UNIVERSITY OF MIAMI

Rosenstiel School of Marine and Atmospheric Science

Gulf and Caribbean Fisheries Institute

PROCEEDINGS

OF THE

25th ANNUAL SESSION

MIAMI, FLORIDA · NOVEMBER, 1972

CORAL GABLES, FLORIDA MAY, 1973

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Gulf and Caribbean Fisheries Institute

Executive Committee

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Announcement

The Gulf and Caribbean Fisheries Institute was organized in 1948. There are two classes of membership, one for industry and one for scientists. Inflationary costs have compelled the Institute to increase its membership and registration fees this year. Formal action to again raise these fees was taken at the annual Executive Committee meeting November 29, 1972. Members of the fishing industry and associated businesses will pay a minimum membership fee of $50.00 per year. Technical members will pay $10.00 per year. In addition, a registration fee of $35.00 will be required for attendance at the Institute.

The membership year of the Gulf and Caribbean Fisheries Institute begins on November 1st and ends October 31st of the following calendar year. Membership cards are issued to this effect. Members are entitled to attend the annual meeting and to receive the published *Proceedings* of the Gulf and Caribbean Fisheries Institute.

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EXECUTIVE DIRECTOR
GULF & CARIBBEAN FISHERIES INSTITUTE
10 RICKENBACKER CAUSEWAY
MIAMI, FLORIDA 33149

OPENING SESSION

MONDAY – NOVEMBER 27, 1972

Chairman – Howard O. Sturgis, *Yarmouth, Maine*

OPENING ADDRESS

The Trend of Our Fisheries Policy

THOMAS N. DOWNING
Congress of the United States
House of Representatives
Washington, D.C. 20515

As many of you know, the old Bureau of Commercial Fisheries became the National Marine Fisheries Service (NMFS) when the President created the National Oceanic and Atmospheric Administration (NOAA) by means of a reorganization plan about 2 years ago. Since that time I have heard about efforts leading toward a cogent national fisheries policy. It has not yet been fully accomplished, but as an example of the difficulty in this area I read a few weeks ago that a committee that reports to the Secretary of Commerce has, for several months, been unable to agree on a definition of "good fisheries management." Fisheries matters are usually highly complex, and not always are they even related to one another.

It has been said, and I am inclined to agree, that the past few years have seen progress in our quest for solutions to some of the vexing fisheries problems that have plagued the overall industry for many years, despite the fact that most of our coastal fisheries are either fully developed or, as in too many cases, seriously burdened by being overdeveloped.

Too often the question is not whether to catch more fish, but how to divide the known quantity of fish internationally, between sport and commercial interests, and between the citizens of neighboring states. I want to return to this point later.

The 92nd Congress was unusually productive in legislative matters of concern to the fishing industry generally. For example, the Farm Credit Act of 1971, which is Public Law 92-181, broadened the scope of the original legislation to include fish cooperatives within existing agricultural cooperative systems, to permit fishermen to borrow from the Production Credit Association and to permit associations of producers or harvesters of aquatic products to borrow from the Banks for Cooperatives.

Another example of the fisheries legislation passed by the 92nd Congress is the Federal Ship Financing Act of 1972. This amends the Merchant Marine Act of 1936 to expedite procedures relating to vessel mortgage guarantees, simplifies paperwork, and better meets current industry needs for investment capital. This legislation would broaden the time limits on the use of government-assisted financing and provide refinancing authority enabling vessel owners to convert to financing with longer maturities and/or lower interest rates, thereby making additional resources available for modernization and expansion of the domestic fleet.

Legislation that received considerable attention in the public press was the Marine Mammal Protection Act of 1972, which sets up a Marine Mammal Commission with a committee of scientific advisors. The Act sets forth a goal of the protection and development of marine mammal stocks, with the primary aim of maintaining a healthy and stable ecosystem.

Many other bills of interest to fisheries were passed by the 92nd Congress. The Amendment to the Fishermen's Protective Act, the Coastal Zone Management Act, an act to extend the provisions of the Commercial Fisheries Research and Development Act, the Ocean Dumping Act and a number of other laws were enacted. The list is long, and I cite only some of them to show that progress is being made and that Congress is aware of the problems facing our fisheries.

Regarding legislative activity in the next session of Congress, I look forward to legislation dealing more directly with fisheries management than we have seen in the past. I feel that such legislation should enable the appropriate authorities to manage all our fisheries, even on the high seas. This management should be accomplished in a way to encourage state cooperation in the development and implementation of fisheries management plans and should provide funding for that purpose. Generally we should enhance cooperation in fisheries management *among the states, and between the states and the federal government.*

It has been only in recent years that an inherent federal role in fisheries management began to be recognized. Historically, and under common law, the actual management of domestic fisheries was believed to be the sole responsibility of the coastal state, with the federal input largely confined to scientific studies. The only exceptions were in cases where, because of international treaty obligations incurred by the federal government, federal control was required. In 1947, however, the Supreme Court abruptly modified this tradition. The Court ruled that "all power and dominion" over the resources of the territorial seas was reserved to the federal government. Congress responded in 1953 with the Submerged Lands Act, a section of which essentially quitclaimed all the federal interests in the resources of the territorial seas back to the states.

It has become obvious since 1953 that the states, in many cases, have met increasingly difficult problems in the management of many of the coastal resources. In some cases this is because the resources are migratory, moving from one state jurisdiction to another, or outside territorial waters, to the high seas.

The Stratton Report of 1969 identified this problem as one of "splintered jurisdiction."

The role of the federal government, and indeed its responsibility in such cases, is becoming increasingly obvious, because important resources and the industries, both commercial and recreational, they support, cannot be sustained adequately under the present "splintered" system. For this reason, NOAA and NMFS are beginning to identify fisheries that can appropriately be described as possessing a *broad national interest*.

These are fisheries that cross state boundaries, which involve multi-state or foreign fishermen or which become significant in the interstate commerce of the United States. The federal interest arises, not through the states but independently of them. It arises out of a national concern for the consumer in Iowa, for the marine angler who lives in Virginia but who fishes in North Carolina, and through the constitutionally reserved control of interstate commerce and authority for the conduct of foreign relations. This interest does not include all fisheries. Many coastal marine fisheries do not possess these attributes. Those fisheries are based upon resources which do not migrate or which do not enter commerce in a significant way.

Having determined that a specific fishery has that broad national interest, it follows that the federal government has a clearly defined responsibility, in full cooperation with the states, to assist in the development and implementation of rational management practices. Such practices are needed so that the return, biologically, economically and socially, may be optimized for the benefit of the present generation, while preserving important options for future generations. Failure on the part of Washington to meet this obligation would be clearly inconsistent with the responsibility of the federal government to the states and to the citizens of our country. This is one trend I see in our fisheries policy.

I understand that NMFS is working on this newly defined responsibility. The Office of State-Federal Relationships in NMFS is developing cooperative programs with the appropriate states in several major fisheries. This trend is accelerating. And I say it is high time. In general fisheries management efforts have not kept pace with exploitation, even though there has been widespread activity in a number of international commissions. Some fisheries have undergone extremely wide fluctuations, some have virtually collapsed; few have been managed wisely.

In the established fisheries of the future, more imaginative and controllable management programs must be initiated. The objective of such programs should be to maintain the resources at their maximum annual sustainable yield and to utilize the fisheries in the most effective manner.

Another program now underway in NMFS may do a great deal to guide us in future fisheries policies. I refer to the MARMAP program the acronym means Marine Resources Monitoring, Assessment and Prediction Program. This is an integrated ocean survey of a size and scope never before attempted; it seeks to evaluate all living marine resources off the coasts of the United States. Preliminary surveys began in June 1972 off the Atlantic coast. When the program is completely operational it is expected to provide: (1) notice of real or incipient damage to marine resources because of overfishing or changes in the marine environment; (2) scientific information in support of the need for legislation or regulations to protect living marine resources and (3) a series of reports describing the distribution and abundance of various species, data on catches, statistics, analytical documents and fishery advisory bulletins.

We hear a good deal of the need for a National Fisheries Policy, and while I agree we probably need some updating, I recall the Fish and Wildlife Act of 1956. The first paragraph reads:

> "The Congress declares that the fish, shellfish, and wildlife resources of the Nation make a material contribution to our national economy and food supply, as well as a material contribution to the health, recreation, and well-being of our citizens; that such resources are a living, renewable form of national wealth that is capable of being maintained and greatly increased with proper management, but equally capable of destruction if neglected or unwisely exploited; that such resources afford outdoor recreation throughout the Nation and provide employment, directly or indirectly, to a substantial number of citizens; that the fishing industries strengthen the defense of the United States through the provision of a trained seafaring citizenry and action-ready fleet of seaworthy vessels; that the training and sport afforded by fish and wildlife resources strengthen the national defense by contributing to the general health and physical fitness of millions of citizens; and that properly developed, such fish and wildlife resources are capable of steadily increasing these valuable contributions to the life of the Nation."

The section states further that " . . . the fishing industry . . . can prosper . . . only, if certain fundamental needs are satisfied . . . ," and that "these needs include freedom of enterprise, protection of opportunity, and a degree of governmental assistance." One hears it said that this statement may no longer represent current needs or the best interest of the public today and is, therefore, best ignored or forgotten. Others say it has stood the test of time, that it may not be perfect, but that until it is changed or superseded it is not only the best we have but pretty good at that.

I believe the Director of National Marine Fisheries Service put it well when he spoke to the 101st Annual Meeting of the American Fisheries Society last year about a national fisheries policy. He said, "As is so frequently the case, we cannot stop operations in midstream, awaiting the evolution of a neat new policy package. Indeed, our programs for the current and next fiscal years already reflect policy shifts stimulated by the administrative and congressional actions that created NOAA.

Other factors playing a role in formulation of our fisheries policy are further preliminary meetings leading to a proposed International Law of the Sea Conference. I will not attempt to deal with such a complex subject during my limited time today, but bear in mind what Ambassador Donald L. McKernan said to the United Nations in August of this year: "We remain committed to the concept that both sound conservation and rational utilization must be linked directly to the biology and distribution of the living marine resources involved." He said further, "We believe that the coastal state should have the right to regulate the fish stocks inhabiting the coastal waters off its shores as well as its anadromous resources. We also believe that inherent in this right of the coastal state would be a strong preference to the utilization of such stocks. Those are the particular resources upon which its coastal fishermen must rely for their livelihood and upon which its people rely for a substantial part of their nutritional requirements."

That, of course, is only part of the Ambassador's statement. To those of you interested, I would recommend reading his entire statement, dated August 4, 1972.

On the domestic scene, there are the problems of conflicts between sport and commercial fishermen which seem to be always with us. The research program on migratory marine game fish went to NMFS when NOAA was created, and to me this was an expression of the desire to have our living marine resources treated and managed as a whole, rather than as disparate factions based on constituency difference. It seems abundantly clear that only by doing so can we insure that these resources are afforded the protection essential to their existence.

The goal of NMFS is to carry out a national marine fisheries research and management program, and to achieve an integration hitherto impossible. Our fisheries scientists are convinced that even though there are conflicts between sport and commercial fishermen, if the characteristics of a fish population and its potential become known through competent research, there will be reasonable people on both sides who will strive for acceptable solutions.

The NMFS and NOAA are still new on the national scene, and while there is an urgent need for a fisheries policy that is known and understood by all concerned, there is a more urgent need to make haste slowly so that when a formal policy is promulgated, it will be one we can live with and be proud of in the years ahead.

TERRITORIAL SEAS SESSION

MONDAY – NOVEMBER 27, 1972

Chairman - Steven E. Schanes, *Fishery Oceanographic Center, National Marine Fisheries Service, La Jolla, California*

The Progress of the Law of the Sea as to Fisheries – Geneva 1972

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In discussing a subject as complicated as fisheries law of the sea, one cannot always presume a sophisticated audience. On the other hand, too labored a background may tend to bore those well-acquainted with the subject.

We are now engaged in preliminary conferences through committees appointed by the United Nations. This series of committee conferences has been going on for 2 years, at the rate of 2 or 3 months a year. To highlight the deliberate speed of the project, I point out that the present "committee" is composed of some 86 members, each of whom may speak to the point. In 1958 and 1960 the *total* number of nations participating in the Geneva Conference was only 86. There are now more than 130 nations members of the United Nations, and the latest additions are the "newly emerging" ex-colonials who protest loudly that they had no voice in formulating the basic maritime law of nations, but they *will* now be heard. Also a recent and vocal addition is the People's Republic of China, which takes every occasion to engage in diatribes against the "superpowers" and the "hegemony."

If it is true that politics makes strange bed-fellows, imagine on a global basis the effect of the several blocs of nations arguing among themselves to reach fixed and final positions to which they can then adhere positively and, by sheer weight of numbers, control the outcome of events. To name a few, there are the "Latin-American," the "Afro-Asian," the "Landlocked and Shelf-locked," the "European" and others.

For working purposes the Preparatory Plenary Committee has three sub-committees. The diversity of subjects adds more complication, and this is especially hard on those smaller nations which do not have large staffs, and which must keep up with all of the papers ground out by the duplicating machines. I have accumulated files fully 2-feet thick, and weighing countless pounds. Among the subjects are: the regime of the deep sea bed, pollution, scientific research, fisheries, territorial sea, passage through international straits and problems in connection with the definition and uses of the Continental Shelf and Slope.

The basic disagreement is not a new one. It concerns the width of the territorial sea. No agreement was reached at the Hague Conference in 1929, nor at Geneva in 1958 and 1960. The maritime powers need a narrow territorial sea to maneuver their fleets, and they also want passage through strategic straits throughout the world. Likewise the nations that fish off other nations' coasts prefer a narrow territorial sea, for example, the United Kingdom off Iceland. The extremes are (1) a narrow territorial sea of not more than 12 miles versus (2) seas up to 200 miles for sovereignty.

Since 1960 there has been developed the concept that there may be several "seas" for several reasons. There is almost universal agreement, really, that a nation may have a 12-mile territorial sea, where its sovereignty is as supreme as on land, and have beyond this some kind of jurisdiction over adjacent waters, for fisheries, pollution, control of smuggling or what have you. This area has been referred to as a "contiguous zone." How to define it is a real problem and causes wide divergences of opinion.

This concept is further complicated by the continental shelf doctrine, which became new law of the sea in 1958. Here the nations with large continental shelves do very well, whereas those with narrow shelves, or those landlocked, get little or nothing. Essentially the continental shelf comprises only the seabed and subsoil, presently omitting fisheries, but is important because of oil and minerals. Where does it end? The present unsatisfactory formula says: to a depth of 200 meters (about the 100-fathom line) or to the limits of exploitability. Under modern technology, who can define the limits of exploitability?

We can define the argument in simple terms. *Who* gets the oil? *Who* gets the minerals? *Who* gets the fish?

Under a now-hallowed slogan enunciated by Malta there is much talk about "the benefit of all mankind." This is a global profit-sharing scheme, in which the haves divide up with the have-nots. There are always more have-nots, and since each nation, large or small, has one vote, any final formula seems destined to aid the under-privileged. It is true that this slogan was developed in connection with the new and unknown deep seabed resources, which have not previously been covered under international law. It is also true that the only nations with money and technology capable of operating in the deep seabed are the large developed nations.

