June 2000 and 2001(n = 2) showed ovaries in the late maturation class, capable of spawning. Furthermore, the ovaries of one of the specimens examined contained 24 h postovulatory follicles (POF), suggesting spawning occurred within the past 24 h of capture. Male bluefin tuna (n = 1) had testis in the mid maturation class with spermatozoa evident in the sperm ducts. Collections of bluefin tuna larvae reflected a similar temporal pattern of late spring/early summer spawning; all larvae (n = 33) were collected in May. Yellowfin tuna were collected during June 2000 and 2002, and most specimens were male (n = 9). The majority of the males (56 %) were in the mid maturation reproductive class and all males contained spermatozoa in the sperm ducts, indicating all fish were in spawning condition. Yellowfin tuna appear to have a slightly later spawning season than bluefin tuna in the Gulf, as only 50 % of the females were in spawning condition, however, all females in the late maturation class (n = 2) had POF in the ovaries. This is the first report of yellowfin tuna spawning in the northern Gulf. Larvae of yellowfin tuna are more difficult to identify than bluefin tuna and have not yet been recognized in USM/COMS plankton collections. These preliminary results suggest the northern Gulf of Mexico is an important spawning ground for many large pelagic fishes.

KEY WORDS: Large pelagic fishes, reproduction, northern Gulf of Mexico

Aspectos de la Reproducción de Peces Pelágicos Grandes en el Norte del Golfo de Méjico

La información sobre la reproducción de peces pelágicos grandes en el norte del Golfo de Méjico es casi inexistente. Las especies como aguja azul (*Makaira nigricans*), rabil (*Thunnus albacares*) y atún (*T. thynnus*) son capturadas por los pescadores comerciales y recreacionales en el norte del Golfo. La aguja azul se pesca durante el verano (Mayo- Septiembre), el atún se encuentra a partir de enero hasta Junio y el rabil se captura casi durante todo el año. La examinación histológica de las gónadas de la aguja azul, capturadas durante Junio del 2000, 2001 y 2002 (n = 5), exhibieron ovarios en estado de regresión o etapa temprana de maduración. Las colecciones de larvas del istiophorid en el norte del Golfo indicaron que el desove de la aguja azul estaba en un nivel bajo en Mayo y creciente durante los meses del verano. Las hembras del atún colectadas durante Junio del 2000 y 2001 (n = 2), mostraron ovarios en los estados finales de maduración, con capacidad de desove. Además, los ovarios de uno de los especimenes examinados contuvieron folículos post-ovulatorios (FPO) de 24h, sugiriendo que el desove ocurrió en las 24 h previas a la captura. El atún macho (n = 1) tenia testis en estado intermedio de maduración con los espermatozoides en los conductos espermáticos. Las colecciones de larvas de atún reflejaron un patrón temporal de desove similar a finales de la primavera/principios de verano; todas las larvas (n = 33) fueron colectadas en Mayo. Rabil fue colectado en Junio del 2000 y 2002, la gran mayoría de estos fueron machos (n = 9). La mayoría de los machos (el 56 %) presentaban un estado intermedio de maduración reproductiva. Todos ellos contuvieron espermatozoides en los conductos espermáticos, lo que indica que los peces estaban en la condición de desove. Rabil parece tener una estación de desove levemente mas tardía que la aguja azul en el Golfo, solamente 50 % de las hembras estaban en la condición de desove. Sin embargo, todas las hembras en el estado tardío de maduración (n = 2) tenían FPO en los ovarios. Larvas de rabil son mas difíciles de identificar que las de atún y hasta ahora no han sido identificadas en el plankton. Este es el primer reporte sobre el desove del rabil en el norte del Golfo.Estos resultados preliminares sugieren que el norte del Golfo de Méjico es una importante zona de desove para muchos peces pelágicos grandes.

PALABRAS CLAVES: peces pelágicos grandes, reproducción, orte del Golfo de Méjico

Estructura de la Pesquería Artesanal de Especies Pelagicas en la Isla de San Andrés, Caribe Occidental

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En la isla de San Andrés, Colombia, la extracción de especies pelágicas ha ganado importancia en las últimas décadas como consecuencia de la disminución de peces arrecifales de interés comercial, representando en el período comprendido entre agosto de 1998 y julio de 1999 el 80% del total de las capturas desembarcadas por pescadores artesanales.

Participan en la pesquería 78 embarcaciones distribuidas en cinco lugares de desembarque localizados alrededor de la isla. La embarcación más utilizada es la denominada "King Fiver" fabricada en fibra de vidrio con dimensiones de 25 pies de eslora y 5 pies de manga, dotada para su propulsión de un motor fuera de borda a gasolina de 40 hp. La mayoría no cuenta un sistema para el almacenamiento en frío de los productos capturados.

El arte de pesca predominante es la línea de mano, la cual es empleada de diferentes formas dependiendo de las especies a capturar. Se utiliza como carnada señuelos artificiales o trozos de atunes o land fish (Carangidae). Las faenas de pesca duran entre 5 y 10 horas, participan dos pescadores por embarcación y se realizan principalmente detrás de la barrera arrecifal, al noroeste y sur de la isla, y en los cayos Bolívar y Albuquerque. El manejo post captura es mínimo y la comercialización de los productos es a pequeña escala en los lugares de desembarque.

Las especies más importantes son *Thunnus atlanticus, Acanthocybium solandri, Elagatis bipinnulata, Coryphaena hippurus* y *Sphyraena barracuda*, las cuales son capturadas durante todo el año, presentando algunas de ellas variaciones estacionales asociadas posiblemente con cambios en las condiciones ambientales.

PALABRAS CLAVES: Pesquería artesanal, especies pelágicas, Colombia

Structure of Pelagic Small-scale Fishery in San Andrés Island, Occidental Caribbean

In San Andrés Island, Colombia, pelagic species extraction has gained importance throughout the last decades, as a consequence of diminishment in reef species of commercial interest, representing 80% of the total capture landings by small-scale fishermen, between August 1998 and July 1999.

78 boat participate in the fisheries, distributed in five landing places around the

island. The most common boat is the so-called AKing Fiver@, glass-fiber made, 25ft long and 5ft wide, propelled by an off board 40 hp gasoline motor. Most of them lack a cold storage device for captured products.

The prevailing fishing skill is the hand line, which is used in different manners, according to the species to capture. An artificial bait can be used, or tuna or land fish (Carangidae) pieces. The fishing task lasts from 5 to 10 hours, two fishermen per boat, and it is done mainly behind the reef barrier, northwest and south of the island, and at the Bolivar and Albuquerque cays. Post capture management is minimum and there is small-scale product commercializing at the landing places.

The most representative species are *Thunnus atlanticus, Acanthocybium solandri, Elagatis bipinnulata, Coryphaena hippurus* y *Sphyraena barracuda,* captured all year-round, some of them showing seasonal variation possibly associated to environmental conditions changes.

KEY WORDS: Artisanal fishery, pelagic species, Colombia

Local and Latitudinal Differences in Growth During the Early Life History of Gray Snapper, *Lutjanus griseus*

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The gray snapper, *Lutjanus griseus*, is an ecologically and commercially important fish throughout the Caribbean. Despite its significant role in the marine ecosystem and its economic value, relatively little is known about the growth of this species, especially during its early life history stages. As part of a larger study of population connectivity, young of the year *L. griseus* were collected from five sites in the Southeastern United States during Fall 2000 and 2001: Florida Bay, Biscayne Bay, Sebastian Inlet, and Jupiter in Florida, and Core Sound, North Carolina. Fish were measured and weighed and the sagittal otoliths removed for aging. Daily growth increments were enumerated using standard otolith aging techniques and the deposition of daily rings validated. Larval and juvenile growth rates as well as the planktonic larval duration (PLD) appear to be influenced by various environmental factors across a latitudinal gradient. Otolith records indicate differences in growth rates among sites and years. Comparison of these data with similar data collected along the west coast of Florida provides further insight into environmentally induced differences in growth rate. The age data collected during this project eventually will be used in conjunction with otolith microchemistry to help elucidate the likelihood of population connectivity in this species.

KEY WORDS: Gray snapper, *Lutjanus griseus*, growth

Diferencias Locales y Latitudinales en el Crecimiento del Pargo de Mangle, *Lutjanus griseus*, Durante su Vida Pelagica

El pargo de mangle, *Lutjanus griseus*, es un pez ecologicalmente y commercialmente importante en todo el Caribe. A pesar de su importante función dentro del ecosistema marino y de su valor económico se sabe muy poco sobre el crecimiento de esta especie, especialmente durante los estadios pelágicos de su vida . Como parte de un estudio de conectividad de poblaciones, los *L. griseus* mas jovenes del año fueron colectados en cinco sitios al sureste de los Estados Unidos durante la temporada de otoño de los años 2000 y 2001: Bahia de Florida, Bahia de Biscayne, Inlet de Sebastian y Jupiter en Florida, y Core Sound en Carolina del Norte. Los peces fueron medidos y pesados y los otolitos sagitales fueron extraidos para determiner la edad. Incrementos diarios de crecimiento fueron contados usando técnicas estandarizadas de edad y la deposición del incremento diario fue validada. La tasa de crecimiento durante los estadios larvales y juveniles, y asi como la duración de las etapas larvales planctonicas parecen estar influenciadas por varios factores medioambientales a lo largo del gradiante de latitud. Los records de otolitos indican diferencias en las tasas de crecimiento entre sitios y años. Comparaciün de estos datos con datos similares colectados en la costa oeste de la Florida, indican la posibilidad que las diferencias entre las tasas de crecimiento sean causadas por el medio ambiente. Los datos de edad colectados a traves de este proyecto seran utilisados juntos con datos de microquimica para ayudar a dilucidar la probabilidad de conectividad de las ploblaciones de esta especie.