Matters needing resolution are, for example: Where does the continental shelf end? Where does the continental slope end? Where does the continental rise begin? If you can't answer these, how do you know where the deep seabed and ocean abysses are? Geographers are in great demand for technical reasons, but decisions as to voting are in the hands of diplomats and legal people, and the reasons for voting, nation by nation, arise from self-interest, and there is a great hue and cry from smaller nations, particularly, to seek aggrandizement of their territory by going to sea.

Up to now, we have said little about fisheries. We have learned that the living resources of the sea are not inexhaustible. In many areas of the world, as in the North Sea, groups of nations have reached reasonably good agreements concerning *who* gets the fish under optimum conservation measures.

Under ancient law, like the law of hunting, the hunter who subdued the beast, or the fish, owned it. Now it appears that many nations wish to shrink the fishable oceans by an enlargement of national boundaries which would leave little to outsiders, as there are not too many fish far away from shore.

One cannot quarrel with the concept that the under-privileged nations need more protein. But this is not the effect attained by enclosing large areas of the ocean under contiguous zones. The extreme objective sought is *ownership* of the resources, and the right to license others to fish within that area. Some nations have openly declared that they expect to make plenty of money out of this, and others have said they will license only neighboring nations, and will exclude the traditional distant-water fishing nations. With no financial limit on licenses, the licensor may set an exorbitant price which amounts to total exclusion. What happens, then, to annual sea-crops like shrimp? If uncaught, they are lost to the food supply of the world. It is for this reason that we, in shrimp, have fought to have acknowleged the principle of under-utilization; that it is not right "for the benefit of mankind" that the unused living resources of the sea should go unharvested.

Drawing lines in the ocean is a politician's way of trying to deal simply with a complex problem. It is an old adage that fish do not recognize such lines. Unfortunately, the politicians do not listen to the scientists. Any reputable fisheries biologist will tell you that to manage a fishery properly you need control over the stock of that fishery, that is, the entire population, as well as control over the ecology, which includes pollution, estuaries and a multitude of other matters. The area of control should go as far as the fish go. If the stock occurs off the coasts of more than one nation, then those nations concerned should get together on the management problem. When it comes to *sharing the catch*, it may happen that at the harvestable stage the fish are gathered in one place, so where several nations are concerned, the *sharing* is also a matter to be negotiated. Otherwise, one nation can take all of the fish stock before it is full grown, simply because it crossed an imaginary line in the water, and play hob with proper management, and even kill the stock because it did not allow growth to maturity and spawning age.

Our trouble with getting a proper world-wide convention on a sound scientific basis is that it is almost too complex to put down on paper, and that many diplomats who control their nation's votes like simpler solutions. And yet the United States, which has both a large coastal fishery and a respectable distant-water fishery in tuna and shrimp, is doing its best to bridge the gap between the extremists by proposing such intermediate solutions. The role of arbiter is a difficult one. When you are in the middle, distant-water fishing nations such as Russia and the United Kingdom swear at you for going too far, and the newly-emerging African nations swear at you for not going far enough.

What is the essence of the United States' position on fisheries? It is contained in the latest U.S. proposal, August 4, 1972, at Geneva, and fully explained by a major intervention (or speech) by Ambassador McKernan on the same date. It was reinforced on August 10, 1972, by an intervention by Ambassador John R. Stevenson, Legal Advisor to the Department of State and Head of the United States Delegation to the Law of the Sea Conference. Mr. Stevenson said, in part:

> "Our basic interest is to assure rational use and conservation of all fish stocks . . . . We can support broad coastal State jurisdiction over coastal and anadromous fisheries beyond the territorial sea subject to international standards designed to assure conservation, maximum utilization and equitable allocation of fisheries, with compulsory dispute settlement, but with international regulation of highly migratory species such as tuna . . . . "

Such a laudable aim can be achieved by the scientific treatment of fisheries on a proper management theory. The coastal state, it is admitted, has a major interest in the nearby fish. Therefore this formula gives them substantial jurisdiction over all fisheries, except migratory tuna, but it also requires of management that it be sound and reasonable, a steward for the world, as it were, and accountable for its actions. If the coastal nation can take *all* of the fish nearby, let it do so, but do not let the unused fish stagnate and die.

I mention that salmon are protected in the United States proposal by a formula that protects a fishery that originates in the fresh waters of a nation, and on which that nation spent large sums to improve and increase the stock.

Last year I was supposed to talk to this meeting about the fishing industry's reaction to our government and its handling of fishery matters internationally. Unfortunately I was hospitalized, but I did send you a report which was read; I said then that we were most unhappy with government. We had been shut out at the council table, and other interests were superimposed upon the interests of fisheries. We have come the full cycle. The protests by the fishing industry to the President and the Congress were effective. Fishing industry advisors were again designated as members of the United States delegation and I can report to you happily that we were fully consulted and participated completely in the affairs of the delegation, as in the days of yore.

I cannot predict that the United States position paper will meet with overwhelming approval at a world conference on fisheries, but it is a sound, reasonable and scientific approach of which we can be proud, and it is possible that with a little give-and-take in the high-flown area of world diplomacy, the essence of our proposal may meet with sufficient approval to become the basis of new fisheries international law. I take my hat off to Ambassador Stevenson and Ambassador McKernan, who are negotiators of high-caliber and purpose, and say that if a species approach can prevail, they can do it.

Implications to North Atlantic Fisheries of Preparatory Sessions on Law of the Sea

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The program for this morning says that we are to discuss the implications of the preparatory sessions on the law of the sea to the fisheries in our respective areas. I'm sure it was expected that we would take some liberties in emphasizing certain aspects of this very broad subject. Accordingly, I've depended on my fellow panelists to give you an overview of the background and range of the complicated issues that face us in the law of the sea, and what has been going on at the most recent sessions. Their analyses are thorough and accurate and I won't try to cover the same ground. However, there may be some value in presenting some of the same circumstances and developments from a different point of view.

Although the various fishery interests of the United States have managed to espouse and support a common policy on the fishery question in the law of the sea negotiations, and the position they have taken is essentially that which the U.S. government outlined in its latest fishery proposal at Geneva on August 4, 1972, the position is a compromise; and a compromise, as we all know, is something the parties concerned hope to be able to support but none of them like. So let's examine some aspects of the present situation in the conference and in the fisheries of the North Atlantic with the understanding that the North Atlantic coastal fishermen support the present government approach and that the proposed articles, though we may not expect them to sell as is, represent a pretty good position for the U.S. *at this point in time*.

First, in the conference, the votes are heavily weighted towards the developing nations. Not only are the votes heavily weighted this way, but the representatives of these nations to the preparatory meetings — who are diplomats and lawyers — are working overtime to create an atmosphere favorable to their interests. This consists substantially of repeating over and over the following theme: (1) that they had no voice in formulating the present law of the sea; (2) that, at least partially because of this exclusion from the lawmaking process, they are desperately poor "have not" nations and the gap between them and the developed nations is widening; and (3) that the purpose of this conference is in the most part to redress the present situation and achieve a more equitable distribution of the wealth of the oceans.

Understandably the developed nations are not in complete agreement with this attitude, but we must not lose sight of the fact that this type of thinking permeates the atmosphere of the United Nations, and this is the arena in which any decisions that are reached will be made. So what position do these developing nations take at the present time? It seems to me that they are saying that, beyond their territorial sea, there shall be what is called an economic zone or patrimonial sea or whatever you wish to call it. They say that the extent of this zone is the subject of compromise at the conference and may even vary from one part of the world to another, but 200 miles is the most mentioned figure. The developed nations attempt to talk about whether there shall be a zone or not, but the developing nations have already decided that there shall be a zone and are offering to discuss whether the zone will be totally exclusive or whether they will compromise and allow foreign activities, such as scientific research and some controlled resource exploitation, within their zone. Furthermore they are saying that, although they would prefer that such zones be created by international agreement, if it becomes necessary they will create them unilaterally, and as you know some of them have already done so.

In the face of this attitude from the predominant force at the preparatory meetings, it seems to me inevitable that any treaty which is signed will include a zonal approach to resources. Certainly we can hope to combine the species approach of the present U.S. position with a zone and still come out with something with which all U.S. fisheries can live. But to expect to devise a treaty that does not have a rather exclusive resource zone as a cornerstone of the arrangements agreed upon is, in my view, wishful thinking.

So what of the coastal fisherman in the New England and Middle Atlantic area? Well, his situation is not the best. In 10 short years, production of food fish in New England has dropped in half. Yet in that same period the production of fish by highly mobile and heavily subsidized foreign fleets has increased from near zero to about four times the present take of the U.S. vessels. In other words, 10 years ago we took all of the fish and now we get only about 1/5 of it.

Let me describe for you the management tools we have presently available in this area. They are the International Commission for the Northwest Atlantic Fisheries, commonly called ICNAF, and bilateral agreements with the USSR, Poland and Canada. Some people have said that ICNAF has made more progress in the past 2 years than in all of the previous years of its existence. This may be true from the point of view of a government official. Country quotas have been established on several species of fish and the principle of coastal state preference to coastal stocks of fish has been recognized. However, from the point of view of the fisherman, ICNAF continues to be the facade which stands in the way of effective management. Among the many reasons for this situation are: the continued excess of total fishing pressure, lack of effective enforcement, non-member catches over which ICNAF has no control and fleets so massive that the incidental catch of some species exceeds the allowable catch without any directed fishery at all for that species.

Let me give you an example. Last Wednesday a group of us spent all day wrestling with the problem of herring. In January 1973, quotas must be set for the two stocks of herring off the Atlantic coast of the U.S. The stock in the Gulf of Maine is small and in poor shape. It is under quota. But, although we don't know for sure -- because we don't even recognize them as a nation and if we did and they were members of ICNAF we would still have to take their word for what they caught -- it appears that the East Germans caught more herring from this stock than the U.S., Canada and all other ICNAF members combined in 1972.

Thus from this stock under ICNAF management there was probably taken three times the fish allowable to maintain the stock even at its present low level. The other stock on George's Bank and south was a very large stock only 4 or 5 years ago. The scientists tell us that the standing stock now may be at 10% of the original level. In spite of this situation, the members of ICNAF insisted on taking 150,000 tons of fish from this stock last year, which was about double the recommended catch. Of this amount the U.S. quota was 5,000 tons, or 3.3% of the overall quota. The U.S. has a developing fishery on this stock and expects to be able to catch more than this quota, but the expectation is that the total will be drastically reduced and the U.S. will be expected to reduce its take.

Now as to the bilateral agreements. The most important one is with the Russians because they take more fish from the area than all others combined. The overriding reason that they entered this bilateral was to gain access to our ports for their vessels. The agreement was originally signed in 1967 and has periodically been reviewed, but there has been no effective access to our ports for the Russian fishing fleet. Needless to say, the agreements leave much to be desired under these circumstances.

The rest of the day could be spent going into the details of the frustrating situation in which the fisherman in my part of the world finds himself, but these brief samplings convey the general idea. So to get back to the law of the sea preparatory meetings – what promise of relief do we have from this source? Well, it appears that if there is agreement at the conference, it could well be an agreement which is most satisfactory to the east coast fishermen. But it is also most obvious that there is a good chance of no ageement and that if agreement is reached it will not be timely. In other words by the time the law of the sea approach is translated into effective management tools, both the resources and fishing businesses will be ruined.

This inescapable conclusion leads to the inevitable further conclusion that long before an international solution emerges from the law of the sea conference, the pressure for interim unilateral action by the U.S. will cause this question to erupt on the national scene, including the halls of Congress, in a more or less violent fashion. It is my view that this will happen regardless of what position those of us in the coastal fisheries, who have had some influence to date, take. We can only hope to channel it into taking forms which are the least damaging to U.S. fisheries as a whole.

Suggestions that *have* been made for such action include: (1) ultimatums that the U.S. withdraw from multilateral and bilateral agreements if they are not made much more effective; (2) vigorous application of the conservation provisions of the 1958 convention; (3) moratorium on foreign fishing; (4) unilateral application of the principles of the U.S. Law of the Sea position if not applied in timely fashion internationally; and, of course, (5) a 200-mile fishery zone -- to mention only a few.

Representatives of our distant water fisheries, including some present here today, are quick to point out that almost any aggressive action by the U.S., while the present law of the sea exercise is going on, will have an effect on those deliberations – possibly, though not certainly, detrimental to their fisheries – and therefore have opposed all proposals put forward to date. What I ask now is that we rethink the situation and try to determine whether it may not be in the interest of us all to join in support of some rather aggressive measures designed to bring relief to the coastal fisheries during the period before an international agreement becomes effective. I am hopeful that we can. The alternative – which is distant water U.S. fishermen opposing any aggressive moves by the U.S. coastal fisherman (and that only perhaps because of potential adverse effect) – in my view not only will not enhance their law of the sea negotiating position, it will reflect unfavorably on the whole industry in many ways.

I guess what I'm trying to say is that the question on the law of the sea facing all of us at the moment is not what comes out of a conference some years hence, but what happens on the domestic scene in the next few months, and that it is my hope we can continue to work together to the mutual benefit of all U.S. fishermen during what promises to be a critical period.

Informal Comments as to Prognosis for a Fisheries Regime

BURDICK H. BRITTIN
U.S. Department of State
Washington, D.C. 20520

"The seas are ancient, yet they are new; their regimes are immutable, yet they are fragile; they are catalysts for progress, yet platforms for discord."

If I am to speak in terms of making a prognosis on an emerging fisheries regime growing out of the Law of the Sea conference, I am mindful that I am stepping on dangerous grounds. It is somewhat akin to my pronouncing at this time that the Washington Redskins and the Miami Dolphins will play in the Super Bowl and that the Redskins will win by seven points. Obviously one of the problems with that kind of a statement is that it represents a blend of a factual possibility plus a personal desire. Pragmatism at its best eliminates personal feelings – I doubt if anyone can do that but I will try to give my estimates based on as much fact as possible.

Permit me to read a few quotations.

> "All peoples have the right of navigating in the interests of commerce. Navigation ought also to be free for fishing. States in this respect have no right or privilege for their own fishermen to the detriment of foreign fishermen." [Bluntschli, 1895]

> "The open sea is not capable of being possessed as private property. The free use of the ocean for navigation and fishing is common to all mankind, and the public jurists generally and explicitly deny that the main ocean can ever be appropriated. The subjects of all nations meet there, in time of peace, on a footing of entire equality and independence. No nation has any right of jurisdiction at sea, except it be over the persons of its own subjects." [Kent, 1896]

> "The various uses to which the sea near the coasts can be put render it a natural object of ownership. Fish . . . may be obtained from it. Now . . . the resources of coast seas are not inexhaustible, so that the nation to which the shore belongs may claim for itself an advantage thus within its reach and may make use of it, just as it has taken possession of the lands which its people inhabit. If a nation has specially profitable fisheries along its coasts, of which it can take possession, are we not to allow it to appropriate that gift of nature as being connected with the territory it occupies, and to keep to itself the great commercial advantages which it may enjoy, should there be fish enough to supply neighboring nations?" [Vattel, 1758 (about)]

These quotations identify the fisheries issue before us today as well as any long dissertation on the subject. In essence, they represent the two basic polar views: one, that there should be complete freedom of fishing on the high seas and the other that the coastal state should have a title in or jurisdiction over the fish off its coast. What I find to be of particular interest in the quotations is the fact that they are from the writings of world-known international law publicists, all of whom made their contributions to international law in the 18th and 19th centuries.