PALABRAS CLAVES: Pargo de mangle, *Lutjanus griseus*, crecimiento

Estructura de la Comunidad de Peces Juveniles en la Laguna Yalahau, Quintana Roo (Época de Lluvias)

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El número de especies asociadas a los ecosistemas costeros varia en función de la complejidad estructural de cada hábitat. Las camas de pastos marinos se encuentran entre los sistemas costeros más complejos. El presente estudio permite determinar la estructura de la comunidad de peces asociadas a las camas de pastos de *Thalassia testudinum* en la Laguna Yalagau, para lo cual se realizaron muestreos

quincenales durante los meses de junio y julio del 2001 considerando las fases de luna nueva y llena. Se colectaron un total de 42 especies durante los dos meses en 2 zonas del ecosistema por medio de una red de barra Renfro. Las familias más representativas fueron Syngnathidae y Haemulidae. *Lagodon rhomboides* representó la especie más dominante tanto en abundancia como en biomasa para ambos meses (30.2 %), seguido de *Syngnathus floridae* en luna llena de junio y *Ortopristis chrysoptera* en luna nueva del mismo mes, por su parte *Lucania parva* representó la segunda especie dominante en ambas lunas del mes de julio. La mayor riqueza de especies se presentó en las lunas de junio con 28 especies, mientras que para el mes de julio se observó una disminución a 18 y 16 especies en luna llena y nueva, respectivamente. La mayor diversidad se obtuvo en la luna nueva de junio mientras que la mayor equidad se presentó en luna nueva de julio. La comunidad de peces de las camas de pastos marinos en Yalahau es muy similar a las reportadas por otros autores en ecosistemas similares. Finalmente, el ecosistema de pastos funcionó como área de alimentación, protección y crianza de especimenes de talla pequeña y juveniles de especies de diferente origen ecológico. Este conocimiento es importante para evaluar la importancia biológica y ecológica que representan las camas de pastos marinos en la laguna de Yalahau.

PALABRAS CLAVES: Ecosistemas costeros, estructura de la comunidad de peces, Laguna Yalagau, México

Structure of the Community of Juvenile Fish in the Lagoon Yalahau, Quntana Roo (Rainy Season)

A number of coastal species associated with coastal ecosystems varies based on the structural complexity of each habitat. The beds of marine grass are found among the most complexes coastal systems. The present study allows as to determine the structure of the community of fish associated with the beds of turtlegrass (*Thalassia testudinum*) in the lagoon of Yalahau, for which biweekly samplings were made during the months of June and July 2001 considering the phases of New Moon and Full Moon. A total of 42 species were collected during both months in 2 zones of the ecosystem with a Renfro net. The most representative families were Syngnathidae and Haemulidae. *Lagodon rhomboides* represented the most dominant species in abundance as in biomass for both months (30.2 %), followed of *Syngnathus floridae* in Full Moon of June and *Orthopristis chrysoptera* in New Moon of the same month, on the other hand, *Lucania parva* represenst the second species dominant in both moons of the month of July. The greater number of species appear in moons of June with 28 species, whereas for the month of July a decrease 18 and 16 species is observed in Full Moon and New Moon respectively. The greater diversity was obtained in the New Moon of June whereas the evenness appeared in New Moon of July the community of fish of the beds of turtlegrass in Yalahau is very similar to the reported ones by other authors

in similar ecosystems. The ecosystem of turtlegrass functions as an area of feeding, protection and raising of small and juvenile specimens of small size of species of different ecological origin. This knowledge is important to evaluate biological and ecological importance that represents the beds of turtlegrass in the lagoon of Yalahau.

KEY WORDS: Coastal ecosystems, community structure of fish species, Laguna Yalagau, Mexico

Asociacion Trofica de Peces Dominantes en la Laguna De Terminos, Campeche

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Se estudió la ecología trófica de 3,927 individuos pertenecientes a siete especies de peces dominantes en una zona de vegetación sumergida en la Laguna de Términos: *Eucinostomus gula, Lutjanus griseus, Sphoeroides testudineus, Cathorups melanopus, Achosargus rhomboidalis, Cichlasoma urophthalmus y Opsanus beta.* El muestreo incluyó la variación espacial (sustratos con y sin vegetación) y la variación temporal (día y noche y tres estaciones climáticas), durante un año. Se estimó la abundancia (individuos m^{-2} y g m^{-2}). Se analizaron los estómagos de 2,505 individuos y se calcularon los índices de importancia relativa (IIR) y amplitud de dieta. Se determinó el grado de interacción entre las dietas mediante un índice de similitud al igual que la distribución y preferencia de hábitat. La abundancia de *A. rhomboidalis* y *C. urophthalmus* fue independiente de la salinidad y la temperatura. *E. gula, A. rhomboidalis, C. uropthalmus* y *O. beta* se encontraron sobre vegetación de día y de noche, *L. griseus* se encontró sobre vegetación y por la noche, *C. melanopus* sin vegetación y de noche y *S. testudineus* fue frecuente en las cuatro condiciones analizadas. *C. melanopus* no formó asociación con el resto de las especies estudiadas. La sobreposición de dietas entre especies tuvo como resultado una unión entre *C. melanopus* y *S. testudineus* (0.78) y con *C. urophthalmus* (0.65). Se encontró además relación entre las dietas de *A. rhomboidalis* y *S. testudineus* (0.51) y de *L. griseus* y *O. beta.* Se encontraron cambios ontogénicos con relación a las dietas de las especies y una tendencia hacia una mayor especificidad. Aparecieron los mismos componentes en

los estómagos para cada una de las especies por lo que las variaciones estaciónales de las dietas se relacionaron a las variaciones en las proporciones en peso y número de los componentes tróficos. Esto es una consecuencia de la estabilidad de la zona que presenta gran influencia marina y alta abundancia y diversidad específica de las comunidades de invertebrados bentónicos.

PALABRAS CLAVES: Ecología trófica de peces, abundancia y diversidad, Laguna de Términos, Mexico

Trophic Association in Dominant Fishes Species from Laguna De Terminos, Campeche

Results of a study of the trophic ecology of 3,927 individuals from seven fish species (*Eucinostomus gula, Lutjanus griseus, Sphoeroides testudineus, Cathorups melanopus, Achosargus rhomboidalis, Cichlasoma urophthalmus* and *Opsanus beta*) which are dominant in a zone with submerged vegetation at Laguna de Términos are presented. The investigation was accomplished according to an intensive-sampling scheme that followed a spatial scale (bottoms with and without vegetation), and temporal scale (including day and night, and three climatic periods) with sampling throughout a year. Abundance (individuals m^{-2} and g m^{-2}) was estimated. Diet composition of each specie was determined by the analysis of 2,505 stomach contents. The index of relative importance (IRI) and the trophic niche range index were calculated. Affinities among each species diet, their distribution, and habitat preferences were analyzed using a similarity index. *A. rhomboidalis* and *C. urophthalmus* abundance was independent of temperature and salinity. *E. gula, A. rhomboidalis, C. uropthalmus* and *O. beta* occurs on bottoms with vegetation during day and night. *L. griseus* has preference for habitats with submerged vegetation and has nocturnal habits. *C. melanopus* was collected mainly on bottoms without vegetation during the night, and *S. testudineus* was found in the four sampling conditions. Cluster analysis showed relation in diets between *C. melanopus* and *S. testudineus* (0.78) and with *C. urophthalmus* (0.65). *A. rhomboidalis* and *S. testudineus* were related at 0.51, and *L. griseus* and *O. beta* diets were related at a low level. There were found ontogenetic changes in diet composition with a tendency to grater specificity. Seasonal variations in diets of all species were related to changes in weight and numerical proportions of the food items due to the stability of the studied area, which presented strong marine influence and high abundance, and diversity of benthic invertebrates, which provide the food basis for many local fish species at some point in their life cycles.

KEY WORDS: Trophic ecology, abundance and diversity, Laguna de Términos, Mexico

Biological Surveys to Assess the Relative Abundance and Distribution of Coastal Sharks and Teleosts of the Mexican Gulf of Mexico, 1997, 1998, 2001 and 2002

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In an effort to maintain viable shark populations in U.S. waters, the National Marine Fisheries Service (NMFS, an agency of NOAA) developed the 1993 Fisheries Management Plan (FMP) for Sharks of the Atlantic Ocean (NOAA 1993). To determine the efficacy of the1993 FMP for sharks, NMFS Mississippi Laboratories instituted field surveys (1995 - 2002) to assess the distribution and relative abundance of coastal sharks in the western U.S. North Atlantic Ocean and U.S. Gulf of Mexico. In order to expand survey coverage for several shark species, NMFS and the Instituto Nacional de la Pesca (INP) initiated a series of cooperative research projects (1997, 1998, 2001 and 2002) within Mexican territorial waters of the Gulf of Mexico. The primary objective of the Mexican Gulf of Mexico project was to develop a fisheries independent data base for shark management species (i.e., large and small coastal sharks) and important teleosts (i.e., snappers and groupers). Secondary objectives included tagging studies and biological sampling. Two-hundred and three bottom longline stations were completed during 44 survey days. Captures included 97 sharks (11 species), 63 other elasmobranchs (3 species) and 246 teleosts (30 species).

KEY WORDS: Bottom longline, fisheries-independent, Mexico

Estudios Biológicos para Evaluar la Abundancia Relativa y Distribución de Tiburones Costeros y Teleósteos del Golfo de México, 1997, 1998, 2001 Y 2002

En un esfuerzo para mantener viables las poblaciones de tiburón en aguas de los Estado Unidos, el Servicio Nacional de Pesquerías Marinas de los Estados Unidos

(the National Marine Fisheries Service, NMFS) implemento a partir de 1993 un Plan de Manejo Pesquero para los Tiburones del Océano Atlántico. Para evaluar la eficacia del plan, el Laboratorio de la NMFS en Mississippi condujo una serie de cruceros de prospección (1995 - 2002), para evaluar la distribución y abundancia relativa de tiburones costeros en la costa occidental de los E.U. del Océano Atlántico Norte y del Golfo de México. Para extender la cobertura de los estudios para varias especies del tiburón, la NMFS y el Instituto Nacional del la Pesca (INP) iniciaron una serie de cruceros de investigación conjuntos (1997, 1998, 2001 y 2002) dentro de las aguas territoriales mexicanas del Golfo de México. El objetivo fundamental del proyecto del Golfo de Mexico fue desarrollar una base de datos de pesquerías independiente para el manejo de las diferentes especies de tiburón (tiburones costeros grandes y pequeños) y teleósteos de importancia comercial (huachinangos y meros). Los objetivos secundarios incluyeron estudios de marcado y muestreo biológico para el conocimiento de las historias de vida de las principales especies.. En cuatro cruceros conjuntos de investigación se realizaron 203 estaciones de palangre de fondo durante 44 días del estudio. Las capturas incluyeron 97 tiburones (11 especies), 63 de otros elasmobranquios (3 especies) y 246 teleósteos (30 especies).