Thus our present-day debate in search for a new international regime for fisheries is not new. It has, however, been colored and refined by advanced technological change and by the increasing clamour for protein from the sea. Innumerable disputes in the last 50 years have helped to hone the issue to a sharp razor's edge. Increased scientific knowledge about the biology and life cycles of fish has not only served to help us conserve the fish but has served to better understand the fisheries issue.

Let me turn then to the debate between nations as evidenced in the forum of the Law of the Sea Preparatory Committee created for that debate.

Over the past 2 years there have been well over 100 interventions on fisheries made by various members of the 91-country Committee. In this debate you can well imagine that there has been a wide spectrum of offerings ranging from the view that there should be no substantive change in the legal framework for fishing on the high seas to the proposal that the coastal state should have exclusive control over all fisheries within a zone of 200 miles or more off its coast. It is clear that some of the initial proposals were made without full knowledge of the fishery question or indeed, in some cases, without knowledge of the particular interests of the spokesman's own country.

My reporting would be grossly incomplete if I did not say that the dialogue is influenced, in varying degrees, by political considerations -- indeed, in some cases, political factors dominated the factual fishery situation. It is also manifest that there is a clear interrelationship between fisheries and other major issues in the law of the sea forum; thus several statements were based on those interrelationships. It is the factor of the political coloration, plus a very human desire for economic gain, that prompts one to have the fisheries issue looked upon as a confrontation between developed and developing countries. Indeed the theme of developing versus developed countries is present in a large number of interventions and statements made by developing countries in the law of the sea forum, but when one goes behind that generality it becomes clear that from a purely scientific, technical and pragmatic base, developing versus developed is not the true situation.

There are some developing countries, just as there are some developed countries,whose primary interest in fisheries is distant water in character and their energy has been put into expanding the distant water effort. There are countries, both developed and developing, that have been blessed with large stocks of fish off their coast just as there are other developing and developed countries that are faced with but meager living resources off their coasts. There are some developing countries which have a high degree of skill in harvesting living resources the same is true of certain developed countries; conversely there are several, both developed and developing, countries that have not developed the basic skills. There are developed and developing countries that are landlocked or have but limited coastlines – included in this list would be Zaire, Austria, Nepal and Kuwait. Geography operates to their detriment, but by the same token the geography of access to the sea for developed and developing countries such as the United States, India, Argentina and Canada makes their situation different from other countries.

Obviously, it is these kind of differences and not whether a country is labeled developing or developed which should dictate the flow of negotiations on the fisheries issue. It is my impression that we are moving toward that recognition of the different national interests of countries regardless of their economic status. Ideally the best method of procedure would be to have the fishery issue completely depoliticized, for solution would then be easier and the likelihood of an equitable regime enhanced. But reality dictates that the political factors, plus the interrelationships with other issues, are a basic ingredient in the law of the sea forum and must be dealt with along with the specifics of the fisheries question itself.

You are all familiar with the proposal made by the United States in the person of Ambassador Donald McKernan at this last summer's session of the Law of the Sea Preparatory Committee. Essentially our approach, which has been rightly labeled "the species approach," would grant to the coastal state a preferential allocation of the catch of coastal and anadromous stocks limited only by that state's fishing capacity or perhaps, to some degree, by traditional foreign fisheries. The remaining portion of the allowable catch, if any, would be available to foreign fishermen, subject to coastal state regulations and licensing. Highly migratory oceanic species such as tuna – because of their broad range and the transitory nature of their distribution – would be managed by international organizations and would not be subject to any preferential allocation to the coastal state.

Where does the world community stand today? My opinion dictates that some countries are generally dedicated to the thought that the less change there is in the present international fisheries regime the greater their benefit. This is precisely what they are advocating. On the other hand, a large number of countries – so many that in fact it can be called a trend – are looking toward an explicit or less than explicit zonal approach for the management of fisheries. The United States position, along with a few others, is pretty much in the middle.

I have stated that the debate over fisheries has been going on for a period of 2 years. I believe that during that period all participating countries have had a significant opportunity to express their views and at the same time a great educational effort has been accomplished. By that I mean delegations now know more about fisheries than they ever have before and have a better sense or understanding of the problems faced by other nations. To me this was a necessary period and, although one fraught with a good bit of sidetracking and increasing frustrations, it has brought us to the point where negotiations rather than debate can begin. I say "can begin" because at this stage no one can say that the negotiations will begin when the Preparatory Committee holds its next session in March 1973. But in my view many of the impediments to getting to the negotiating table have been dissipated and from private comments by a large number of delegations I know that they want negotiations to begin.

You can label me as an optimist when I state that I believe they will begin negotiations at the next session. But here again, when I state that they will begin it is my expectation that the major elements of basic decisions on a fisheries regime will be reserved for the Conference itself.

What will the emerging fisheries regime be like? In my estimation, it will not be an exclusive fisheries zone nor will it be a system of *laissez faire*, but the resolution will lie somewhere between these two polar views. I base this on the premise that there is enough realization on the part of all participants that a regime brought forward that is not acceptable to the most powerful fishing states in the world will not succeed, nor will a regime that is too favorable to the most powerful fishing states in the world be acceptable to those countries with but a developing interest in fisheries. The regime must provide for accommodations from both polar groups if the vast majority of countries are to accept it. With the acceptance a new era in international fisheries will emerge. The position of the United States is such that I believe the two polar groups will have to move towards it or something similar to it in making the necessary accommodations.

There is much work to be done, but should we be able to reach our twin goals of producing a sea of tranquillity and one that permits our own fisheries to thrive, then the work before us is well worth it.

Mexico's Concept of the Patrimonial Sea

HECTOR MEDINA NERI
Undersecretary of Fisheries
Department of Industry and Commerce
Mexico, D.F., Mexico

Current advances in technology and fishing intensity, coupled with the ever increasing world population, have created one of the most disturbing problems of our times for most countries. This problem is the imperative need of developing countries to significantly increase the production of high value protein foods from the ocean to satisfy the constantly growing world demand and to prevent a greater deficit that would prove ruinous to their economic and social structure.

You, no doubt, are aware that Mexico has registered rapid development in both these areas and consequently is one of the nations most greatly affected by the problem. With this in mind and recognizing the strong sentiment of several of the Latin American countries in extending their maritime jurisdiction to 200 miles, we feel the necessity to propose the concept of the Patrimonial Sea as a means whereby coastal states may exercise sovereignty and control over the resources of the sea and may regulate the exploration, exploitation and conservation of all living and non-living elements of the seabed and its subsoil within its patrimonial sea and also combat and prevent the common menace – pollution.

The policy of our President, to the effect that Mexican waters should become a source of work, food and progress, is well known. Our Constitution provides that the exploitation of the natural resources should serve as a vehicle for an equitable distribution and protection of the common wealth.

The Secretary of Industry and Commerce, through the Undersecretary of Fisheries, has always upheld, in all international treaties in which he has participated, Mexico's concept, demanding recognition of the preferential rights of the coastal states to the resources of the sea within their adjacent waters and the freedom to dispose of these resources in a manner favorable to their economic development, for acquisition of food with high protein content and to obtain foreign exchange for industrial development.

Our idea of an equitable and true social justice, as declared by our President, is that highly developed countries should meet their needs for seafood by purchasing processed products from coastal developing countries, contributing to their progress, to their sound economy and, consequently, to "Peace."

Mexico's conception of this issue has been clearly defined on several occasions in recent months, in that all countries should recognize and respect the right of any nation to dispose freely of its natural resources without any external coercion. However, we must realize that these important problems require the creation of a new structure to conform to the current needs of developing nations. The preservation and replenishment of those species that have been overexploited and are near possible depletion claims immediate and adequate attention to ensure future supplies. We are firmly convinced that the rules of the past and of today are not adequate to regulate present conditions. A change is imperative.

The time has come when maximum utilization of the resources of the sea under proper administration has become compulsory, because the unlimited exploitation of numerous species has brought them to the verge of extinction. The activity of fishermen from distant areas in the waters adjacent to developing coastal countries unjustly limits their potential for economic advancement and constantly causes international friction. Mexico views with sympathy the efforts, verging on severe conflict, of sister countries to establish a 200-mile territorial limit. Without detriment to these aspirations, Mexico will strive, at the 1973 United Nations Conference on the Law of the Sea, to obtain juridical recognition, through a world convention, for a Patrimonial Sea extending up to 200 miles, over which the coastal countries will exercise exclusive preferential rights over fishing and in general over all its marine resources. Irrespective of legalities, one of the primary concerns of the U.N. should be the best possible economic use of the resources of the seas to aid all nations. This is of special interest to developing countries not only because they will find food in the oceans required for their growing populations but because the exploitation of these resources, living or mineral, may constitute a powerful instrument for their development.

To the above we must add the issue relating to the continental shelf. The conference held in Geneva in 1958 granted coastal states sovereign rights to their seabed, subsoil and resources of the shelf, to a depth of 200 meters or to that depth which may be exploited. This decision is a clear indication of the necessity of the coastal states to extend the limit of their Patrimonial Sea.

The urgent need for this change is applicable not only to the developing nations; right here in the United States groups of fishermen have made statements in favor of this change. Let me mention the resolution adopted by fishermen and their representatives attending the Annual Fishermen's Forum held on February 26, 1972, at Point Judith, Rhode Island, where it was resolved to officially request the United States government to extend its fisheries jurisdiction to 200 miles. Also, the recent 102nd Convention of the American Fisheries Society held at Hot Springs, Arkansas, September 10, 1972, resolved to encourage the governments of the United States, Mexico and Canada to favor the extension of their fisheries jurisdiction to 200 miles at the Law of the Sea Conference to be held in Geneva in 1973.

In view of the above we deem it advisable to refer to the Declaration of Santo Domingo, approved at the Meeting of Ministers of Foreign Relations at the Specialized Conference of Caribbean Countries on the Problems of the Sea, held on June 7, 1972, in anticipation of the 1973 United Nations Geneva Conference, and which follows:

DECLARATION OF SANTO DOMINGO

Recalling: That the International American Conference, held in Bogota in 1948, and in Caracas in 1954, recognized that the peoples of the Americas depend on the natural resources as a means of subsistance, and proclaim the right to protect, conserve and develop these resources, as well as the right to ensure their use and utilization.

That the principles of Mexico on the legal regime of the sea which were adopted in 1956 and which were recognized "as the expression of the juridical conscience of the continent"and as applicable, by the American States, established the basis for the evolution of the Law of the Sea which culminated, that year, with the annunciation by the specialized conference, in the capital of the Dominican Republic, of concepts which deserved endorsement by the United Nations Conference on the Law of the Sea, Geneva 1958.

Considering: That the General Assembly of the United Nations, in its Resolution 2750 (XXV) decided to convoke in 1973 a Conference on the Law of the Sea and recognized "the need for early and progressive development of the Law of the Sea."

That it is desirable to define, through universal norms the nature and scope of the rights of States, as well as their obligations and responsibilities relating to the various oceanic zones, without prejudice to regional or sub-regional agreements, based on the said norms.

That the Caribbean countries on account of their peculiar conditions, require special criteria for the application of the Law of the Sea, while at the same time the coordination of Latin America is necessary for the purpose of joint action in the future.

That the economic and social development of all peoples and the assurance of equal opportunities for all human beings are essential conditions for peace.

That the renewable and non-renewable resources of the sea contribute to improve the standard of living of the developing countries and to stimulate and accelerate their progress.

That such resources are not inexhaustible since even the living species may be depleted or extinguished as a consequence of irrational exploitation or pollution.

That the Law of the Sea should harmonize the needs and interests of States and those of the international community.

That international cooperation is indispensable to ensure the protection of the marine environment and its better utilization.

That as Santo Domingo is the point of departure of the American civilization, as well as the site of the first Conference of the Law of the Sea in Latin America in 1956, it is historically significant that the new principles to advance the progressive development of the Law of the Sea be proclaimed in this city. Formulate the following declaration of principles.

PATRIMONIAL SEA

(1) The coastal state has sovereign rights over the renewable and non-renewable natural resources, which are found in the waters, in the seabed and in the subsoil of an area adjacent to the territorial sea called the Patrimonial Sea.

(2) The coastal state has the duty to promote and the right to regulate the conduct of scientific research within the Patrimonial Sea, as well as the right to adopt the necessary measures to prevent marine pollution and to ensure its sovereignty over the resources of the area.

(3) The breadth of this zone should be the subject of an international agreement, preferably of a worldwide scope. The whole of the area of both, the territorial sea and the Patrimonial Sea, taking into account geographic circumstances, should not exceed a maximum of 200 nautical miles.

(4) The delimitation of this zone between two or more States, should be carried out in accordance with the peaceful procedures stipulated in the charter of the United Nations.

(5) In this zone ships and aircraft of all States, whether coastal or not, should enjoy the right of freedom of navigation and overflight with no restrictions other than those resulting from the exercise of the coastal State of its rights within the area. Subject only to these limitations, there will also be freedom for the laying of submarine cables and pipelines.

CONTINENTAL SHELF

(1) The coastal State exercises over the continental shelf sovereign rights for the purpose of exploring it and exploiting its natural resources.

(2) The continental shelf includes the seabed and subsoil of the submarine areas adjacent to the coast, but outside the area of the territorial sea, to a depth of 200 meters or, beyond that limit, to where of the superjacent waters admits the exploitation of the natural resources of the said areas.

(3) In addition, the States participating in this Conference consider that the Latin American delegations in the Committee on the Seabed and Ocean Floor of the United Nations should promote a study concerning the advisability and timing for the establishment of precise outer limits of the continental rise.

(4) In that part of the continental shelf covered by the Patrimonial Sea the legal regime provided for this area shall apply. With respect to the part beyond the Patrimonial Sea, the regime established for the continental shelf by international law shall apply.

INTERNATIONAL SEABED

(1) The seabed and its resources, beyond the Patrimonial Sea and beyond the continental shelf not covered by the former, are the common heritage of mankind, in accordance with the declaration adopted by the General Assembly of the United Nations in Resolution 2749 (XXV) of December 17, 1970.

(2) This area shall be subject to the regime to be established by international agreement, which should create an international authority empowered to undertake all activities in the area, particularly the exploration, exploitation, protection of the marine environment and scientific research, either on its own, or through third parties, in the manner and under the conditions that may be established by common agreement.

HIGH SEAS

The waters situated beyond the outer limits of the Patrimonial Sea constitute an international area designated as high seas, in which there exists freedom of navigation, of overflight and of laying submarine cables and pipelines. Fishing in this zone should be neither unrestricted nor indiscriminate and should be the subject of adequate international regulation, preferably of worldwide scope and general acceptance.

MARINE POLLUTION

(1) Is the duty of every State to refrain from performing acts which may pollute the sea and its seabed, either inside or outside its respective jurisdictions.

(2) The international responsibility of physical or juridical persons damaging the marine environment is recognized with regard to this matter the drawing up of an international agreement, preferably of a world wide scope, is desirable.

REGIONAL COOPERATION

(1) Recognizing the need for the countries in the area to unite their efforts and adopt a common policy vis-a-vis the problems peculiar to the Caribbean Sea relating mainly to scientific research, pollution of the marine environment, conservation, exploration, safeguarding and exploitation of the resources of the sea.

(2) Decides to hold periodic meetings, if possible once a year, of senior governmental officials, with the purpose of coordinating and harmonizing national efforts and policies in all aspects of oceanic space with a view to ensuring maximum utilization of resources by all the peoples of the region.

(3) The first meeting may be convoked by any of the States participating in this Conference.

Finally, the feelings of peace and respect for international law which have always inspired the Latin American countries, are hereby reaffirmed. It is within this spirit of harmony and solidarity and for the strengthening of the norms of the inter-American system, that the principles of this document shall be realized.

The present declaration shall be called: "Declaration of Santo Domingo."

Done in Santo Domingo de Guzman, Dominican Republic, the ninth day of June, nine thousand nine hundred and seventy-two (1972) in a single copy in the English, French and Spanish languages, each text being equally authentic. Mexico participated and is a subscriber to this Convention.

U.S.–Brazil Shrimp Conservation Agreement
A Status Report

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INTRODUCTION

My purpose today is to provide you with a status report on the U.S.–Brazil Shrimp Conservation Agreement which was signed on May 9, 1972, in Brasilia. Donald L. McKernan, Special Assistant for Fisheries and Wildlife to the Secretary of State, who headed the U.S. delegation, explained that the agreement establishes a basis for regulating the conduct of shrimp fishing in a defined area off the coast of Brazil. It also helps conserve the shrimp resources of the area and provides an interim solution for the problems which have arisen concerning jurisdiction over these resources. These problems developed as a result of Brazil's unilateral claim to a 200-mile territorial sea in 1970. In signing the 2-year agreement the two parties expressly reserved their juridical position on the question of territorial seas and fisheries jurisdiction under international law pending the outcome of the 1973-74 Law of the Sea Conference.

PRINCIPAL PROVISIONS OF THE AGREEMENT

(1) It is a 2-year compact terminating on January 1, 1974, unless the parties agree to extend it, and applies only to a specific area off the coast of Brazil lying north of the mouth of the Amazon River. This area is roughly equivalent to 7,680 square miles of ocean.

(2) It restricts the number of U.S. flag vessels which may fish in this designated area during a single season to 325 shrimp boats. The season for most of the area will be limited to the period between March 1 and November 30. A small subarea is limited from March 1 to June 30. No limitation is placed on Brazilian boats.

(3) A further limitation provides that no more than 160 boats will be allowed to fish in the designated area at any given time. A 15-vessel leeway will be granted U.S. fishing vessels during the first year of the agreement. There is no penalty for a violation of this limitation.

(4) U.S. vessels will be required to register with an agency of the U.S. government, since designated as the National Marine Fisheries Service (NMFS) and will be granted a permit to fish in the designated area. During the time the U.S. shrimp boats are off the coast of Brazil, they will be subject to the control of Brazilian authorities and may be boarded for inspection. Failure to produce a permit when fishing for shrimp will result in the seizure of the ship by the Brazilian authorities. The vessel and its crew will then be taken to the nearest Brazilian port and delivered to U.S. authorities for prosecution under U.S. law.

(5) The U.S. has agreed, through an exchange of notes, to give the Brazilian government $200,000 in order to aid that country in its enforcement responsibilities. In addition to this sum the U.S. will further compensate the government of Brazil in the amount of $100 for each day a U.S. shrimp vessel is under the control of Brazilian enforcement authorities due to a violation of the agreement. This money will come primarily from the registration fees required of the U.S. shrimp boats. The shrimp industry has indicated that it is willing to pay this amount.

(6) Information on catch and effort and biological data relating to shrimp in the area of agreement is collected and exchanged. Each vessel fishing under the agreement maintains a fishing log; copies of which are collected monthly by NMFS and sent quarterly by the U.S. to Brazil.

STATUS OF AGREEMENT

The agreement has now been consented to by the U.S. Senate and awaits ratification by the President. It will formally enter into force on a date to be mutually agreed upon by an exchange of notes with Brazil and shall remain in force until January 1974, unless the parties agree to extend it.

VOLUNTARY COMPLIANCE BY U.S. FISHING INDUSTRY

Between the time the agreement was signed and the date it officially enters into force, the U.S. shrimp industry has voluntarily complied with the agreed provisions. In effect this has amounted to a major portion of the first season since shrimping in the area closes on November 30, 1972. It is noteworthy that voluntary compliance has paid off for U.S. fishermen in that no confrontations with Brazilian enforcement authorities have occurred since the agreement was signed.

A total of 173 U.S. shrimp vessels have been assigned identification numbers by my office during this voluntary compliance period. Owners of these vessels are asked to provide identification information on their vessel and gear and to deposit $700 for each vessel for eventual use as a registration fee when the agreement enters into force. When this deposit is made and the identification information received, we issue a letter of voluntary compliance to be displayed in the wheelhouse while in the agreement area. We have issued 150 letters of voluntary compliance to date.

It is anticipated that the agreement will be officially in force prior to the opening of the 1973 season on March 1, 1973. If not, the voluntary compliance period will be continued and a $700 deposit will only be required for new vessels. Vessels which received a letter of voluntary compliance in 1972 will not be asked to deposit another $700 in 1973. When the agreement does become official, identification numbers issued to vessels during the voluntary period will remain the same when official letters of registration and numbers are issued. Applicants for official registration for 1973 will pay a fee of about $700 in addition to the $700 which was voluntarily deposited for 1972. If such applicants did not participate in the voluntary compliance program or fish off Brazil during 1972, their registration fee for 1973 will be about $700. These funds will be used to partly offset the $200,000 annual U.S. obligation to Brazil to help defray enforcement costs.

SUMMARY OF LOGBOOK ACTIVITY

Logbooks with charts of the agreement area were placed aboard all registered U.S. vessels fishing off Brazil in June of this year. NMFS representatives visited fishing ports in the Guianas and assisted plant personnel with instructing vessel captains in procedures for entering catch and other fishing information in the logbooks. Logbook returns for the first 2 months (July and August) were sketchy as we expected, but began to improve in September. We are satisfied that good progress is being made in keeping and submitting logbooks. Another training and assistance visit by NMFS personnel to landing ports in the Guianas and Trinidad is planned before the next shrimp season opens on March 1, 1973.

Investigations and Management of the Guianas Shrimp Fishery Under the U.S.–Brazil Agreement [1]

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The U.S.–Brazil Agreement signed on May 9, 1972, is the most recent of the U.S. bilateral fishery agreements. The National Marine Fisheries Service (NMFS) was given, among other responsibilities connected with the Agreement, the task of collecting information about the fishery to meet the terms of the Agreement and to acquire a scientific understanding of the resource. This paper decribes the progress made, which includes setting up a logbook system for recording catch and effort statistics and carrying out a resource survey to determine the species composition of the shrimp population on the fishing grounds.

HISTORY OF THE OFFSHORE FISHERY

The commercial shrimp fishery off the northeast coast of South America, as we know it today, began in 1959. The general location and the approximate extent of the offshore fishing grounds are shown in Figure 1. The results of cruises by the U.S. exploratory fishing vessel *Oregon* in the fall of 1957 and the late summer of 1958 focused the attention of the U.S. shrimp industry on the Guianas region (Bullis and Thompson, 1959). Other surveys also contributed to the knowledge of the shrimp and fish resources of the region (U.S. Fish and Wildlife Service, 1954; Higman, 1959; Durand, 1959; Richards, 1955; Salmon, 1958; and Mitchell and McConnell, 1959). Commercial shrimp vessels began operating from Paramaribo in October 1958, from Georgetown in January 1959 and from other ports in the early and mid 1960's. Landings are presently made at six ports (Fig. 1). The vessels of a number of different countries participate in the fishery: Brazil, Guyana, Japan, Korea, Surinam, Trinidad and Tobago and the U.S. (Gross, 1973).

The Guianas shrimp fishery grew rapidly from its beginning. In 1960, the first year for which reliable catch statistics are available, the total landings were 4 million pounds (Fig. 2) (Naidu and Boerema, 1972). By 1968, the year of peak catch, the landings had increased to 27 million pounds. The total catch remained high in 1969 but declined in 1970 and 1971. The smaller total landings in 1971 (20 million pounds) are coincident with the jurisdictional problems of U.S. flag

[1] Contribution No. 224, Southeast Fisheries Center, National Marine Fisheries Service, NOAA, Miami, Florida 33149.

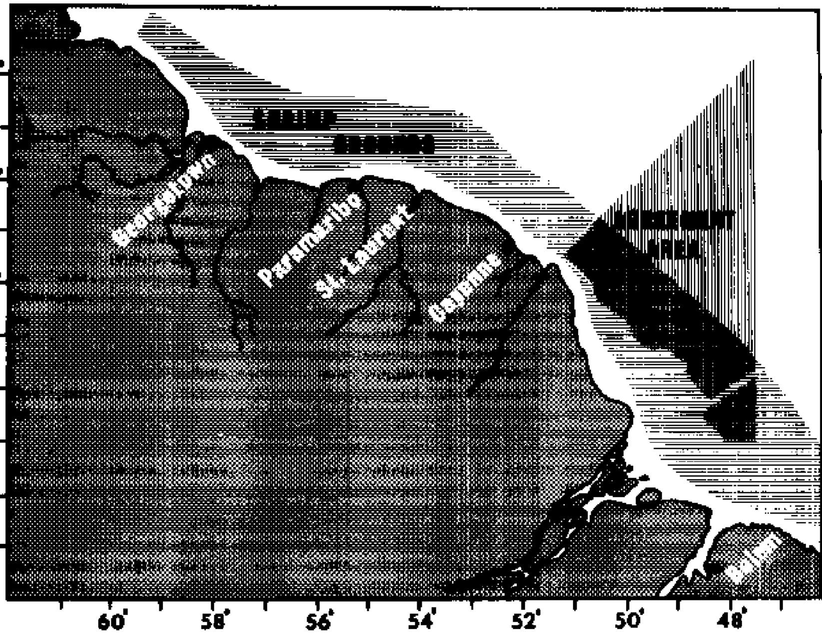

Fig. 1. The Guianas shrimp grounds off the northeastern coast of South America and the area of the U.S.-Brazil Shrimp Agreement. The Agreement area is bounded inshore by the 30-meter depth contour, offshore by the 47° 30′ W longitude line, on the north by the northern border of Brazil and on the south by the 1° N latitude line. The principal ports of landing adjacent to the shrimp grounds are shown: not shown is one additional port of landing, Port-of-Spain, Trinidad.

vessels operating off Brazil and the consequent move of these vessels to other fisheries.

The present Guianas shrimp fleet is modern and fairly uniform in size, power and gear. Figure 3 shows the characteristics of the first 163 U.S. vessels which applied for permits to fish in the Agreement area. Their mean age is 4 years; overall length, 73 feet; gross tonnage, 99; and horsepower, 348. Wood-hull vessels make up 69% of the fleet; steel-hull vessels, 27%; and fiberglass-hull vessels, 4%. The catch is preserved by freezing in 53% of the boats and by ice in the remainder.

The catch per unit fishing effort for the Guianas fishery has been calculated from the data on the total annual catch and the total number of vessels in the fishery (Fig. 4). The number of vessels in the fleet increased progressively through 1970. The average catch per vessel increased in the early years of the fishery through 1965 and gradually declined thereafter. The trends in the average catch per vessel vary considerably among the various ports, both for the early years of the fishery (Naidu and Boerema, 1972) and also for the more recent years, 1970 and 1971. This variability is partly because the measure of effort (boat years) is a crude one. Boat counts were made once per year; thus

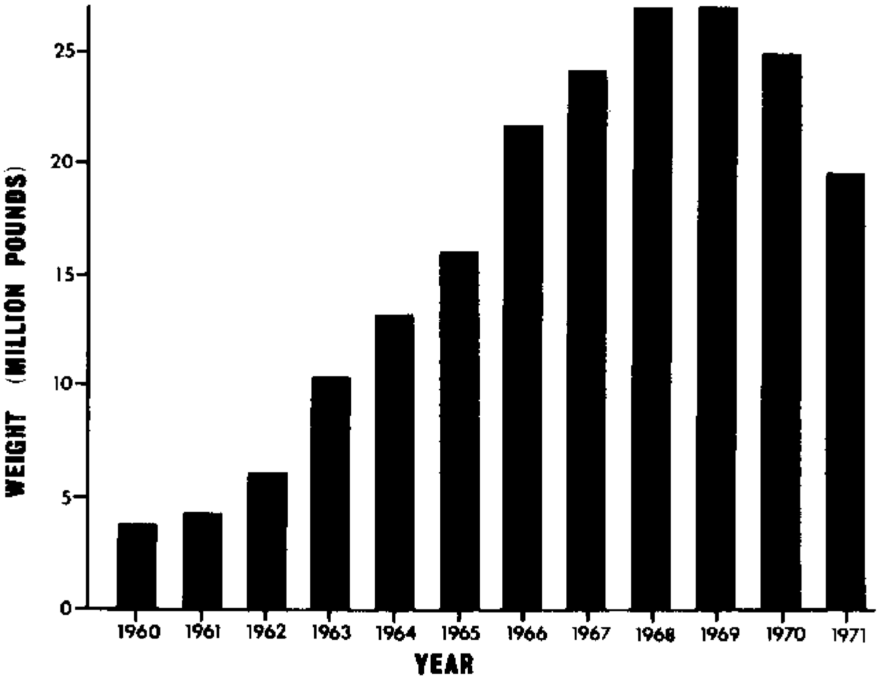

Fig. 2. Landings of shrimp (heads-off weight) for the Guianas fishery, 1960-71.

some boats counted in the fishery may not have fished the entire year and some which fished only part of the year may not have been counted. The different trends in the average catch per vessel at the various ports may be due to the imprecise measure of fishing effort used or may indicate real differences in the stocks fished.

DATA COLLECTION UNDER THE AGREEMENT

In 1972 NMFS established a system for collecting information on catch and fishing effort as part of its responsibility under the U.S.–Brazil Agreement. The Agreement requires that vessel skippers keep records of their fishing activity. A logbook form was designed after consultation with fleet operators, plant processors and representatives of the Brazilian fisheries department (Fig. 5). Completion of the form provides a record of information on fishing time, area and catch for each trip. To aid the skipper in describing his fishing area the logbook form includes a chart of the fishing grounds marked with grid zone number and depth. Fishing time is recorded as number of drags made and number of hours fished each day and separate entries are made for fishing during the day and at night. Catch is given as total pounds (heads-off weight) caught each day and the fisherman is asked to indicate the species and the predominant size category.