PALABRAS CLAVES: Tiburones, distribución estacional, palangre, marcado, pesquerias, Golfo de Mexico

A Comparison of Age Estimates from Sagittal Otoliths and the First Dorsal Spine for Cobia (*Rachycentron canadum*) from the Northern Gulf of Mexico

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Cobia, *Rachycentron canadum*, are migratory, coastal pelagic fish that are distributed worldwide in tropical and subtropical seas, except for the eastern Pacific. Previous research established that cobia from the northern Gulf of Mexico recreational fishery could be exactly aged using sectioned sagittal otoliths. The collection of sagittae from cobia harvested by fishers typically requires removal of the entire head for subsequent otolith extraction and sectioning in the laboratory, often a difficult and time consuming process. We conducted a comparison of age estimates obtained from analyses of whole and sectioned sagittal otoliths and sectioned first dorsal spines. Whole sagittae contained growth zones assumed to be annual events, and dorsal spine sections revealed a succession of alternating opaque

and translucent bands that, although not validated as annuli, were used in age estimations. Vascular erosion of the central core of spines from some large fish obscured the inner (early) growth bands which required their statistical replacement. The accuracy of age estimates from readings of whole sagitta and dorsal spine sections was ascertained by comparison with age data from sectioned sagittae from the same fish. Although more difficult to collect, sagittae provide more detailed age information, however, dorsal spines are more practical in terms of ease of collection and may represent an alternative for deriving age estimates for cobia.

KEY WORDS: Cobia, *Rachycentron canadum*, age estimates, otoliths

Comparacion de la Edad Estimada con Otolitos Sagitales y la Primera Espina Dorsal en Cobia (*Rachycentron canadum*) en el Norte del Golfo de Mejico

Cobia, *Rachycentron canadum*, es un pez costero pelágico y migratorio distribuido en los mares tropicales y subtropicales de todo el mundo, con excepción del Pacífico oriental. Previas investigaciónes establecieron que la edad de la cobia capturada recreacionalmente en el norte del Golfo de Mejico podría ser estimada con exactitud utilizando otolitos sagitales seccionados. La colección de sagittae en la cobia cosechada por los pescadores típicamente requiere la remoción de la cabeza entera para extraer el otolito y luego su disección en el laboratorio, a menudo un proceso difícil que consume mucho tiempo. Realizamos una comparación entre las edades estimadas utilizando los otolitos sagitales enteros y seccionados y las primeras espinas dorsales seccionadas. Los sagittae enteros presentaron las zonas del crecimiento asumidas como acontecimientos anuales, y las secciones de la espina dorsal revelaron una sucesión de bandas opacas y translúcidas alternas, aunque no validas como piezas anuales, fueron utilizadas en la valoracion de la edad. En algunos peces grandes, la erosión vascular de la base central de las espinas dorsales obscureció las bandas (tempranas) internas de crecimiento lo que requirio su reemplazo estadístico. La exactitud de la edad estimada con las lecturas de la sagitta entera y de la espina dorsal seccionada fue comprobada comparando esos datos con los obtenidos con los sagittae seccionados de los mismos peces. Aunque es más difícil colectar, los sagittae proporcionan una información más detallada de la edad, sin embargo, las espinas dorsales son más prácticas en términos de la facilidad de colección y pueden representar una alternativa para derivar las estimaciones de edad para la cobia.

PALABRAS CLAVES: Cobia, *Rachycentron canadum*, edad estimada, otolitos

Documentation of Traditional Knowledge in the British Virgin Islands: Filling the Information Gap in Fisheries Management

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Caribbean fisheries often have poor scientific knowledge and limited resources to implement conventional management tools. Yet fishers possess a wealth of knowledge on where and when fish migrate or aggregate, how they behave and how marine environmental conditions have changed over time. Fishers spend more time at sea than fisheries scientist and have built up a complex knowledge bank over the years. It is therefore important that this traditional fisheries knowledge be systematically collected, organized, and then evaluated.

This paper gives the results of a three-month documentation exercise on the traditional knowledge possessed by the local fishers in the British Virgin Islands. Seventy-one fishers with 10 to 70 years of fishing experience from five of the inhabited islands; Tortola, Virgin Gorda, Anegada, Jost Van Dyke, and Copper Island, were interviewed. Information was recorded on fish ecology, fishing methods, changes in social conditions, imposition of regulations and how fishers adjusted.

KEY WORDS: Traditional fisheries knowledge, poor scientific knowledge, documentation

The Effects of Trap Fishing in Coral Reef Habitats: A Preliminary Analysis

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Trap fishing is common near coral reefs in Florida and the U.S. Caribbean but the effects of traps on reefs or reef-associated habitats have not been well documented. A cooperative study between NOAA Fisheries, local resource agencies, academic researchers, and the fishing industry has completed its first year investigating such effects in the Florida Keys (lobster and stone crab traps) and in Puerto Rico and the U.S. Virgin Islands (fish and lobster traps). The project design includes: 1) mapping the distribution of traps, 2) quantifying trap densities by habitat, and 3) quantifying damage to corals and other structural organisms. Preliminary findings suggest that a relatively small percentage (<20%) of the traps set in shallow water (< 30 m) actually contact hard corals. More are found in contact with gorgonians or sponges. In this preliminary analysis, patchy damage was documented mainly on hard corals, at a scale less than the total trap foot print. Continued research will assess whether these preliminary findings are representative of coast-wide trap fisheries and will provide more precise data on trap fishing intensity by habitat type, seasonal movement of traps among habitats, and the potential for gear impacts to associated habitat components such as seagrasses, macroalgae, and sponges. Understanding trap-fishing effects on essential fish habitats like coral reefs at larger than local scales will improve resource management and lead toward more sustainable fisheries.

KEY WORDS: Trap fishing, coral reef habitats

Los Effectos de la Pesca con Trampas en los Arrecifes de Coral y en los Habitat Associados con estos: Analysis Preliminares

La pesca de la trampa en los arrecifes coralinos cercanos comunes en la Florida y los ESTADOS UNIDOS el Caribe pero los efectos de trampas en los arrecifes o los habitat asociados con arrecifes no se han documentado bien. Un estudio cooperativo entre las industrias pesqueras de NOAA, las agencias locales del recurso, los investigadores académicos, y la industria de pesca ha terminado su primer año investigando tales efectos en las llaves de la Florida (las trampas de la langosta y del cangrejo de la piedra) y en Puerto Rico y las islas de la Virgen de ESTADOS UNIDOS (las trampas de los pescados y de la langosta). El diseño del proyecto incluye: 1) traz la distribución de trampas, 2) cuantificando densidades de la trampa por el habitat, y 3) cuantificando daño a los corales y a otros organismos estructurales. Los resultados preliminares sugieren que un porcentaje relativamente pequeño (el < 20%) de las trampas fijara en agua baja (< 30 m) entran en contacto con realmente corales duros. Más se encuentran en contacto con los gorgonians o las esponjas. En este análisis preliminar, el daños desigual fueron documentados principalmente en corales duros, en una escala menos que la impresión total del pie de la trampa. La investigación continuada determinará si estos resultados preliminares son representante de las industrias pesqueras costa-anchas de la trampa y proporcionará datos más exactos en intensidad de la pesca de la trampa por el tipo del habitat, el movimiento estacional de trampas entre habitat, y el potencial para los impactos del engranaje a los componentes asociados del habitat tales como seagrasses, macroalgae, y esponjas. Los efectos de la atrapar-pesca que entienden sobre habitat esenciales de los pescados como los arrecifes coralinos en las escalas más en gran parte que locales mejorarán la gerencia de recurso y conducirán hacia industrias pesqueras más sostenibles.

PALABRAS CLAVES: Pesca con trampas, habitat del arrecife coralino

Aspectos Reproductivos del Robalo (*Centropomus undecimalis*) en la Bahia de Cispata, Colombia

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Para estimar la talla de primera madurez, el índice gonado-somático y la época

de desove del Róbalo {*Centropomus undecimalis*) se colectaron 247 ejemplares entre abril 1999 y marzo 2000 en la Bahía de Cispatá, Colombia. Las tallas oscilaron entre 28.0 y 88.0 cm de longitud total (LT), el peso total entre 110.0 y 8,000.0 g, y el peso de las gónadas entre 0.100 y 301.00 g. La proporción de sexos machos:hembras fue de 3:1, y el índice gonado-somático estimado fue 0.111, 2.107 y 1.109 para machos, hembras y sexos combinados, respectivamente. La época de reproducción se presenta entre marzo y octubre, con un máximo pico en abril. Las tallas medias de madurez sexual estimadas fueron 57.5, 67.8 y 62.2 cm LT para machos, hembras y sexos combinados, respectivamente. Debido a que el Róbalo es hermafrodita protándrico y cambia de sexo de macho a hembra, la mayoría de individuos pequeños son machos y la mayoría de grandes son hembras.

PALABRAS CLAVES: Robalo, *Centropomus undecimalis*, aspectos reproductivos, Colombia

Reproductive Aspects of Common Snook (*Centropomus undecimalis)* in the Cispata Bay, Colombia

In order to estimate the length at first maturity, the gonad-somatic index and the spawning season of the common Snook (*Centropomus undecimalis*), 247 samples was collected between April 1999 and March 2000 in the Cispata Bay, Colombia. The sizes oscillated between 28.0 and 88.0 cm in total length (TL), the total weight between 110.0 and 8,000.0 g, and the gonads weight between 0.100 and 301.00 g. The proportion of sexes males:females was of 3:1, and the gonad-somatic index was 0.111, 2.107 and 1.109 for males, females and combinated sexes, respectively. The spawning season occurs from march to october, with peak activity in April. The length at first maturity estimates were 57.5, 67.8 y 62.2 cm TL for male, female and combinated sexes, respectively. Because to the common Snook is protrandic hermaphrodite and change sex from male to female, the majority of small common snooks are males and the majority of large common snooks are females.