The Agreement requires that logbook records be kept for fishing in the area of Agreement off Brazil. However the U.S. industry, realizing the importance of

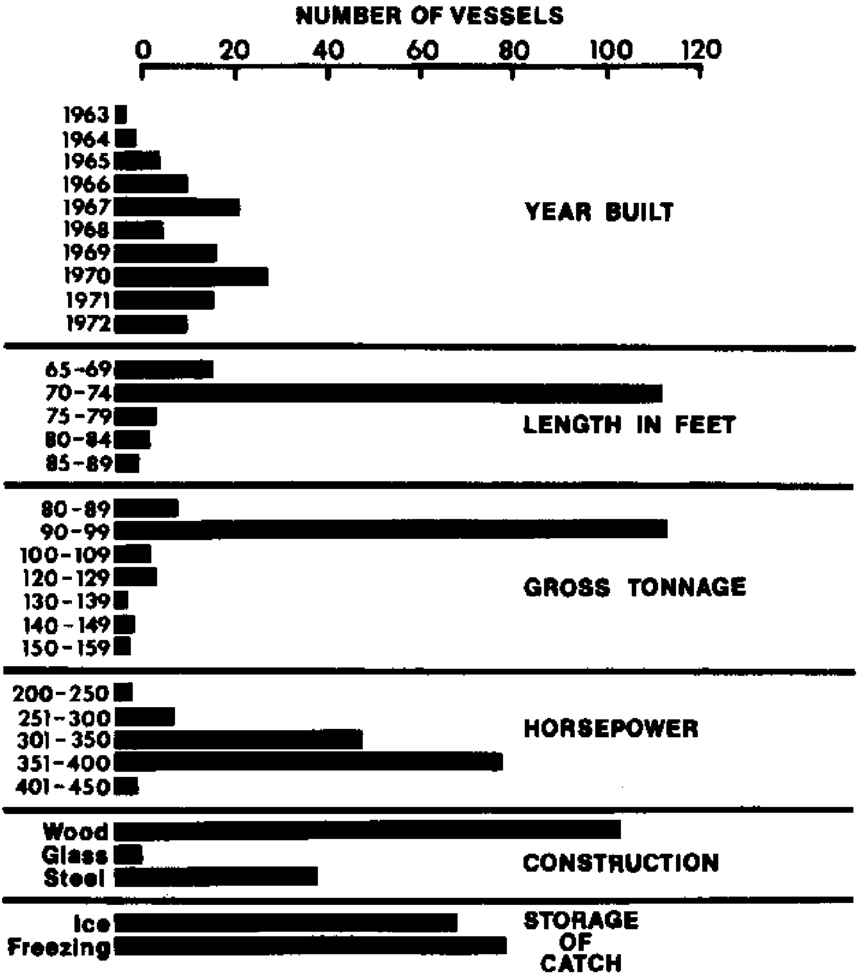

Fig. 3. Characteristics of U.S. flag shrimp vessels currently registered under the U.S.-Brazil Shrimp Agreement. No vessels were included in the 110-119 gross tonnage category.

this information, has taken a far-sighted step by volunteering to record and submit these data for the entire area of the fishery. In addition to the logbook reports, we receive a report from each processing plant of the size composition of each vessel's landings. It is important to point out that although NMFS provides the logbook forms and processes and analyzes the statistical data, the U.S. industry collects and submits the information. The collection of raw data is the most important part of any fishery statistics system and represents a significant input of time and effort by industry members – the vessel captains and the fleet managers – towards providing the basic information necessary to understand and manage this fishery.

The information from the logbook reports will be tabulated and made available in summary form. The summary, prepared by computer print-out on a monthly or quarterly basis, will show the catch in pounds and the fishing effort in number of drags made and number of hours fished for each fishing zone and depth range. This information will be further used to study the unit of fishing effort which will best describe the fluctuations in the stocks.

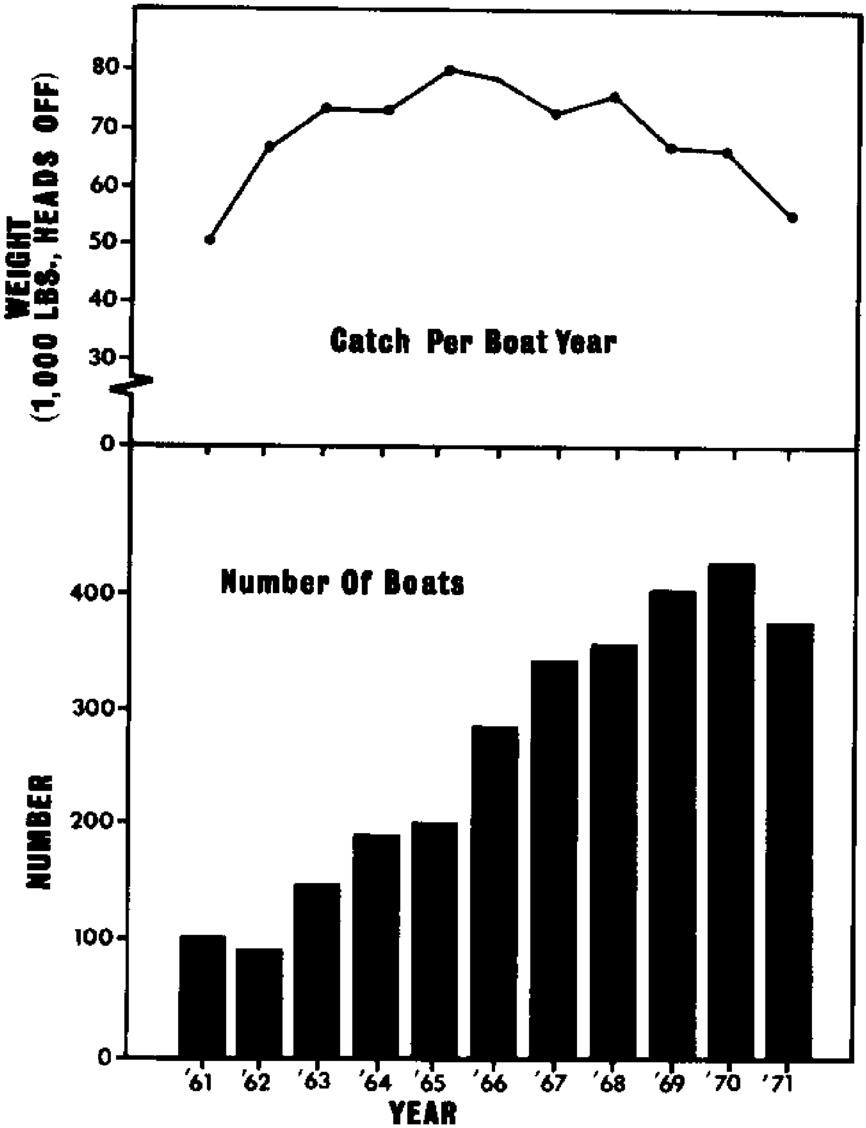

Fig. 4. Average annual catch per vessel and the number of vessels operating each year in the Guianas shrimp fishery.

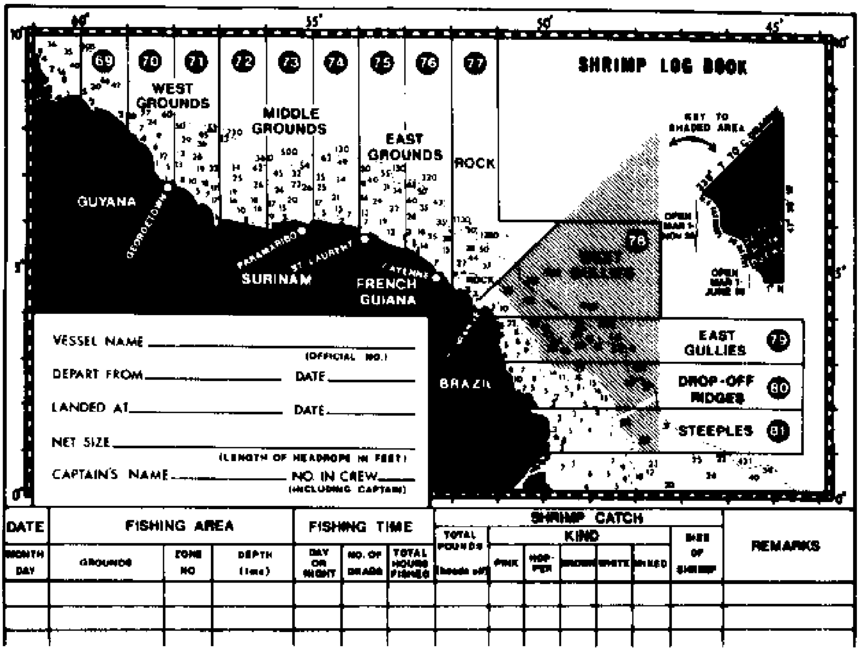

Fig. 5. Logbook used for recording catch and effort information from the Guianas shrimp fishery.

RESOURCE SURVEY

Three species of penaeid shrimp *(Penaeus brasiliensis, P. aztecus subtilis* and *P. duorarum notialis),* which make up the majority of the commercial landings, are processed under the single category "pink shrimp." There is, therefore, no information available for this category on the landings by species. White shrimp *(P. schmitti)* make up the remainder of the landings and are processed as a distinct category. We carried out a resource survey during the June-July 1972 cruise of the *Oregon II* to determine the areal distribution of the four species of shrimp off Guyana, Surinam and French Guiana. A one-half or 1-hour tow with two nets was made at night at stations along 14 inshore-offshore transects at planned depths of 15, 20, 25, 30 and 35 fathoms. The average catch for 66 stations occupied during the survey was 14 pounds per hour of towing (7 pounds per net hour). The largest catch was 122 pounds per hour of towing. Fifteen percent of the total number of hauls had commercial-size catches (above 25 pounds per hour's towing – equivalent to 200 pounds per 8 hours of fishing). The catch rates were comparable to those reported by Bullis and Thompson (1959).

The distribution of the four species of shrimp is shown in Figure 6. At the four transects off eastern Guyana and western Surinam the shrimp catch consisted of a majority of pink spotted shrimp *(P. brasiliensis)* at the offshore stations and a majority of pink shrimp *(P. duorarum notialis)* at the inshore stations. The

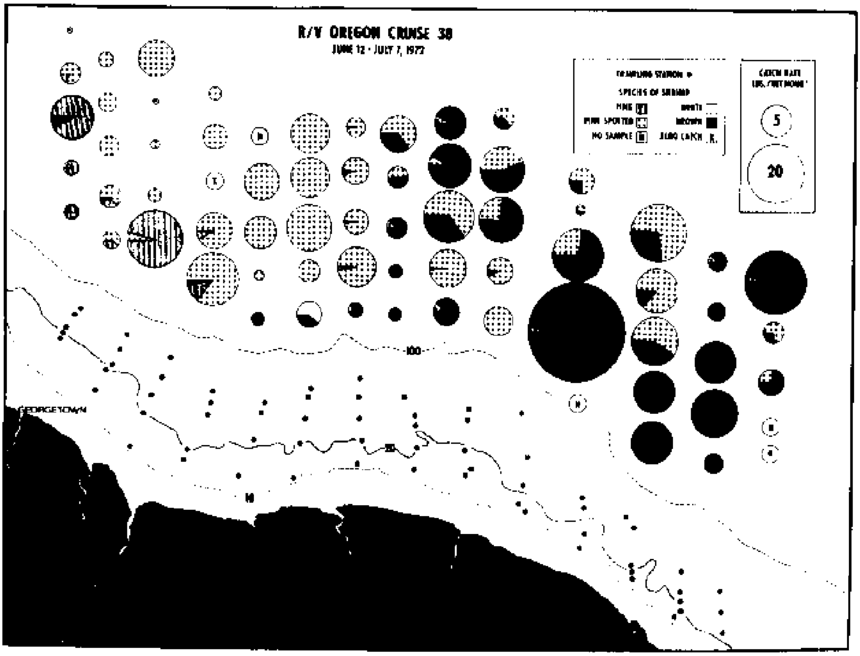

Fig. 6. Species distribution and catch rate of commercial shrimp off the Guianas in June and July 1972. The black dots indicate the geographical location of trawling stations of the *R/V Oregon II* along 14 inshore-offshore transects. The corresponding circles represent the catch rate and species composition of shrimp at these stations.

highest catch rate of pink shrimp (18.5 pounds per net hour) was made at 15 fathoms off the mouth of the Corentyn River. At the offshore stations of the three transects off central Surinam the catch consisted almost entirely of pink spotted shrimp; at the inshore 15-fathom stations, of brown shrimp *(P. aztecus subtilis)* or a mixture of brown shrimp and white shrimp *(P. schmitti)*. At the remaining transects off eastern Surinam and French Guiana the catch was almost exclusively brown shrimp and pink spotted shrimp, with brown shrimp predominating at 19 out of the 32 stations. Catches of brown shrimp were highest at the 20-fathom station, 50 miles northwest of Cayenne (60.5 pounds per net hour).

Our survey showed that a single species of shrimp dominates the catch in many areas. For the present we are asking the fishermen to indicate on the fishing logbooks the kind or kinds of shrimp caught. Later it may be desirable to sample the landings in order to get more exact data on the species composition of the catch.

DISCUSSION

The sustained harvest from a living marine resource usually requires proper management of its fishery. Tropical shrimp stocks are presently fished in a number of areas throughout the world. Their fisheries have generally remained productive, despite intensive exploitation. Among the reasons for the continued high production of these fisheries is the apparent biological resiliency of shrimp stocks (their high reproductive capacity and turnover rate). Furthermore the environment for shrimp has been affected adversely only in a small part of the total habitat. In spite of these favorable biological and environmental conditions, man's increasing technological capability for exploitation of living resources may eventually require that we regulate the harvest to insure maximum sustained production from the resource. Whether regulation needs to or will be applied to the Guianas shrimp fishery remains to be seen. In any event the U.S. - Brazil Shrimp Agreement provides the opportunity to study this fishery and to collect information necessary to understand its dynamics.

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TECHNOLOGY & MANAGEMENT SESSION

TUESDAY – NOVEMBER 28, 1972

Chairman -- James A. Prunty, *Marine Regulations Advisor, Mobil Oil Corporation, New Orleans, Louisiana*

Impact of International Standards on Fishery Products

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Most of the developed countries of the world today have complex and sophisticated national food standards. Even so, these countries face a continuing need to revise their regulations to take into account new technological developments. On the other hand, newly independent and developing countries are in the process of writing food laws and introducing systems of food regulation and control for the first time. These countries are rapidly learning that food standards should safeguard the national interests, but should not conflict with the requirements of the world's principal sources of food.

What then has brought about the widespread interest in international food standards over the past few years? One identifiable factor motivating most governments is the prospect of facilitating international trade in food by the removal of non-economic barriers to trade, particularly in those countries dependent upon agricultural and fisheries exports. A second factor of equal importance is the need to establish standards to ensure safe and wholesome food in international trade. Hence the two most significant forces behind the development of international food standards are (1) the protection of the health of the consumer and (2) the need to facilitate international trade in foods.