KEY WORDS: Common snook, *Centropomus undecimalis*, aspects of reproduction

Population Parameters of Spiny Lobster, *Panulirus argus*, from the Puerto Rico's Commercial Fishery

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Estimates of growth, mortality and yield per recruit patters of spiny lobster, *Panulirus argus*, were investigated using length frequency data from Puerto Rico=s Commercial Fishery data. Computer based methods of length frequency analysis (FISAT) were used. For males asymptotic length (L4) was 197, body growth rate (k) was 0.25, and total mortality (Z) was 0.70. Results from the exploitation rates and yield per recruit analyses indicate Puerto Rico=s spiny lobster stock is currently heavily fished.

KEY WORDS: Spiny lobster, *Panulirus argus*, commercial fishery, Puerto Rico

Landings Allocation between Different Segments of the Spiny Lobster Fishing Community in Florida

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In Florida, the Caribbean spiny lobster, *Panulirus argus*, supports both an intensive commercial fishery and a popular recreational dive fishery. The fishery has been dominated by the use of wooden-slat traps since the 1950's. From the early 1970s to 1991-92 fishing season, the numbers of traps increased dramatically from approximately 200,000 to 939,000. The State of Florida implemented a trap reduction program in the 1993 - 1994 fishing season that reduced the numbers of traps to 530,000 by the 2001 - 2002 fishing season. Additional reduction of the number of traps to 400,000 is scheduled. Commercial lobster landings have been, on average, higher since the implementation of trap limitation than any previous eight-year period. However, the proportion of total landings by commercial trap fishermen decreased progressively soon after the implementation of the program from a high of 77 % in the 1994 - 1995 fishing season to 62 % in the 2001 - 2002 fishing season, while the proportion of the landings by commercial divers increased from 3 % to 11 %. The proportion of the total landings by recreational divers has also increased by several percentage points in recent years. Such a shift in landings

away from the commercial trap fishery toward commercial and recreational divers was recognized as a potential, but unintended, effect of restricting the number of traps. Fishery managers must now consider the implications of trap limitation on the historic landings allocations between fishing groups.

KEY WORDS: Spiny lobster, *Panulirus argus*, landings allocation

Asignación de Desembarcos entre los Diferentes Segmentos de la Comunidad de Pesca de Langosta en Florida

En Florida, la langosta espinosa, *Panulirus argus*, sostiene tanto una pesquería comercial como una pesquería de buzeo recreacional. El empleo de trampas de madera ha dominado el pesquería desde los años 1950. De los años 1970 a la temporada de pesca de 1991 - 1992, el número de trampas aumentó dramáticamente de aproximadamente 200,000 a 939,000. El estado de Florida puso en práctica un programa de reducción de trampas en la temporada de pesca de 1993 - 1994 que redujo el número de trampas a 530,000 en la temporada de pesca de 2001 - 2002. Una reducción adicional a 400,000 trampas esta programada. Los desembarcos comerciales de langosta han sido más altos desde la reducción de trampas que en cualquier período anterior de ocho años. Sin embargo, la proporción de desembarcos totales por pescadores de trampas comerciales disminuyó de 77 % en la temporada de pesca de 1994 - 1995 a 62 % en la temporada de pesca de 2001 - 2002, mientras que la proporción de desembarcos por buzos comerciales aumentó de 3 % a 11 %. La proporción de desembarcos totales por buzos recreacionales también ha aumentado en años recientes. El cambio en desembarcos de la pesquería de trampa comercial hacia buzos comerciales y recreacionales fue reconocido como un efecto de la reducción en el número de trampas. Los gerentes de la pesquería ahora deben considerar las implicaciones de la reducción de trampas sobre las asignaciones de desembarcos históricos entre los grupos de pesca.

PALABRAS CLAVES: Langosta espinosa, *Panulirus argus*, las asignaciones de desembarcos

Analisis Preliminar de la Distribución y Abundancia de la Comunidad de Peces Asociados al Arrecife de Tipo Borde en Mahahual Quintana Roo, México

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Se realizo el análisis de la comunidad de peces asociados a la laguna arrecifal en el arrecife de Mahahual, ubicado en la parte Sur del estado de Quintana Roo, mediante censos visuales. Para lo cual se dividió la laguna en dos habitats, la parte medias de la laguna y la cresta arrecifal. En cada uno de estos se realizaron transeptos perpendiculares a la costa. Los muestreos se desarrollaron en la época de nortes (septiembre a diciembre) del 2000. Se registraron un total de 67 especies, pertenecientes a 23 familias, de las cuales las familias más importantes en cuanto al número de especies fueron Lutjanidae, Pomacentridae, Guerreidae y Carangidae. De los dos habitas analizados la cresta arrecifal presento un total de 59 especies divididas en 17 familias, de las cuales la familia Pomadasyidae presento 10 especies, la Labridae con 7 especies y las familias Pomacentridae y Scarridae con 6 especies cada una . En la parte media de la laguna arrecifal, se registraron un total de 42 especies repartida en 17 familias, de las cuales la familia Scaridae presento 6 especies. Las especies que presentaron mayor coeficiente simple de dominancia fueron *Haemulon sciurus, Abudefduf saxantilis, Stegastes fuscus* y *Lutjanus apodus,* con un 70%. Se registro un valor general de diversidad de 5.091 bits/ind, con un valor mínimo para la estación 1 de 2,760 y un máximo de 4.638 bits/ind para la estación 8. Estos resultados preliminares resultan ser similares a los reportados por otros autores para la región del Caribe mexicano.

PALABRA CLAVES: Arrecife, Mahahual, peces, diversidad, comunidad

Preliminary Analisis of the Distribution and Abundance of the Community of Fish Associated to the Reef Lagoon in Mahahual Quintana Roo, Mexico

An analysis of the community of fish associated to the reef lagoon in the reef of Mahahual, located in the South part of the state of Quintana Roo, by means of visual censuses. For which the lagoon in two was divided habitats, the part average of the lagoon and the arrecifal crest. In each one of these transects perpendicular to the coast were made. The samplings were conducted in September to December 2000. A total of 67 species, pertaining to 23 families was registered, of who the

most important families as far as the number of species were Lutjanidae, Pomacentridae, Guerreidae and Carangidae. Of both areas analyzed, the reef crest displayed a total of 59 species divided in 17 families, of who the Pomadasyidae family had 10 species, the Labridae with 7 species and the families Pomacentridae and Scaridae with 6 species each. In the average part of the reef lagoon, a total of 42 species distributed in 17 families was registered, of who the Scaridae family had 6 species. The species that had the greater simple coefficient of dominance were *Haemulon sciurus*, *Abudefduf saxantilis*, *Stegastes fuscus* and *Lutjanus apodus*, with a 70%. Registry a general value of diversity of 5,091 bits/ind, with a minimum value for station 1 of 2.760 and a 4,638 maximum of bits/ind for station 8. These preliminary results turn out to be similar to the reported ones by other authors for the region of the Mexican Caribbean.

KEY WORDS: Reef, Mahahual, fish, diversity, comunida

Peces de la Laguna la Esperanza, Laguna de Terminos, Campeche

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Los patrones de abundancia de las especies de peces dominantes de la laguna La Esperanza fueron analizados durante las épocas de lluvias, "nortes" y secas en el periodo comprendido entre septiembre del 2001 hasta junio del 2002. Las colectas se realizaron mediante una red de prueba camaronera cada mes hasta completar diez muestreos. Los valores de la salinidad variaron desde 36 ‰ en septiembre del 2001 hasta 18 ‰ en noviembre del mismo año y la temperatura varió desde 30 °C en septiembre del 2001 hasta 23 °C en febrero del 2002. La comunidad integra 37 especies correspondientes a 23 familias, las especies dominantes resultaron: *Eugerres plumieri*, *Sphoeroides testudineus*, *Cathorups melanopus*, *Archosargus rhomboidalis* y *Bairdiella chrysura*. Las fluctuaciones de densidad y biomasa, así como, la frecuencia de las especies en el área estuvieron relacionadas con el comportamiento ambiental del sistema, excepto *S. testudineus* y *A. rhomboidalis* que fueron independientes de las variaciones de salinidad y temperatura. Las especies dominantes en el área desarrollan estrategias de comportamiento que minimizan la competencia entre ellas.

PALABRAS CLAVES: Peces, abundancia, laguna La Esperanza, Campeche

Fishes from Laguna la Esperanza, Laguna de Terminos, Campeche

Abundance patterns of dominant fishes species in La Esperanza lagoon in the three climatic periods, rainy, "nortes", and dry, were analyzed. Ten fish collections were made from September 2001 to June 2002. Samples were obtained by otter trawl. Salinity range from 36 ‰ in September 2001 to 18 ‰ in November 2001, and temperature were among 30 °C in September 2001 and 23 °C in February 2002. Community was formed by 37 fish species corresponding to 23 families. Dominant species were: *Eugerres plumieri*, *Sphoeroides testudineus*, *Cathorups melanopus*, *Archosargus rhomboidalis*, and *Bairdiella chrysura*. Fluctuations of density, biomass, and frequency of this species in the studied area were related with the environmental behavior system, except *S. testudineus* and *A. rhomboidalis* which behavior resulted independent from salinity and temperature variations. Dominant fish species in the studied area developed behavioral strategies than minimized inter specific competition.

KEY WORDS: Fish, abundance, La Esperanza Lagoon

Identification of Small Scale Coral Reef Habitats from High Resolution Side Scan Sonar Imagery

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A detailed characterization of habitat is important to understand how organisms react and use their immediate environment and to study many ecological processes occurring at these. However, detailed habitat knowledge needs to be extended over broad areas to determine the spatial distribution of benthic habitats and their connectivity. This large scale habitat assessment is crucial to determine the effects of disturbance, heterogeneity and dispersal between habitat patches on marine populations. Unfortunately, detailed habitat identification over large areas is unknown for the majority of reef areas. In this work, a total of 60 km^2 off La Parguera, Puerto Rico were surveyed using a Side Scan Sonar (SSS). The acquired imagery has high spatial resolution (0.15 m) and allowed the identification of 21 different habitat types. The most structured habitats (6) were dominated by corals

and gorgonians, which covered 28 % of the area. Vegetated habitats (8) represented 13 % of the area, while unconsolidated habitats (7) occupied 59 % of the area. Abundant coral patches on a sandy matrix, small coral patches surrounded by a seagrass halo, dominance of coral limestone patches aligned parallel to the prevalent waves, deep sand channels, and extensive gorgonian plains are all examples of previously uncharted habitats. Mangrove habitat could not be mapped with SSS. Habitats recognized were related to biologically relevant measures Bstructure, rugosity, benthic community composition and abundance- that are known to be the factors affecting fish community structure. Therefore, SSS is a particular valuable technique for quantitative assessments of habitat distributions important for fish management, e.g., habitat abundance and connectivity for essential fish habitat or MPA design.