In the past, little progress has been made in the field of international food standards in spite of various attempts and a variety of schemes initiated in Europe, Latin America and Africa. The increase in interest to alleviate trade problems was recognized by member governments of the Food and Agriculture Organization of the United Nations (FAO) and the World Health Organization (WHO), and a decision was made in the early 1960's to create a forum for international action. The two international organizations moved rapidly, after having decided to undertake the challenge of alleviating trade problems. In 1962 a joint FAO/WHO conference on food standards was held. This FAO conference endorsed the establishment of the Codex Alimentarius Commission and developed certain guidelines for its work. WHO subsequently approved the establishment of the Codex Alimentarius Commission and the work of the Commission became a joint FAO/WHO undertaking.

The purpose of Codex Alimentarius is very clearly set forth by the Commission in a Procedural Manual, which states:

> "The Codex Alimentarius is a collection of internationally adopted food standards presented in a uniform manner. These food standards aim at protecting consumers' health and ensuring fair practices in the food trade. The Codex Alimentarius also includes provisions of an advisory nature in the form of codes of practice, guidelines and other recommended measures intended to assist in achieving the purposes of the Codex Alimentarius. The publication of the Codex Alimentarius is intended to guide and promote the elaboration and establishment of definitions and requirements for foods to assist in their harmonization and in doing so to facilitate international trade."

The scope of Codex Alimentarius is also set forth by the Commission, as follows:

> "The Codex Alimentarius includes standards for all the principal foods, whether processed, semi-processed or raw, for distribution to the consumer. Materials for further processing into foods should be included to the extent necessary to achieve the purposes of the Codex Alimentarius as defined. The Codex Alimentarius includes provisions in respect of food hygiene, food additives, pesticide residues, contaminants, labeling and presentation, methods of analysis and sampling. It also includes provisions of an advisory nature in the form of codes of hygiene and technological practice, guidelines and other recommended measures."

The work of the Commission is carried on largely by committees and each committee is chaired by a country. The chairmanship of a committee really means that the country is responsible for convening experts on the subject of its work and for drawing up standards which are then submitted to the Commission.

The Commission has developed a 10-step procedure for the elaboration of Codex standards. After a draft standard has been prepared by an "author" country and considered by the Committee, the procedure allows two rounds of comments by governments, two examinations by the Committee and two considerations by the Commission. Thereafter the standard is formally sent to governments for acceptance. This procedure has been deliberately designed to give governments the fullest opportunity to comment on standards while they are still in draft, and to allow the Commission to satisfy itself that the standards are being prepared in accordance with its general principles.

The nature of Codex committees can be divided into two types. One group of committees works on general subjects which when adopted are applicable to all food standards. These committees and their chairman countries are as follows: (1) General Principles Committee – France. The purpose of this Committee is to set up formats for the adoption of standards and procedures and the format to be used in the preparation of standards. (2) Food Labeling – Canada. The purpose of this Committee is to establish provisions on labeling applicable to all foods in international trade. (3) Food Hygiene – United States. The purpose of this Committee is to develop basic principles for food plant sanitation and for handling food in international trade. (4) Food Additives Netherlands. The purpose of this Committee is to recommend international tolerances for individual additives in specific food items. (5) Pesticide Residues – Netherlands. The purpose of this Committee is to recommend international tolerances for pesticide residue in specific food products. (6) Analysis and Sampling – Federal Republic of Germany. The purpose of this Committee is to determine the best method of analysis and sampling for the products for which Codex standards are in preparation. (7) Meat Hygiene – New Zealand. The purpose of this Committee is to develop basic principles for meat plant sanitation and for handling meat in international trade.

The other group of committees under the Codex Alimentarius is the so-called "commodity committees." Presently there are nine committees working on standards for specific food products. Of course this group of committees does not cover all foods and additional products for standardization are added to their workload from time to time.

The Codex Commodity Committees currently active, along with the country acting as chairman, are as follows: Cocoa Products and Chocolate – Switzerland; Sugar – United Kingdom; Processed Fruits and Vegetables – United States; Fat and Oils – United Kingdom; Fish and Fishery Products – Norway; Dietetic Foods – Federal Republic of Germany; and Meat and Meat Products – Federal Republic of Germany. Two other bodies, both of which are Joint ECE/Codex Groups of Experts, are elaborating international standards for fruit juices and frozen vegetables.

The Codex Committee on Fish and Fishery Products, which is of greatest interest to you, functions with Norway as the chairing country. This committee has the responsibility for developing worldwide standards for fresh, frozen or otherwise processed fish, crustaceans and mollusks. This committee has met in session seven times and has about 20 products for which standards are being developed. Five standards for canned salmon, frozen gutted Pacific salmon, canned shrimp, frozen fillets of cod and haddock and frozen fillets of ocean perch have been completed. Countries will be asked to accept these standards in the near future. At its most recent session held October 2-7, 1972, this Committee completed its work on a standard for canned tuna and bonito in brine or oil and referred the standard to the Commission for approval. The remaining fishery products for which standards are being elaborated are as follows: frozen fillets of flatfish, canned crabmeat, canned sardines, frozen shrimp and prawns, frozen fillets of hake, frozen blocks of cod, haddock and ocean perch (for further processing), frozen tuna (for further processing), frozen herring, canned mackerel in brine or oil, salted anchovy fillets in oil, canned herring, salted cod, salted herring and frozen lobsters and crayfish.

The United States Delegation to the sessions of the Codex Committee on Fish and Fishery Products usually is composed of three government officials. Additionally, several industry advisors to the government delegates also attend and participate in the committee sessions. At the seventh session of the Codex Committee on Fish and Fishery Products, nine industry advisors to the United States Delegate attended. These advisors serve by invitation and frequently are individuals who are experts in more than one commodity.

In respect to standards for fishery commodities, coordination and liaison with the industry is handled through commodity-oriented trade associations such as the Tuna Research Foundation, National Fisheries Institute, American Shrimp Canners Association, Maine Sardine Council, National Shrimp Breaders Association, American Frozen Foods Instutute and others. When needed, meetings are held with the appropriate commodity-oriented industry group in respect to a specific product standard. In addition to coordination with industry, National Marine Fisheries Service (NMFS) technological research centers and other federal and state agencies are invited to comment on the standards and, on occasion, to test the practical applicability of selected provisions of standards such as defects tables. Thus, when comments are presented during the developing stages of standards for fishery products on behalf of the United States, the best technical and responsive industry and government views are presented.

In the 10 years the Commission has been at work, the number of member countries has increased from 44 to 92, and 67 standards have been developed and recommended by the Commission. Forty-one of the 67 standards are now being circulated among member governments for adoption.

In adopting a Codex standard, a country may choose full acceptance, target acceptance or acceptance with deviations. Target acceptance indicates an intention to grant full acceptance after the passage of a stated period of time. However, some countries, including the U.S., do not adopt standards under the target acceptance provision. The last category indicates full acceptance but with certain recognized deviations designed to meet particular national requirements. If a country determines that it cannot grant acceptance in one of its three forms to the standard, it is asked to inform the Commission whether it will nonetheless permit free distribution of products meeting the standard, and in what ways its present or proposed requirements differ from the standard.

Two points must be kept firmly in mind in regard to Codex Alimentarius food standards. First, in no way would competition among brands or consumers choice, in such areas as taste preference, be restricted by the application of these standards. Differences in food quality, nutritive value and taste among competing products would continue as a result of differences in the basic food source utilized, and processing procedures employed in just the same way as do competing domestic food producers, all of which must meet U.S. Food and Drug Administration, (FDA) standards. What these international standards will assure, particulary for those consumers in less developed countries that lack adequate food safety laws and inspection and enforcement procedures, is a food supply meeting basic safety requirements and minimum quality levels. It might also be pointed out that the adoption of such standards may be beneficial to highly developed nations by helping to enhance trade through the elimination of non-trade tariff barriers. The second point is that the Codex Alimentarius Commission has no authority to impose standards on participating nations. Standards may be adopted by nations in accordance with their existing statutes and procedures governing the adoption of food standards. Hence, for example, the U.S. would adopt a Commission standard through the same manner as the FDA, or in some cases the Department of Agriculture, presently promulgate their domestic food standards.

A critical time is at hand for the work of the Codex Alimentarius Commission. With the present submissions in the hands of member governments for consideration and adoption, and with further new standards expected to be submitted in the near future, we will soon learn if it is reasonable or practical to expect governments to give due weight to international as well as domestic concerns in the establishment of food standards.

The United States, as are other countries, is obligated to review the recommended standards for possible adoption. Careful and substantial consideration has been given to developing a way to proceed and meet this obligation. On October 5, 1972, the FDA published in the *Federal Register* a proposed notice to add a new Section 10.8 to Title 21 for the review of Codex Alimentarius Food Standards. This new section will provide for the review to be accomplished in one of three ways, as follows:

"(1) Any interested person may petition the Commissioner to adopt a Codex standard, with or without change. Any such petition shall specify any deviations from the Codex standard, and the reasons for any such deviations. The Commissioner shall publish such a petition in the *Federal Register* as a proposal, with an opportunity for comment; if reasonable grounds are provided in the petition. Any published proposal shall state any deviations from the Codex standard and the stated reasons thereof.

"(2) The Commissioner may on his own initiative propose by publication in the *Federal Register* the adoption of a Codex standard, with or without change. Any such proposal shall specify any deviations from the Codex standard, and the reasons for any such deviations.

"(3) Any Codex standard not handled under paragraph (b) (1) or (2) of this section shall be published in the *Federal Register* for review and informal comment. Interested persons shall be requested to comment on the desirability and need for the standard, on additional or different provisions that should be included in the standard, and on any other pertinent points. After reviewing all such comments, the Commissioner shall either publish a proposal to establish a food standard pursuant to Section 401 of the act covering the food involved, or shall publish a notice terminating consideration of such a standard."

With regard to the third alternative for reviewing Codex standards, FDA stressed the need for "different interest groups (consumers, industry, the academic community, professional organization and others)" to "meet and discuss these standards before petitions or comments are submitted." FDA went on to say that "recent experience has shown that such meetings and discussions often resolve misunderstandings and differences of opinion and avoid unnecessary controversy that can result in protracted disagreement and wasteful public hearings."

Recently the United States reported on the status of acceptance of 41 recommended Codex Alimentarius standards as of September 1, 1972. These are standards that had been officially transmitted to governments and do not include 26 additional standards that have been accepted by the Commission but not distributed to governments. Standards for quick frozen fillets of cod and haddock and quick frozen fillets of ocean perch are included in this group of 26 standards. In the report, the status of fishery products standards was categorized as follows:

Category 1: Quick frozen gutted Pacific salmon and canned shrimps and prawns

Status -- Standards are under consideration, but there are no official regulatory standards now in effect for these products. National standards will likely be promulgated.

Category 2: There were no standards for fishery products in this category

Category 3: Canned Pacific salmon

Status – The standard is under consideration. The United States did not have an official regulatory standard for canned Pacific salmon when the recommended standard was received. The United States through its rulemaking procedure published standards of identity and fill of container for canned Pacific salmon and announced that these standards would become effective October 30, 1972. These standards incorporate most of the provisions of the Codex standard.

Category 4: There were no standards for fishery products in this category

Category 5: General standard for labeling of prepackaged food

Status – The Directors-General were notified on April 25, 1971, of United States acceptance with minor deviations of the Recommended Standard for Labeling of Prepackaged Food. (This general standard, of course, applies to prepackaged fishery products.)

The indications for the future are summarized as follows: (1) More Codex standards will be developed, adopted and applied both nationally and internationally; (2) Advisory codes of technological and hygienic practice for both vessels and establishments will be developed and recommended for national and international use; (3) Newly established and developing countries will establish and implement food regulation and control systems in their respective countries to apply Codex standards and codes for which the countries have indicated acceptance.

Several serious challenges are associated with Codex Alimentarius standards. Solutions to these problems will require a lot of consideration by all phases of food enforcement and all phases of industry that will be affected by Codex standards. One in particular is the matter of uniform enforcement of accepted Codex standards. The present make-up of Codex Alimentarius does not include an enforcement body. Rather, enforcement would be left to the jurisdiction of the countries adopting the standards, and the variability in the level of enforcement of food standards in various countries is well known. Thus, casual treatment of Codex Alimentarius standards in some countries will undoubtedly be the situation for several years.

Developments in Nutritional Labeling

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Increasing consumer awareness and activity are a social phenomenon of the 1970's. Large as the changes have been, it is likely that we have seen only the beginning of a major social change. A considerable part of this awareness has to do with the nation's food supply. This is a proper priority since the food supply is of primary importance to survival as well as to good living and good health.

Our time scales also are shifting. No longer is it sufficient to know that a food will not make us sick today, tomorrow or next week. Now we want to know how it will affect our declining years, our offspring and, indeed, how it will change the course of human heredity. Concisely, we are now interested in carcinogenicity, teratogenicity and mutagenicity. It is a mighty step to shift from the judgment of short-range effects to the measurement of those that may not develop for generations.

We must all consider carefully the size of the questions that are being asked about foods and food additives. We also must remember that many questions have practical, workable answers if they are asked in the light of reason. If they are asked with a demand for a precise, solid, forever-unerring answer, frequently there is no answer at all. The sea food industry is probably more aware of this than most others.

Rapidly changing life styles and technology provide both the need and the means for changing the food supply. Fast food service with advanced packaging and processing methods is one of the most rapidly developing areas. Strangely, an increase in institutional feeding often has been accompanied by a decrease in employees in the kitchen. This has been accomplished by portion packing, precooking, microwave ovens and increased sophistication of food manufacturers, distributors and the food service industry.

As the complexity of food technology increases, the need increases for relevant information. Programs for disseminating this information and for developing educational methods are needed. The Bureau of Foods is attempting to meet this need for increased consumer information and understanding by promulgating or revising various regulations on the labeling of different kinds of foods (Johnson, 1971; Wodicka, 1972). These include regulations on: iodized salt (3.87), hypoallergenic foods (125.9), sodium-controlled foods (125.9) and infant formulas (125.5).

Proposals for amending present regulations include those on: dietary supplements (80.1), foods for special dietary uses (125), fat and oil labeling (3.41 and 125.12), amino acids (121,1002), nutritional quality guidelines (100.1), frozen dinner guidelines (100.20) and nutrition labeling (1.8 and 1.16).

I have been urging more iodized salt. Here, at least, I don't need to do that. The supplementation of table salt with potassium iodide is a vital step in avoiding iodine shortage. However, an increasingly large proportion of the food supply is prepared. This immediately raises the question of whether or not iodized salt should be used in prepared foods. Since people in institutions may eat an even larger proportion of manufactured foods, this question is even more vital for institutional food manufacturers than for those whose products are sold on the retail market. Certainly the cost of using iodized salt in manufactured foods is inconsequential. The presence of iodine might lead to a shorter shelf-life for some products. Thus, mandatory use of iodized salt in all prepared foods might be unwise. It probably is not necessary either if encouragement for the voluntary use of iodized salt leads to sufficient use in processed foods.