KEY WORDS: Habitat characterization, side scan sonar, small scale habitats, coral habitats

Identificación de Habitats de Arrecife de Coral a Pequeña Escala desde Imágenes de Sonar Lateral de Alta Resolución

Una caracterización detallada de hábitats es importante para entender como los organismos reaccionan y usan su ambiente, y para estudiar muchos procesos ecológicos que ocurren a pequeña escala. Sin embargo, un conocimiento detallado necesita ser extendido sobre grandes áreas para determinar la distribución espacial de hábitats y su conectividad. Este asesoramiento de hábitats a mayor escala es crucial para determinar los efectos de disturbios, hetereogeneidad y dispersión entre parches de hábitats sobre las poblaciones marinas. Desafortunadamente, la identificación detallada de hábitats sobre grandes áreas es desconocida para la mayoría de las áreas de coral. En este trabajo, un total de 60 km^2 afuera de La Parguera, Puerto Rico, fue inspeccionada usando un sonar lateral (SSS). Las imágenes adquiridas fueron de alta resolución (0.15 m) y permitieron la identificación de 21 habitats diferentes. Los hábitas más estructurados (6) estuvieron dominados por corales y gorgonios, los cuales representaron un 28% del área. Los hábitas con vegetación (8) representaron un 13 %, mientras que los hábitas de sedimentos no-consolidados ocuparon un 59 % del área. Abundantes parches de coral en una matriz de arena, pequeños parches arrecifales rodeados por un halo de pasto marino, dominancia de parches de coral alineados paralelos al flujo de las olas, canales de arena profundos y extensas planos de gorgonios fueron todos ejemplos de hábitats previamente no mapeados. Los manglares no pudieron ser mapeados con un SSS. Los hábitats reconocidos se relacionaron con mediciones biológicas relevantes B estructura, rugosidad, composición de comunidades bénticas y abundancia- que son conocidos factores que afectan la estructura de la comunidad de peces. Por lo tanto, SSS fue una técnica particularmente valiosa para asesoramientos cuantitativos de la distribución de hábitats importante para el manejo

pesquero, e.g., abundancia de hábitat y conectividad para EFH ó AMP.

PALABRAS CLAVES: Caracterización de hábitats, sonar lateral, hábitats a escala detallada, hábitats de coral

Vertical Distribution of Larval Fishes off La Parguera, Southwest Puerto Rico

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The vertical distribution of fish larvae from the southwest coast of Puerto Rico were described from samples collected during two cruises, Feb/95 and May/96 along three meridional (North-South) transects (67°00'; 67°03; and 67°06 W) running perpendicular to the coastline off La Parguera. The shelf-edge (SE-13) and three offshore positions (OC-17, OC-29 and OC-46) were occupied along each transect, for a total of 12 stations per cruise. These stations were sampled in vertically stratified, step-oblique tows at three discrete depths (surf 0-20, mid 21-40 and deep 41-60 meters) within the surface mixed layer using a 1 m^2 Tucker Trawl fitted with three 202 ìm mesh nets and standard flow meters. Conductivity, temperature, depth, and chlorophyll-*a* concentrations were measured using a CTD profiler with an integrated fluorometer. Water column density profiles at the different stations for February and May cruises showed permanent stratification with well developed pycnoclines associated with increasing salinity and a decline of water temperature with depth.

A total of 15,638 fish larvae representing 82 families were identified during the study. Pre-flexion coral reef fish larvae did not show any statistically significant pattern of abundance in their vertical distribution within the surface mixed layer. Only a few families at post-flexion stage showed statistically significant differences of abundance between depths, or between day and night samplings. While a more comprehensive vertical sampling program based on a larger number of samples may be required to provide definitive conclusions on reef fish vertical distributions for some taxa, some trends were apparent. Abundance of oceanic type larvae, such as myctophids, gonostomatids and photichtyids increased with depth, as well as coral reef fish larvae of the Gobiidae and Scaridae families. Conversely, Clupeiformes, Pomacentridae, Haemulidae and Holocentridae were more abundant at shallower depths within the surface mixed layer. Lutjanidae were found mostly in mid water.

The level of taxonomic analysis (Family) used in the present study may have masked species-specific trends in vertical distribution. Furthermore, patchiness was relatively high, and imposed a large margin of variability in mean abundance at each depth.

KEY WORDS: Fish larvae, vertical distribution, Puerto Rico

Distribución Vertical de Larvas de Peces Fuera de La Parguera, al Suroeste de Puerto Rico

La distribución vertical de las larvas de peces fueron descritas de las muestras colectadas estratificadas verticalmente, por medio de arrastres escalonados a tres profundidades dentro de la capa mixta superficial (superficie 0-20m, profundidad media 21-40m y zona profunda 41-60m). Los perfiles de densidad de agua para los meses de febrero y mayo muestran una estratificación permanente con picnoclinos bien formados asociados a un aumento en salinidad y una disminución en la temperatura con mayor profundidad. Las larvas de arrecife de coral en etapa de pre-flexión, no mostraron diferencias estadísticamente significativas en los patrones de abundancia en su distribución vertical dentro de la capa mixta. Solo unas cuantas familias de larvas en la etapa post-flexión mostraron diferencias significativas en su abundancia para las distintas profundidades o entre el día y la noche. La abundancia de las larvas de las familias oceánicas Myctophidae, Gonostomatidae y Photichthyidae aumentaron con profundidad al igual que las larvas de arrecife de coral de las familias Gobiidae y Scaridae. Por el contrario las larvas de peces del orden Clupeiformes y las familias Pomacentridae, Haemulidae y Holocentridae fueron mas abundantes en la zona de superficie dentro de la capa mixta. Las larvas de la familia Lutjanidae fueron encontradas mayormente en la profundidad media.

El nivel taxonómico de análisis (Familia) utilizado en este estudio pueden haber enmascarado las tendencias en distribución vertical a nivel de especie.

Además, la distribución en agregado fue muy alta e impone un alto margen de variabilidad en la abundancia promedio en cada profundidad.

PALABRAS CLAVES: Las larvas de peces, distribución vertical , Puerto Rico

Estimaciones de la CPUE de la Flota Camaronera de Campeche (Golfo De México) A Través de un Modelo Lineal Generalizado

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En el presente estudio se realizó un análisis de la CPUE perteneciente a la flota camaronera de Campeche durante la temporada de pesca 1997 en el Golfo México mediante la aplicación de un Modelo Lineal Generalizado (MLG). Se utilizaron 240 bitácoras de pesca pertenecientes a 171 barcos camaroneros, obteniéndose 33 940 registros por lance de captura. Adicionalmente se utilizó la información correspondiente a las características de la flota camaronera y en combinación con la información de las bitácoras se realizó una matriz con la siguiente información: nombre de la embarcación, fecha de salida y por lance, hora de inicio y término, zona de pesca (latitud longitud), profundidad, captura por especie y características de barco: eslora, potencia de motor, año de construcción, capacidad de bodega, arqueo neto y bruto y material de casco. Inicialmente con el fin de evaluar la relación entre las características físicas de las embarcaciones (variable independiente) y la CPUE (Kg/días efectivos de pesca por mes, como variable dependiente), se realizó un modelo de regresión múltiple obteniéndose solamente el arqueo neto y la capacidad de bodega como significativos. Estas características junto con las variables de las bitácoras de pesca y sus respectivas variables ADummy@ fueron utilizadas en el MLG, para esto se consideró lo siguiente: la captura de camarón total mensual, 5 niveles de capacidad de bodega (5-15 ton, 16 a 30 ton, 31 a 40 ton, 41 a 50 ton, > a 51 ton), tres niveles de arqueo: 39.5 a 70 ton, 71 a 90 ton, 91 a 110 ton), tres niveles de profundidad (< a 20 brazas, 20 - 40 brazas, 40 a 100 brazas y 0-100 brazas) tres áreas de pesca (1 = Región entre Tamaulipas y norte de Veracruz, 2 = Sonda de Campeche y 3 = Contoy) obteniéndose que el modelo se explica significativamente ($p < 0.05$) en un 42 % ($r^2 = 0.42$). Para realizar el modelo se utilizó como mes de referencia agosto por ser el mes de mayor captura. Este modelo permitió calcular el Poder de pesca y la correspondiente CPUE ajustada para cada mes, profundidad y capacidad de bodega, observándose que el comportamiento de la CPUE es diferente a nivel espacial con mayor captura en la región 1 y 2 y esta influenciado directamente por la temporada de veda ya que la mayor captura obedece directamente a la apertura de la temporada de pesca.

PALABRAS CLAVES: CPUE, Golfo de México, Flota camaronera

CPUE Estimations of the Campeche Shrimp Fleet (Gulf of Mexico) Using a Generalized Linear Model

In the present work CPUE data of the Campeche shrimp fleet operating in the Gulf of Mexico were analyzed for the year 1997 using a Generalized Linear Model (GLM). Data were extracted from 240 logbooks of 171 shrimp vessels that summarized 33940 records of landing-catch. Additionally data included vessels characteristics (vessel name, overall length, horsepower, age built, gross tonnage, net tonnage, carrying capacity, hull material) landing location (Longitude and latitude), depth, fishing area and catch by specie. This information was integrated in a matrix including CPUE (Kg/effective day of fishing) as the dependent variable. A preliminary multiple regression analysis showed that net tonnage and carrying capacity were significant vessel characteristics. These variables plus landing locations, fishing area and depth were included as ranges codified in the GLM as follow: Shrimp monthly catches, five levels of carrying capacity (5-15 tons, 16-30 tons, 31-40 tons, 41-50 tons, > to 51 tons), three levels of net tonnage (39.5-70 tons, 71-90 tons, 91-110 tons), three levels of depth (< to 20 fathoms, 20-40 fathoms, 40-100 fathoms and 0-100 fathoms) three areas of fishing (1 = Region between Tamaulipas and north of Veracruz, 2 = Campeche Sound y 3 = Contoy zone). The GLM resultant was significant ($p > 0.05$), explaining a 42 % ($R^2 = 0.42$) of the shrimp monthly catches. To carry out the estimations, August catches were used as reference since it was the month with the highest shrimp catch. This model allowed us to estimate the fishing power and fitted CPUE values by month, depth and carrying capacity. We could observe that CPUE changed with respect to spatial strata with the greatest on the regions 1 and 2. These regions are influenced directly by the fishing restricted period. The highest catches were observed after restricted fishing period is opened.