The proposal for fat labeling is an interesting one. First, it will provide data with which consumers can follow the recent recommendation of the Food and Nutrition Board and the Council on Foods and Nutrition of the American Medical Association (Anon. 1972). This group recommends increased consumption of polyunsaturated oils for those in "high risk" categories. There seems to be little argument that the consuming public associates "vegetable oil" with unsaturation. Thus it is necessary to develop a label so that fully saturated vegetable oils, such as palm kernel oil and coconut oil, will not be mistaken for "unsaturated oils." This is an interesting illustration of the need to go beyond purely factual labeling, such as percentage ingredient labeling, and to give more specific information to overcome public misunderstanding.

Some people associate prepackaged feeding with monotony of diet. This need not be the case, and usually is not. One small company of my acquaintance scooped the field in egg-custard mixes and successfully fought off competition. They accomplished this by providing excellent quality consistently. Proper use of labeling will permit the food service manufacturer to tell his story of quality and service. Now the "quality" story can include nutritional quality as well as good taste and good performance. The seafood and associated industries certainly have interesting nutritional stories to tell.

This article discusses nutritional labeling primarily, with comments on its application to the sea food industry. However, nutritional labeling is only part of an overall package (as listed above) that is designed to clarify and amplify the Federal Food, Drug and Cosmetic Act.

A major point of contention regarding the nutritional labeling proposal has been the so-called "negative labeling" provision. This provision stipulates that a group of seven of the nutrients must be listed, whether present or not. Industry strongly opposes listing zeroes or "insignificant" after nutrients not present. Many educators and consumer groups believe a standard format is required to help educate consumers and to let them know what they should look for in a given position. It appears that a compromise is needed here or the result will be promiscuous fortification to make the label look better. This, of course, would be highly undesirable.

Negative labeling is associated with the percentage interval selected for listing nutrients. For example, a food containing 2% of the selected standard for a given nutrient would be rated "insignificant" if a 5% cutoff is used. A 2% cutoff would permit listing some contribution for that nutrient. There are reasonable solutions to this specific problem.

Selection of the proper standard has been the subject of warm controversy. Unlike the negative labeling case, the lines are not clearly drawn. Almost all those knowledgeable in nutrition welcome the demise of the Minimum Daily Requirement values as hopelessly outdated. They also agree that a standard related to the Recommended Dietary Allowances (RDA) of the Food and Nutrition Board (Anon., 1968) should be used. But there the agreement ends. Should one or several standards be used? If one value is adopted, should it be a mean value, an average value or a single RDA value? If it is a single RDA value, should it represent the male or female? And if the adult value is selected, what about a standard for children? The possibilities are almost endless.

However when facing the basic issue -- understanding by consumers – a single value is favored by most of the nutritional community. This was the view of the original proposal – to select a single value for each nutrient from the 1968 RDA. Careful comparison will show that the values selected are very similar to the RDA of the adult male, except that an allowance has been added for vitamin D, and the calcium and iron allowances have been increased. The aim here was straightforward: It should not be necessary to go over 100% for the nutrient need of any individual not pregnant or lactating. These values are allowances, not *Minimum Daily Requirements*. The question arises what about children? Do they need these large amounts? No, in general they don't. But the housewife is used to serving larger portions to adults than those served to smaller children. This common practice then becomes a rather natural guide. It should be stressed that these are recommended optimums, but there is wide latitude before the rare case where toxicity occurs.

Then, the question arose, what should this standard be called? There also is considerable discussion over the proper method of referring to this standard. It is a complex question. The nomenclature should make it apparent to anyone using this standard that it is derived from the Food and Nutrition Board tables (Anon., 1968). Also, it is planned that this standard (whatever it is called) will be amended to coincide with any major changes in dietary allowances the Food and Nutrition Board makes. Similarity to RDA is necessary to show the origin of the standard, to give it proper standing in the nutritional community and to give the Food and Nutrition Board proper credit. Further, the nomenclature must be consistent with the proposals for special dietary foods.

I'm sure you are interested in the protein quality measures. From the many comments received, it is apparent that consumers in general fear that they will not be able to differentiate between what they believe is good protein and new protein sources. This fear must be dispelled; the development of new sources must not be impeded. It appears that some rough measure or definition of protein quality is needed.

Finally, many experts and officials express the belief that it is high time the Food and Drug Administration (FDA) got on with nutritional labeling. At the same time, several point out the necessity for allowance for change. This whole packet of regulations involves a massive change to the consumer and industry. It also requires a massive educational effort, for those doing the labeling as well as for those reading. Therefore, the process of labeling must be capable of improvement as history indicates necessary. This is the reason that, to many difficult questions there is a reasonable answer, if that answer can change to reflect the changing times.

Although not explicitly stated, the nutritional labeling proposal deals mainly with the "consumer" and retail packaging. However, as noted in the introduction, an increasingly large proportion of meals are eaten in restaurants, cafeterias or institutions. The diets of some of the people eating such meals are proportioned by dietitians. Effective food service organizations are familiar with the needs of these professionals and are improving their service accordingly. This leaves the other food service organizations with whom many of the seafood industry deal and whose labels generally "stop in the kitchen." What can they do? There is very little they can't do so long as their food products are clearly and correctly labeled within the spirit and meaning of the Federal Food, Drug and Cosmetic Act. This area has not been a major concern of the Nutrition Division of the FDA because the institutional "buyer" often is quite well informed. This is not always true of course. Further the specialist may feel much more pressure for excellence in flavor or functionality rather than nutrition. Certainly an industry must sell what its customers want. However, many restaurants offer a "diet special" – usually restricted in calories and high in protein. Awareness of nutrition is increasing dramatically -- the nutritional labeling proposal received over 3,100 replies. The use of nutrition to motivate sales also is increasing. The real value of such methods will depend upon the ingenuity and validity of the nutritional concepts on which they are based.

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Defrosting Shrimp With Microwaves

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INTRODUCTION

The fishing industry has paid a great deal of attention to rapid freezing in order to reduce quality losses and increase efficiency, and many innovations concerning cryogenic freezing have been developed. Conversely, very little has been done on defrosting applications, and the industry is still using procedures developed many years ago. Much of the U.S. seafood production is dependent on reprocessing, where bulk frozen products are defrosted and processed into consumer items. Fish portion and fish stick processors are required to temper fish blocks up to 20F for cutting operations. Layer-packed fillets must be partially defrosted for proper separation prior to processing, and scallops and shrimp must be completely defrosted for peeling and breading operations. These operations are usually carried out using tempering rooms, water defrosting systems, warm air systems and ambient air. In general, all of these require a large amount of labor and a great deal of time and space, creating problems in production scheduling and leading to quality losses and bacterial contamination problems.

In the shrimp industry, the most common defrosting procedure used is water defrosting. The frozen shrimp in 5-pound boxes are immersed in continuously overflowing tanks with 80F water for periods of 1 to 3 hours. This system often leads to product losses, high labor costs and sanitation problems.

In recent years, technologists have been researching new methods of defrosting and tempering for the fishing industry in an attempt to eliminate the warm air or warm water procedures.

When heat is applied to frozen fish, either by warm air or water or by radiant heat, the surface thaws first. The remaining frozen fish is then surrounded by thawed material having only about one-third the thermal conductivity of the frozen material; consequently the time necessary to thaw fish completely is much greater than that necessary to freeze it under similar conditions of surface heat transfer. Unfortunately thawing time cannot be shortened by subjecting the surface to high temperatures, for this could produce cooking, drying or deleterious effects upon quality.

For these reasons, much research has been carried out on electronic methods of defrosting such as dielectric and microwave heating. The basic principle of these procedures is similar. The frozen mass of material is placed in an alternating electrical energy field which causes individual molecules within the frozen

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material to oscillate with the alternating current. This results in molecular friction within the material generating heat. Since the heat is uniform throughout, great precision in heating can be achieved, and since thermal conductivity is not a factor the time of defrosting can be greatly reduced.

Researchers at Torry Research in Aberdeen (Jason and Sanders, 1962) have carried out extensive testing with fish at 35 mHz and Bengtsson (1963) has demonstrated the defrosting of both meat and fish at 35 and 2450 mHz. The results of these experiments indicated marked advantages over common defrosting procedures and some disadvantages concerning runaway heating and high capital cost for equipment. In general, the lower frequencies indicate a slower heating rate, and "arcing" problems occur, producing spot burning of the product. At the higher frequency, the depth penetration is limited, restricting product thickness. In 1969 the National Marine Fisheries Service (NMFS) with the cooperation of Raytheon Company carried out a series of defrosting and tempering experiments using 915 mHz (Learson and Stone, 1969). Results of these tests indicated that this intermediate frequency eliminated many of the problems previously reported for electronic defrosting. Using a 5 kw conveyorized microwave tunnel, blocks of clam meats, scallops, flounder and shrimp were uniformly heated to internal temperatures of 28-34F, allowing separation of the block for further processing. The most promising applications for the microwave system appeared to be the tempering of fish blocks for cutting applications and the defrosting of shrimp. Fish blocks could be heated from 0F to 15F very rapidly with a temperature differential of less than 3 degrees within the block. Five-pound blocks of frozen raw, headless shrimp were heated to 31 $\pm$ 2F at a rate of 50 lbs per hour per kw at which point semi-thawed shrimp were surrounded by the ice glaze. The block could then be broken easily by impact, releasing the shrimp for processing after removing the ice glaze with a water spray.

The following describes the continued research carried out on shrimp defrosting using microwave energy.

OBJECTIVES

In 1971 it is estimated that over 60 million pounds of raw, headless shrimp were defrosted for further processing in the United States, primarily in breading plants. For this reason, these experiments were conducted with raw, headless shrimp of the intermediate sizes used for breading. During this time, water-defrosting was the prevailing method used by industry. The purpose of this research was to compare quality and sanitation aspects of microwave versus typical industry water-defrosting procedures.

Laboratory tests and production-scale tests in a shrimp breading plant were conducted. Data were obtained on sanitation, quality and economic considerations for both water and microwave-defrosting. The following sets forth the procedures used and results obtained from these experiments.

LABORATORY TEST PROCEDURES

Water-defrosting experiments were carried out at the NMFS Atlantic Fishery Products Technological Center in Gloucester, Massachusetts. Corresponding studies on microwave-defrosting were conducted at the Raytheon Company Microwave and Power Tube Division, New Products Center in Waltham, Massachusetts. Raw, headless brown shrimp *(Penaeus aztecus)* of known history were used for the laboratory experiments. These shrimp were shipped in ice to the Gloucester Laboratory where they were then frozen and glazed in 5-pound cartons. They were held at 0F for 30 days prior to defrosting.

A stainless steel tank holding approximately 50 pounds of 65F water was used to defrost 10-pound batches of shrimp. Water was added periodically to maintain approximately 65F throughout the defrosting process.

The microwave defrosting was carried out in a 915 mHz conveyorized multimode applicator (Fig. 1). Duplicate samples were defrosted by both methods and were analyzed in comparison with a frozen control sample. Determinations of bacterial load and composition were carried out, and organoleptic comparisons were made using an experienced laboratory taste panel.

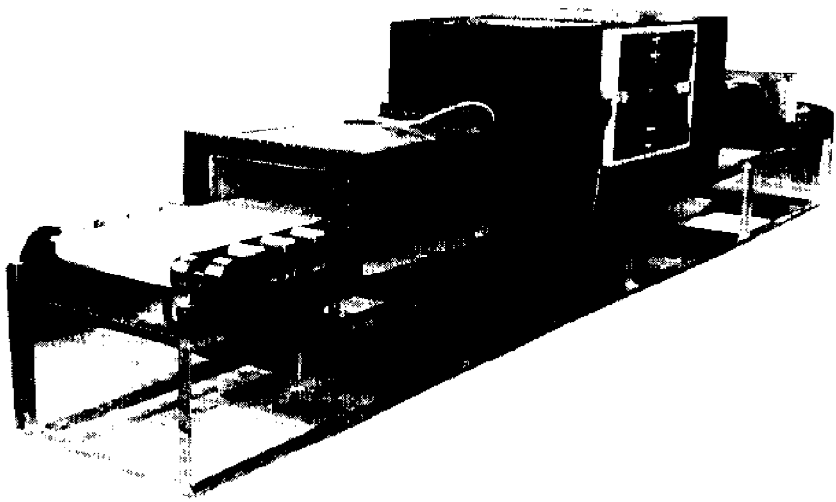

Fig. 1. Photograph of 5 kw microwave defrosting system.

LABORATORY TEST RESULTS

Bacteriological samples taken from the frozen control indicated a total plate count of 1.8×10^5. At the conclusion of microwave-defrosting and at the conclusion of a 2-hour water-defrost, the counts were identical to that of the control. A rapid spray wash with tap water reduced the count by one log cycle to 1.7×10^4 on the microwave-defrosted shrimp. Total plate counts on peeled meats defrosted by the two methods did not differ significantly. These data are summarized in Table 1.

Proximate analyses were carried out on the samples (Table 2). The microwave-defrosted sample did not vary significantly from the frozen control. However, the water-defrosted shrimp contained an average of 16.30% protein compared with 18.70% in the frozen control. The moisture/protein ratio of the

Table 1. Laboratory test – Bacteriological results for microwave vs water defrosted raw, headless shrimp (31-35 per lb)

Sample	Total Plate Count (number per gram)
Frozen control	1.8×10^5
Microwave-defrosted, no wash	1.8×10^5
Microwave-defrosted, spray wash	1.7×10^4
Water-thawed for one hour	7.7×10^4
Water-thawed for two hours	1.8×10^5
Water-thawed, peeled	7.2×10^4
Microwave-thawed, peeled	5.7×10^4

water-defrosted samples averaged 5.05 versus 4.32 for the frozen control and 4.34 for the microwave-defrosted.

Batches of shrimp defrosted by both methods were hand peeled, then cooked for a yield determination. These data are summarized in Table 3. Peeled yield of water-defrosted shrimp was 1.7% greater than the microwave-defrosted samples. However, the cooked yield was 4.5% greater for the microwave-defrosted shrimp. This result is attributed to the improved protein retention associated with microwave-defrosting.

Table 2. Laboratory test – Proximate composition of microwave vs water defrosted raw, headless shrimp (31-35 per lb*)

	Frozen control	Microwave-defrosted	Water-defrosted 1 hour	Water-defrosted 2 hours
% protein	18.70	18.60	16.05	16.55
% moisture	80.68	80.72	81.91	82.35
% fat	.134	.217	.220	.178
% ash	1.05	1.01	1.00	.80
Moisture/ protein ratio	4.32	4.34	5.10	4.97

*For analysis purposes the compositions are based on peeled meats

Table 3. Laboratory test – Peeled and cooked yield from microwave vs water defrosted raw, headless shrimp (31-35 per lb)

	Water-defrosted	Microwave-defrosted
Frozen raw, headless weight (g)	2267	2267
Peeled weight (g)	1828	1788
Peeled yield (%)	80.6	78.9
Cooked weight (g)	1468	1517
Cooked/peeled yield (%)	80.2	84.7
Cooked/frozen yield (%)	64.8	67.0

Taste panel evaluations using a triangle test format indicated that no significant difference could be attributed to either defrosting method.