KEY WORDS: CPUE, Gulf of Mexico, shrimp fleet

Pêche sur les Frayères de Mérous en Martinique

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Une enquête a été réalisée en Martinique pour faire suite aux propositions faites lors de la dernière réunion du GCFI sur les pêches sur frayères de mérous. Cette enquête révèle l=existence de ce type de pêche sur une espèce : *Alphester afer* et marginalement sur *Epinephelus fulvus*. Une première description des techniques de pêche et de leur évolution est faite. Une localisation grossière des zones où se pratique cette activité est également présentée.

MOTS CLÉS: Frayères de Mérous, pêche

Groupers Spawning Aggregation Fisheries In Martinique

Following the last GCFI meeting proposition on groupers spawning aggregations fisheries, a survey has been undertaken in Martinique. This survey reveals that fishing occurs on one species *Alphester afer* and marginally on *Epinephelus fulvus*. This poster present a first description of the fishing techniques and their evolution. A rough localisation of this fishing areas is presented.

KEY WORDS: Grouper spawning aggregation, fishery

The Use of Fish Traps in Puerto Rico: Current Practice, Long Term Changes, and Fishers' Perceptions

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Traps are used extensively in the Caribbean region for catching fishes and crustaceans in diverse habitats, and traps may affect the natural dynamics of habitats as well as exploited populations. An interdisciplinary study incorporating fisher knowledge and quantitative field surveys is investigating the habitat effects of traps. Here, we report on trap fishing methods today and fishers' perception of current trends and localized problems in Puerto Rico. Forty-seven trap fishers representing 5 regions (north, south, east, west, and islands) were interviewed on site about gear construction, effort, habitat preferences and fishers' perceptions of the main problems in the fishery and their possible solutions. Materials used in fish traps have been changing, over time; however, the main routine for setting traps remains generally the same with some localized variations. Despite its traditional dominance in local artisanal fisheries, more than half of the interviewed trap fishers have reduced their number of traps; therefore individual effort seems to be declining. Coral reefs were not reported as a preferred fish trap location, but rather areas adjacent to reefs (sand, seagrass, gorgonian, and algal habitats) are targeted. The

main problems reported by fishers in Puerto Rico are trap theft, loss of buoys, and environmental degradation, problems that correspond to increasing effort by commercial divers, increasing numbers of recreational vessels in fishing areas, and coastal development. Additionally, the numbers of unregulated recreational vessels and the increases in trap/catch theft in fishing areas have promoted the use of unbuoyed traps, which in turn leads to an increase in ghost traps. Ghost traps are known to continue fishing long after they are lost and may be causing unknown effects on fishing grounds, therefore trap loss needs to be considered in fisheries management regulations. Some suggestions to alleviate these problems include enforcement at sea and zoning schemes.

KEY WORDS: Fish traps, practices and perceptions, Puerto Rico

La Pesca de Nasas en Puerto Rico: Situación Actual, Cambios a Largo Plazo y la Percepción de los Pescadores

Las nasas son utilizadas en la mayoría de las islas del Caribe para la captura de peces y crustáceos en diversos hábitats, por lo que tienen un impacto sobre la dinámica natural del hábitat y de las poblaciones pescadas. En un enfoque interdisciplinario describimos la metodología de la pesca de nasas actual en Puerto Rico y la percepción de los pescadores sobre los cambios y problemas en la pesquería. Cuarenta y siete pescadores de 5 regiones (norte, sur, este, oeste e islas) fueron entrevistados in situ. El propóstio de la encuesta era describir el método de construcción de las nasas, el tipo de esfuerzo, preferencias de hábitat y la percepción de los pescadores sobre los principales problemas de la pesquería y sus posibles soluciones. Los resultados indican que el material utilizado en las nasas ha cambiado aunque la manera en que se utilizan se ha mantenido igual con algunas variaciones por localidad. A pesar de ser el arte de pesca tradicional de Puerto Rico, más de la mitad de los dueños de nasas han reducido el número de trampas, y por ende, el esfuerzo. Los arrecifes de coral no son la localidad preferida para pescar con nasas, pero si las áreas adjacentes a éstos (rastreales, yerbazales, fondos de algas y gorgónios). Los mayores problemas que afectan a los pescadores de nasas en Puerto Rico son: el robo de artes de pesca, la pérdida de boyas y la degradación ambiental, entre otros. Estos problemas están correlacionados al aumento en el esfuerzo pesquero por parte de los buzos, el aumento en el número de embarcaciones recreativas en áreas pesqueras y el desarrollo costero. El aumento desregulado de embarcaciones en las areas de pesca ha causado el uso de nasas 'ahogadas' (sin boyas), lo que ha provocado un aumento en la pérdida del arte. Las nasas perdidas tienen un efecto en los hábitats y debe considerarse en las regulaciones de manejo de pesquerías. Algunas sugerencias para aliviar estos problemas incluyen vigilancia en el mar y zonificación de aguas costeras.

PALABRAS CLAVES: Las nasas, situación actual, percepción

Cultivo en el Laboratorio del Gasterópodo *Melongena corona bispinosa* (Neogastropoda: Melongenidae)

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El gasterópodo *Melongena corona bispinosa* representa una fuente de trabajo para los habitantes de Chuburná Yucatán, México, donde es explotado durante todo el año de manera artesanal por ribereños de todas las edades. El 70 % de la población (1,000 habitantes) realiza la pesca de este caracol, extrayendo en promedio 3 kg de pulpa por persona en una jornada de 8 horas dando un total de 40 toneladas anuales de peso vivo y la captura de 12 millones de organismos.

En el trabajo se determinó el efecto de dos alimentos a tres raciones sobre el crecimiento y sobrevivencia de *Melongena corona bispinosa*. Estos fueron: tejido blando de la almeja *Polymesoda maritima*, que es el alimento natural de estos organismos y alimento para tilapia. Las raciones fueron proporcionadas al 3 %, 6 % y 9 % de la biomasa húmeda de los organismos. Las tasas de crecimiento diario en términos de longitud de la heliconcha de *M. corona bispinosa* alimentada con la almeja fueron: al 3 %, 32 cm/día y 4 μg/día en peso húmedo total. Al 6 %, 28 cm/día y 5 μg/día y al 9 %, 29 cm/día y 6 μg/día. Con el alimento para tilapia, la tasa de crecimiento obtenida fue igual para las tres raciones, siendo de 12 cm/día y 3 μg/día. La mayor sobrevivencia se obtuvo con el lote de organismos amentados con alimento para tilapia al 6 %. Se realizó el análisis entre dietas y raciones con diferentes índices fisiológicos de condición.

M. corona bispinosa posee características adecuadas para su manejo, aportando este trabajo algunas de las bases para un programa de engorde y cultivo.

PALABRAS CLAVES: Gasterópodo, *Melongena corona bispinosa*, alimentación, cultivo

Culture in the Laboratory of the Gasteropod *Melongena crowns bispinosa* (Neogastropoda: Melongenidae)

The gasteropod *Melongena crowns bispinosa* represents a source of work for the inhabitants of Chuburná Yucatan, Mexico, where artisanal fishing is conducted through the year. Seventy percent of the population (1,000 inhabitants) make the fishing of this snail, extracting in average 3 kg of pulp per person in a day of 8 hours giving a total of 40 tons annual of alive weight and the capture of 12 million organisms. In this work the effect two diets, at three ration levels, was determined

on the growth and survival of *Melongena crowns bispinosa*. These were: soft tissue of the marine clam *Polymesoda*, that is the natural food of these organisms and the second was tilapia feed . The rations were provided to 3 %, 6 % and 9 % of the meat biomass of the organisms. The rates of daily growth in length terms of heliconcha of M. crown bispinosa fed with the clam were: to 3 %, 32 mm/día and 4 μg/día in total wet weight. To 6 %, 28 mm/día and 5 μg/día and to 9 %, 29 mm/día and 6 μg/día. With the food for tilapia, the obtained rate of growth was equal for the three rations, being of 12 mm/día and 3 μg/día. The greater survival was obtained with organisms fed with food for tilapia at 6 %. It was made the analysis between diets and rations with different physiological indices from condition. *M. crowns bispinosa* has characteristics adapted for their handling, contributing some of the bases for a culture program to enhance yield.

KEY WORDS: Gasteropod, *Melongena crowns bispinosa*, feeding, culture

Caracterización de los Paisajes que Integran la Estructura Bentonica de la Zona Costera de Chabihau, Yucatán, México

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El objetivo de este trabajo fue estudiar los diferentes paisajes bentónicos que conforman el ambiente marino de la zona costera de Chabihau, Yucatán, México. Se estudió la composición geo-morfofuncional del bentos mediante la toma y análisis de video-transectos. Esta técnica es un método que permite analizar comunidades bentonicas sin deteriorar su ambiente. Para observar tendencias de agrupamiento se aplico a los datos un método jerárquico de agrupamiento y el índice de similitud de Gower. Se observaron tres principales paisajes subacuaticos: cama de pastos, coberturas algales y blanquizales. Con estos datos, se realizo la clasificación supervisada de una imagen satelital LANDSAT TM de la zona de estudio, se ubicaron geográficamente los diferentes paisajes y se realizo una estimación del área comprendida por cada uno de estos. La zona de estudio posee un amplio potencial productivo por la presencia de numerosas especies de importancia socio-económica, como el camarón, que se reproducen y crían en la zona de humedales adyacentes, para finalmente habitar los diferentes paisajes marinos de la región. La información aquí generada proporciona un amplio panorama sobre los paisajes que conforman la zona y constituye el conocimiento básico para la realización de estudios futuros

enfocados en la planificación y manejo sustentable de los recursos en esta región.

PALABRAS CLAVES: Ecología del paisaje, paisajes subacuaticos, video-transecto, camarón, manejo sustentable

Characterization of the Benthic Landscape and Structure of the Coastal Zone of Chabihau, Yucatán, México

The objective of this work was to study the different bentónic landscapes that they conform the marine environment of the coastal zone of Chabihau, Yucatan, Mexico. We studied the geo-morfofunctional composition of the benthos by taking and analyze of video-transects. This technique is a method that allows to analyze bentonic communities without disturbing its environment. In order to observe group tendencies we applied to the data a hierarchic method of group and the index of similarity of Gower. Three main subaquatics landscapes were observed: bed of grass, seaweed and sandy covers. With these data, we made the supervised classification of a satellite image of LANDSAT TM of the zone of study, the different landscapes were located geographically and we made an estimation of the represented area by each one of these. The zone of study has an ample productive potential by the presence of numerous species of socioeconomic importance, like the shrimp, that reproduce and raise in the zone of adjacent wetlands, finally to inhabit the different marine landscapes from the region. The information generated in this study provides a wide panorama on the landscapes that conform the zone and constitutes the basic knowledge for the accomplishment of future studies focused in the planning and sustainable handling of the resources in this region.

KEY WORDS: Ecology of aquatic landscapes, video transects, shrimp, sustainable management

Use of Single-stranded Conformational Polymorphisms (SSCPs) to Detect Species Relationship and Population Structure in *Rhizoprionodon terraenovae* and *R. porosus*

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The Atlantic Sharpnose Shark, *Rhizoprionodon terraenovae*, and the Caribbean Sharpnose Shark are small coastal-temperate and tropical sharks of the continental shelves that overlap in distribution along the Gulf of Mexico, Florida and around the Yucatan Peninsula to the Caribbean Sea. In order to properly distinguish between the two species, current methods require counting caudal and precaudal vertebrate. These species used to be highly abundant within their prospective ranges, but current fishery pressures have caused declines in landing. Assessment of population size and structure is necessary to determine future management plans for this species. Use of SSCPs is a viable method to differentiate between the two species and to measure population structure. SSCP analysis was able to detect unique haplotypes indicative to a particular species. Use of sequencing confirmed the variation between the species with an estimated nucleotide divergence as high as 1.08 %. AMOVA analysis comparing Atlantic sharpnose sharks collected in the Bay of Campeche with samples obtained from four other sites throughout the Gulf of Mexico and along the Northwestern Atlantic Ocean found that the eleven haplotypes observed were evenly distributed throughout the range ($\ddot{O}_{ST} = 0.022$, $p = 0.191$). However significant differences were observed in pairwise analysis between the Bay of Campeche and other sites. These differences disappeared when samples were examined based on temporal data suggesting that genetic bottlenecking is occurring in the *R. terraenovae* along the Mexican Coast.

KEY WORDS: SSCPs, Atlantic and Caribbean sharpnose shark, Rhizoprionodon terraenovae, R. porosus

Uso de los Polimorfismos Solo-trenzados de Conformational (SSCPs) de Detectar la Relación de la Especie y la Estructura de la Población en los de *Rhizoprionodon terraenovae* y *R. porosus*

Los tiburones atlánticos de terraenovae el Rhizoprionodon de Sharpnose, y el tiburón del Caribe Sharpnose son tiburones costero-templados y tropicales pequeños de las plataformas continentales que se traslapan en la distribución a lo largo del golfo de México, la Florida y alrededor de la península de Yucatan al mar del Caribe. Para distinguir correctamente entre las dos especies, los métodos actuales hay que contar el vertebrado caudal y precaudal. Estas especies eran altamente abundantes dentro de sus gamas anticipadas, pero las presiones actuales de la industria pesquera han causado declinaciones en el aterrizaje. El gravamen del tamaño y de la estructura de la población es necesario determinar los planes futuros de la gerencia para esta especie. El uso de SSCPs es un método viable a distinguir entre las dos especies y para medir la estructura de la población. El análisis de SSCP podía detectar los haplotypes únicos indicativos a una especie particular. El uso de ordenar confirmó la variación entre la especie con una divergencia estimada del nucleotide de hasta 1,08 %. El análisis de AMOVA que comparaba tiburones atlánticos del sharpnose recogió en la bahía de Campeche con las muestras obtenidas a partir de cuatro otros sitios a través del golfo de México y a lo largo del Océano Atlántico del noroeste encontró que los once haplotypes observados fueron distribuidos uniformemente a través de la gama (ST = 0,022, p = 0.191). Las diferencias al menos significativas fueron observadas en en parejas análisis entre la bahía de Campeche y de otros sitios. Estas diferencias desaparecieron cuando las muestras fueron examinadas basaron en los datos temporales que sugerían que el bottlenecking genético está ocurriendo en los terraenovae del R. a lo largo de la costa mejicana.

PALABRAS CLAVES: SSCPs, Tiburón de atlántico y del Caribe del sharpnose, *Rhizoprionodon terraenovae*, *R. porosus*.

Large Eddy, Small Eddy : Supplying Recruits to the South Florida Ecosystem

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Where spawning and juvenile habitats are spatially disjoint in marine populations, connectivity is important to ensure sustainability. In the diverse subtropical marine ecosystem of South Florida, keystone species such as snappers (*Lutjanus* spp.), spiny lobster (*Panulirus argus*), and pink shrimp (*Farfantespenaeus duorarum*) use the shallow, estuarine Florida Bay for nursery. A principal spawning ground lies in the Dry Tortugas archipelagos some 150 km upstream of the Bay. A large, semi-permanent cyclonic eddy frequently resides at the Dry Tortugas for periods of 1-3 months. Its evolution is modulated by the flow configuration of the Loop Current upstream in the Gulf of Mexico. Eventually, the Tortugas eddy moves eastward from the Dry Tortugas, propagating downstream in the form of a transient eddy towards the coastal waters offshore of Florida Bay. The eddy diminishes in dimensions with progress and ultimately disintegrates. The evolution of the Tortugas eddy provides a mechanism for the retention and nourishment of early life stages at the spawning source. The subsequent progress of the eddy downstream provides transport to the juvenile nursery. The association of eddy formation with the major boundary current in the Intra-Americas Seas also implies possible connections to Caribbean sources of recruits further upstream. To determine the significance of the eddy process to the supply of early life stages to the South Florida ecosystem, we followed the evolution of the Tortugas eddies using satellite SST and SSH imagery, and sampled within and around these eddies on separate occasions. We expect to find high concentrations of early life stages along the edge of an eddy, to indicate retention; when an eddy passes offshore of the channels that connect coastal waters with Florida Bay, we expect to find high influx of early life stages through the channels, as evidence of onshore transport.

KEY WORDS: Recruitment, eddies, Florida Bay

Giros grandes, Giros pequeños- Proveen Reclutas al Ecosistema del Sur de la Florida

En el ecosistema marino, subtropical y diverso del sur de la Florida, especies CLAVES como pargos (*Lutjanus* spp.), langostas (*Panulirus argus*) y camarones (*Farfantespenaeus duorarum*) usan las aguas someras de la Bahía de la Florida como áreas de cría para sus juveniles. Una de las áreas principales de desove se encuentra ubicada en el archipiélago de Dry Tortugas a unos 150 km corriente arriba de la Bahía. En dicha área se presenta un giro grande ciclónico que reside por períodos de 1-3 meses. Su evolución es modulada por la configuración del flujo hacia arriba de la corriente del Golfo de México. Eventualmente, el giro de las Tortugas propagándose corriente abajo en forma de un giro transitorio hacia las aguas costeras de la Bahía de la Florida, disminuyendo progresivamente su dimensión hasta que finalmente se desintegra. La evolución del giro de Tortugas proporciona un mecanismo para la retención y alimentación en los estadios tempranos de desarrollo para aquellas especies que utilizan como áreas de desove las cercanas al giro. El progreso subsiguiente del giro proporciona el transporte a los habitas de desarrollo de juveniles. La asociación de la formación del giro con la corriente mayor en los mares Ínter-Americanos además representa posibles conexiones a fuentes de reclutas corriente arriba. Para determinar el papel del proceso del giro en el suministro de etapas tempranas de vida al ecosistema del sur de la Florida, sé monitoreo la evolución de los giros de Tortugas por imágenes satélite de SST e SSH, muestreándose dentro y alrededor de estos giros en ocasiones separadas. Esperamos encontrar concentraciones altas de etapas tempranas de vida a lo largo del paso del giro como un indicador de retención. El paso de un giro cerca de los canales que conectan aguas costeras con la Bahía de la Florida suponemos produzca una entrada alta de etapas tempranas de vida a los canales, como evidencia del transporte a la Bahía.

PALABRAS CLAVES: El giro, Bahía de la Florida

Coberturas Subacuáticas de la Zona Marina Costera De Chabihau, Yucatán, México: Análisis de una Imagen Satelital TM del Año 1997

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Se realizó un estudio cualitativo y de distribución de las coberturas subacuáticas que conforman el fondo marino de la zona costera de Chabihau, Yucatán, México, a partir del registro visual de 24 estaciones y de la clasificación supervisada de una imagen de satélite Landsat TM (Thematic Mapper) del área de estudio, tomada en el año 1997. Fueron identificados seis coberturas diferentes: (1) cama de pastos de Thalassia sp, (2) cama de pastos de Syringodium, (3) pastos escasos de Thalassia sp, (4) Algas escasas, (5) Algas densas y (6) blanquizales. La cobertura predominante fue la cama de pastos de Thalassia sp, la cual representó el 31.49% del área total. Este trabajo constituye un esfuerzo complementario en la creación de un Sistema de información Geográfica (SIG) de la porción marina de esta área y forma parte de un estudio integral que pretende obtener el conocimiento básico que permita alcanzar un manejo sustentable de los recursos naturales de la región.

PALABRAS CLAVES: Ecología del paisaje, coberturas subacuáticas, manejo sustentable, percepción remota, Sistemas de información geográfica.

Subaquatic Covers in Marine Portion of the Coastal Zone of Chabihau, Yucatan, Mexico:

Analysis of Satellital Image TM from 1997

A qualitative and distribution study about subaquatic covers was achieved in the marine portion of the coastal zone of Chabihau, Yucatán, México, from visual samples of 24 localities and from the supervised classification of an satellite image Landsat TM (Thematic Mapper) of this study zone from 1997. Were identified six different subaquatic covers: (1) seagrass beds of Thalassia sp, (2) seagrass beds of Syringodium, (3) scarce seagrass of Thalassia sp, (4) scarce seaweeds, (5) dense seaweeds and (6) sand flats. The seagrass beds of Thalassia sp was the predominant landscape, with 31.49 % of cover. This work represent a complementary effort on the creation of a Geographic Information System (GIS) about the marine portion of

this area, and form part of an integral study that intend to obtain the basic knowledge that allow to reach a sustainable management of the natural resources of the region.

KEY WORDS: Landscape ecology, subaquatic covers, sustainable management, remote sensing, Geographic Information Systems.

Cohort Strength and Size at Age of Red Drum *Sciaenops ocellatus* from the Northern Gulf of Mexico: 1986-1988 and 1997-1998

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Red drum *Sciaenops ocellatus* were randomly sampled from among large schools captured with purse seine gear during the National Marine Fisheries Service tag-recapture efforts of 1986-1988 (1980s) and 1997-1998 (1990s) in the northern Gulf of Mexico. Totals of 1,352 specimens from the 1980s sampling and 929 specimens from the 1990s sampling were provided for age analysis. Ages estimated from counts of otolith annuli ranged from 2 to 35 years and from 2 to 42 years in the 1980s and 1990s, respectively. The 1980s sample population was dominated by individuals from the 1971-1974 cohorts while the 1990s population was largely composed of specimens from the 1990-1993 cohorts. Fork length data indicate a recent decrease in size at age among younger red drum. Compared during maximum growth early in life (age 3.5 - 6 years), red drum captured in the 1990s were on average 91 % - 93 % the length of specimens taken in the 1980s.

KEY WORDS: Red drum, *Sciaenops ocellatus*, age estimates

Fuerza y Tamaño de la Cohorte en la Edad de la Corvina Roja *Sciaenops ocellatus* del Noroeste del Golfo de México: 1986-1988 y 1997-1998

Especímenes de corvina (*Sciaenops ocellatus*) fueron seleccionados al azar de

colectas realizadas mediante una red de cerco durante los muestreos de captura y recaptura por el Servicio Nacional de Pesquerias Marinas en 1986-1988 (80s) y 1997-1998 (90s) en el norte del Golfo de México. Un total de 1352 individuos provenientes del muestreo de los 80s y 929 individuos del muestreo de los 90s fueron analizados en su edad. Las edades fueron estimadas a partir de conteos de otolitos anuales con un rango de 2 a 35 años para los 1980s y de 2 a 42 años para los 1990s. La población muestreada en los 1980s estuvo dominada por individuos de las cohortes de 1971 a 1974, mientras que la población de los 90s estuvo compuesta en su mayoría por individuos de la cohorte de 1990 a 1993. Recientemente, la longitud furcal indica una disminución de las tallas de la misma edad entre los individuos mas jóvenes de corvina. Una comparación de crecimiento máximo en los estadíos tempranos (edades de 3.5 a años), señala que las corvinas capturadas en los 90s alcanzaron sólo, en promedio, un 91 a 93 % del largo de los especímenes capturados durante el muestreo de los 1980s.

PALABRAS CLAVES: Corvina, *Sciaenops ocellatus*, las edades fueron estimadas

La Pesquería de la Almeja *Mercenaria* sp. en México

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Se realizaron censos pesqueros socioeconómicos durante 1998, 1999 y 2002, donde se entrevistó a pescadores, compradores, personal del gobierno y gente local, con el objetivo de reportar las áreas donde se localiza la almeja *Mercenaria* sp., además se describen algunos aspectos de la pesquería, como: equipos y métodos de captura, horas de trabajo y comercialización. Se encontró que en la mayoría de las áreas visitadas, la extracción es esporádica y su consumo es doméstica, únicamente en la Laguna del Carmen, Tabasco existe una pesca comercial incipiente, aunque existen pequeñas extracciones en Tamaulipas y El Bellote, Tabasco. Las capturas en

la Laguna del Carmen, Tabasco de 1995 a 1998 fueron de alrededor de las siete toneladas. En esta zona existen 20 pescadores de almeja, todos ellos hombres, cuyas edades fluctúan entre 15 y 20 años. Se transportan a las áreas de captura en lanchas de 7.5 metros de longitud. El método de captura es manual y mediante tacto con los pies a una profundidad de 1 y 1.20 m. Cada pescador extrae de 200 a 250 almejas en una jornada de cuatro horas. El precio pagado por almeja a los pescadores varía dependiendo del tamaño ($ 0.40 a $ 0.80 pesos por pieza) y el precio de venta en los mercados va desde $1.50 a $ 2.00 pesos. Los lugares donde se comercializa son: la capital, diversas ciudades y poblaciones del país como son Oaxaca, Coatzacoalcos, Veracruz y Paraíso. La pesquería de esta almeja se encuentra subdesarrollada debido a la poca demanda local. Existe poca información sobre el potencial de los bancos de almeja, así como su biología y ecología, por lo tanto, se recomienda realizar estudios para conocer la disponibilidad del recurso en las diferentes zonas para recomendar futuras medidas de administración para su extracción.

PALABRAS CLAVES: Almeja, *Mercenaria* sp., la pesquería

Fishery of Clam *Mercenaria* sp. in Mexico

Surveys were carried out during 1998, 1999 and 2002, interviews were performed to fishermen, buyers, government officers and local people. With the main objective to report the existent areas where the clam *Mercenaria* sp. is located, some important fishing issues as fishing gears, harvesting methods, labor periods and marketing were described. In most areas, clam harvest is uneven and has domestic consumption, only in Carmen lagoon, Tabasco an incipient commercial fishing exists, although small extractions exist in Tamaulipas and El Bellote, Tabasco. Clam harvest production in Carmen Lagoon, Tabasco, from 1995 to 1998 were around seven tons. In this area exists 20 clam fishermen, all are men, which age fluctuation is between 15 to 20 years. They attend the harvest areas using boats of 7.5 meters of length. Harvest method is manual and it comprises "feet touching" to a depth of 1 to 1.20 m. Each fisherman extracts 200 to 250 clams in one single trip of four hours. The paid price by clam depends on size ($ 0.40 to $ 0.80 Mexican pesos by piece) and the prices of sale in the markets are $1.50 to $ 2.00 pesos. Marketing clam places are: Mexico City and other cities and towns such as Oaxaca, Coatzacoalcos, Veracruz and Paraiso. Due to the demand's small scale, fishery is underdeveloped. Few information about the potential of clam banks is available, as well as their biology and ecology. Therefore, is recommended to carry out studies to know the resource availability in the different zones to recommend future management measures for extraction.

KEY WORDS: Hardshell clam, *Mercenaria* sp., fishery

Ciclo Gonadico y Condicion Fisiologica del Mejillon Tropical *Ischadium recurvum* (Bivalvia:mytilidae) en el Sureste de Mexico

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En México, la producción de mejillón es reducida. Esta pesquería está presente solamente en la Península de Baja California. Los mejillones en México han sido poco valorados, pero con una explotación local a lo largo de las costas del país. El mejillón curvado *Ischadium recurvum* se consume a escala regional y presenta un potencial acuícola en la costa del Golfo de México. En este trabajo, se determinó el ciclo gonádico y tres índices de condición con el fin de establecer el periodo de desove y la condición fisiológica de la población de I. recurvum en la laguna de Mecoacán, en el sureste de México. Las muestras fueron obtenidas mensualmente durante un año. Se fijaron en bouin, se embebieron en parafina y se obtuvieron cortes de 6 um de espesor. Las preparaciones se tiñeron con hematoxilina-eosina, con las cuales se determinó el ciclo gonádico. Se definieron cinco fases del desarrollo gonádico : gametogénesis, madurez, desove, postdesove e indiferenciado. Los índices de condición fueron: peso seco de tejidos / cavidad interna de la concha (PST/CIC), peso seco de tejidos / peso seco de la concha (PST/PSC) y peso seco libre de cenizas / peso seco de la concha (PSLC/PSC). Se determinaron dos periodos de desove prolongados, de enero a mayo y de julio a octubre, con picos de 30 % (marzo) y 40 % (septiembre), respectivamente. El patrón de desove y gametogénesis es similar a otros mejillones tropicales. El índice de condición mostró un incremento significativo en el perido octubre-marzo, indicando una producción somática alta en este mitílido, comparado con otros mejillones.

PALABRAS CLAVES: *Ischadium recurvum*, ciclo gonádico, mejillón, México, reproducción.

Gonadic Cycle and Condition Index of the Tropical Hooked Mussel *Ischadium recurvum* (Bivalvia : Mytilidae) in Southeast México

In México, mussels production is almost inexistent. This fishery is present only in Baja California peninsula. Mussels in México had been low valued, but with local exploitation along country's coasts. The hooked mussel *Ischadium recurvum* is a

species consumed in a regional scale and with aquacultural potential in Gulf of México coast. In this work, the gonadic cycle and three condition index of *I. recurvum* was determined for stablishing, the spawning period and the physiological status of *I. recurvum* population in Mecoacán lagoon, in the Southeast of Mexico. The samples were obtained monthly during a year and fixed in bouin, embebed in parafin and cut for obtain 6 um thick slides. The staining method used was hematoxilin and eosin. The gonadic cycle was based in observations from these histological preparations. It was defined five phases of gametogenic development: gametogenesis, matury, spawning, postspawning and indifferent. Physiological condition index were: tissue dry weigh / shell cavity volume (TDW/SCV), tissue dry weigh / shell dry weigh (TDW/SDW) and ash free dry weigh / shell dry weigh (AFDW/SDW). Two protracted spawning periods was determined, from January to May and from July to Octuber, with peaks of 30 % (March) and 40 % (September), respectively. The patron of spawning and gametogenesis is similar to other tropical mussels. The condition index showed a significative increment during Octuber-March period, indicating a high somatic production for this mytilid, compared with other mussels.

KEY WORDS: *Ischadium recurvum*, gonadic cycle, mussel, México, reproduction