PRODUCTION TESTS

The 5 kw microwave system used in the laboratory tests and illustrated in Figure 1 was installed in a shrimp breading plant and operated for 11 days. During this time 16,010 pounds of raw, headless shrimp of various sizes were microwave-defrosted (Table 4).

The optimum flow condition was found to be 350 pounds per hour at 5 kw. Typical shrimp temperatures at the tunnel exit ranged from 28.5F to 30F, while input temperatures ranged from 5F to 17F. It was possible to achieve separation of individual shrimp at flow rates up to 450 pounds per hour (26F) but those shrimp required considerable additional heat input before they became suitable for peeling.

Conversely, flow rates as low as 250 pounds per hour were tested in order to try to raise the temperature of the shrimp above 30F. However this resulted in

Table 4. Production test – Type and quantity of raw, headless shrimp defrosted with 5 kw microwave tunnel

Size	Type	Origin		Quantity (lb)
26-30	White	Texas		1,800
31-35	White	Colombia		1,210
36-40	White	Colombia		2,950
41-50	White	Colombia		2,400
40-50	Brown	Louisiana		1,200
51-60	Pink	Mexico		6,450
			TOTAL	16,010

some spot overheating of shrimp. This condition was attributed to three factors: (a) defrosted shrimp absorbs microwave energy faster than frozen shrimp, (b) substantial temperature gradients existed in shrimp blocks entering the tunnel and (c) the tunnel used in the tests was subsequently found to have an energy gradient, so that more energy was applied to the sides of the shrimp blocks than to the center portion.

It was found that the microwave energy had little effect on the glaze ice. At all flow rates, a matrix of ice surrounded the partially-defrosted shrimp upon exit from the tunnel. This ice matrix could be easily broken into small fragments by impacting the carton once on a flat solid object. Careful inspection to determine whether this impact had any adverse effect upon the shrimp, such as broken tails, indicated no damage to the shrimp. Shrimp that were lightly glazed (Colombian, poly-lined cartons) could be separated without impacting. Shrimp mixed with as much as 2-pounds of glaze ice (Mexican, pan-frozen) could be separated effectively after impacting the carton on its large side.

Bacteriological samples were not obtained during the production tests, but some general observations relative to water-defrosting were made. First, it was not possible to completely remove the carton from frozen shrimp, so the exterior packaging material normally accompanied the shrimp into the defrosting tank. This could lead to cross-contamination of the entire contents of the defrosting tank. Second, the temperature of the tap water was approximately 80F and this

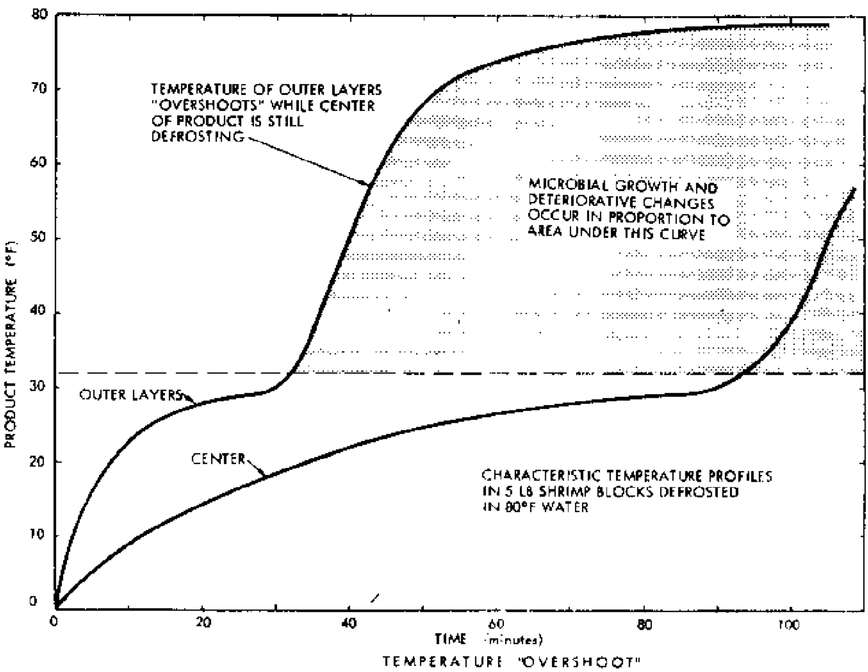

Fig. 2. Temperature overshoot curve.

temperature was maintained during most of the defrosting process. Typical time-temperature profiles in the water-defrosted shrimp are shown in Figure 2.

Proximate analyses were carried out on samples defrosted under production conditions by both methods. These results are set forth in Table 5. As reported in the laboratory tests, the water-defrosted shrimp consistently contained less protein than the microwave-defrosted. Moisture/protein ratios were also higher in the water-defrosted samples.

Loss of protein during water-defrosting was further investigated by sampling the defrosting water. Figure 3 shows this protein-leaching effect. Soluble protein in the water was found to increase steadily throughout the 4-hour test.

Shrimp defrosted by both methods were subjected to informal taste tests at the plant. For both boiled and fried breaded samples, the panelists indicated a preference for the microwave-defrosted shrimp. A "sweet" flavor was attributed to microwave-defrosted samples versus a "bland" flavor for water-defrosted shrimp.

During the production tests, a number of attempts were made to obtain comparative yield data for the two defrosting methods. Based on composition difference, one might expect that microwave-defrosting would improve yield at least 1% over water-defrosting. The value of a 1% gain in yield could exceed $150,000 per year in a large shrimp breading plant. Conclusive data were not obtained, however, because of excessive variables and difficulties encountered in making accurate measurements under production conditions. For example, suc-

Table 5. Production test – Proximate composition of microwave vs water defrosted raw, headless shrimp*

	Louisiana brown 40-50 count	Louisiana brown 40-50 count	Colombia white 41-50 count	Colombia white 36-40 count
% protein (water defrosted)	16.57	17.13	16.68	15.54
% protein (microwave-defrosted)	18.66	17.80	17.49	16.36
Protein difference (% of total weight)	2.09	.67	.81	.82
Moisture/protein ratio (water-defrosted)	4.97	4.76	4.93	–
Moisture/protein ratio (microwave-defrosted)	4.28	4.53	4.65	

*For analysis purposes the compositions were determined from peeled meats

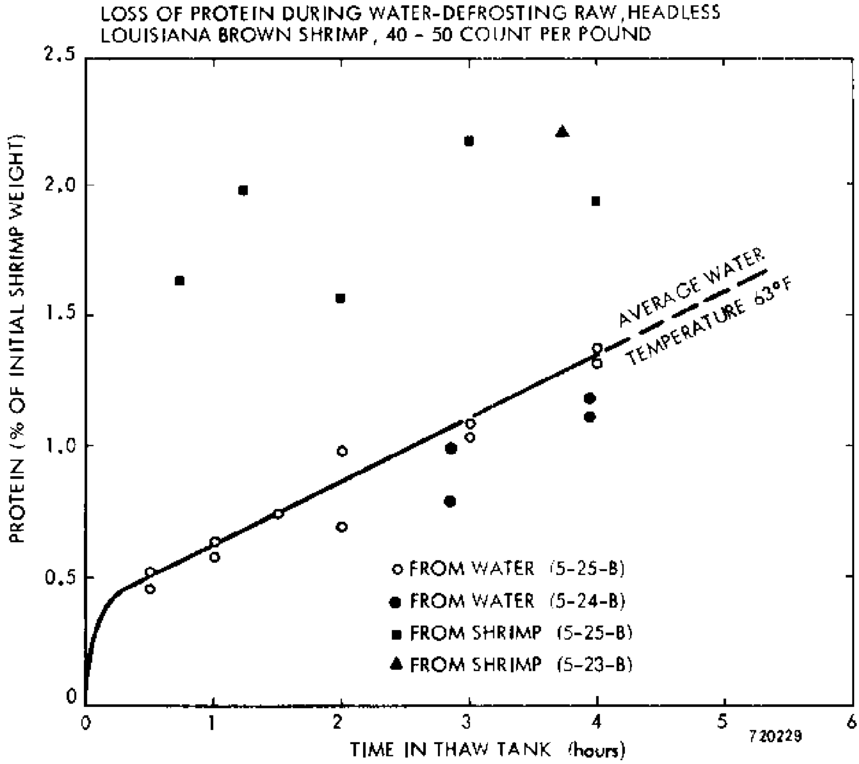

Fig. 3. Loss of protein vs time.

cessive tests on shrimp from the same lot, defrosted and handled under identical conditions, showed production yield differences of 3%.

The only significant measure of yield that is relevant for this analysis would compare the weight of the frozen raw, headless shrimp versus peeled or breaded weight. However, frozen weight is indeterminate because all frozen raw, headless shrimp contain glaze. Therefore, label weights must be used. Accordingly, an experiment was conducted to determine true frozen weights in one lot of Mexican, pan-frozen shrimp. Individual 5-pound boxes were microwave-defrosted, drained and weighed under uniform conditions. The standard deviation in the individual weights was ± 3.3%, and distribution was not normal in the sample measured (28 boxes). Therefore, a large number of comparative tests would be required to establish statistical validity.

Drained weight of raw, headless shrimp is also of little significance since it was shown that defrosted shrimp lose weight continuously with time. Also, since water-defrosting significantly alters the composition, there may be differences in the physical properties of water and microwave-defrosted shrimp. This could affect the subsequent peeled yield, especially when machine peeling is employed. In similar studies on herring defrosting, Jason and Sanders (1962) reported yields, after subsequent processing, of 88% for electronic-defrosted herring versus 68% for water-defrosted samples.

It proved to be very difficult to follow individual lots of shrimp through the peeling stage and obtain accurate weight measurements under commercial conditions. Mechanical adjustments of the peeling machine and variable residence time of peeled shrimp in water were two variables contributing to differences in peeled yield. If an attempt had been made to measure yield differences on the basis of breaded weights, even more variables, such as breading percentage, would be introduced. When these factors became apparent, no further attempts were made to measure comparative production yields.

Table 6. Comparison of defrosting and drip loss costs[1] for processing frozen shrimp[2]

	Air		Water		Microwave	
			OPERATING COSTS			
Initial investment	1.00		.18		3.12	
Operation & maintenance	1.00		1.00		1.50	
Space cost	1.50		.12		.20	
Inventory cost	1.00		–		–	
Labor cost	6.00		4.00		4.00	
Icing cost	2.00		4.00		–	
Water cost	–		.30		.02	
Water disposal cost	.15		.45		.03	
Subtotal of Operating Costs		12.65		10.05		8.87
			EFFECT OF YIELD			
Drip loss (estimated)	4%		3%		2%	
Cost of drip loss	60.00		45.00		30.00	
Total Operating & Effect of Yield Costs		72.65		55.05		38.87
Cost Difference		33.78		16.18		–
Annual Savings from Microwave ($)		101,340		48,540		–

[1]Costs in $ per 1,000 lbs. of shrimp

[2] Based on 3 million pounds annual production

ECONOMICS: AIR, WATER AND MICROWAVE-DEFROSTING

Ambient air and forced warm air defrosting are commonly used at the present time, especially for block-frozen peeled shrimp. The great advantage of this method is that little or no investment is required. However, the resultant time-temperature profiles in shrimp defrosted by this method contribute to high drip loss and unsatisfactory sanitary conditions. The Food and Drug Administration's Good Manufacturing Practice (GMP) guideline for raw breaded shrimp indicates that air defrosting should not be carried out above 45F. Defrosting in chilled air is common in the meat industry where procedures are closely regulated. However, this is a very expensive method from the standpoint of operating costs. If the material to be defrosted is left on pallets, a week or more may be required to defrost the interior cases. This is not a desirable practice from the standpoint of quality and sanitation. Furthermore, the value of the product tied up in inventory and the space required generate high operating costs.

Normally, the product to be defrosted in chilled air is set out on racks to permit circulation. The time required is dependent on spacing and air flow, but typically may be 2 days for shrimp. This method is also attended by high operating costs for space and inventory. In addition, there is a significant labor factor in setting out shrimp cartons on racks and cleaning racks before they are reused. Although the outer layers of shrimp are held under 45F, they are likely to undergo considerable drip loss during the time required for the center portion to defrost. In Table 6, an estimate of $12.65 per 1,000 pounds is given as the cost of defrosting by this method. The writers estimate that this method would result in an average drip loss of 4% which would add approximately $60 per 1,000 pounds to the defrosting cost. Table 6 also contains an analysis of operating cost for a water-defrosting system. This method is less costly ($10.05 per

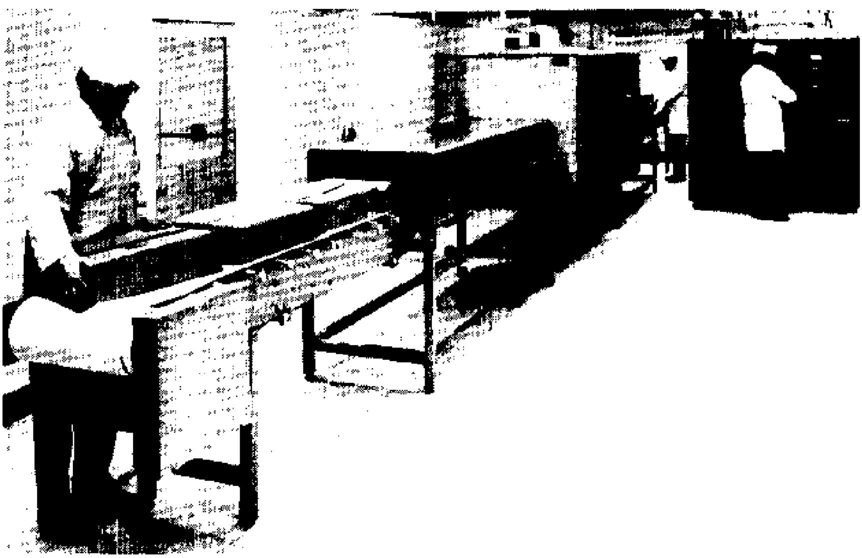

Fig. 4. Photograph of 25 kw microwave defrosting system.

1,000 pounds) than air-defrosting. Water-defrosting results in higher product temperatures, as shown in the "temperature overshoot" condition illustrated in Figure 2. This in turn generates a requirement for careful icing. The cost of this ice, and the labor of applying and later removing it, make a substantial contribution to overall operating cost. Also, the pressure created by this ice may induce shrinkage. Drip loss varies among types of shrimp, method of freezing, conditions of storage, etc., but the writers estimate 3% as an average for water-defrosting. This would add about $45 per 1,000 pounds to the total defrosting cost.

An analysis is also presented in Table 6 for microwave-defrosting with a production model 25 kw conveyorized system.[4] A typical system used in the meat industry is illustrated in Figure 4. This equipment has a higher initial cost than air or water systems, equivalent to $3.12 per 1,000 pounds defrosted, when amortized over 8 years at 3 million pounds per year. However, the total operat-

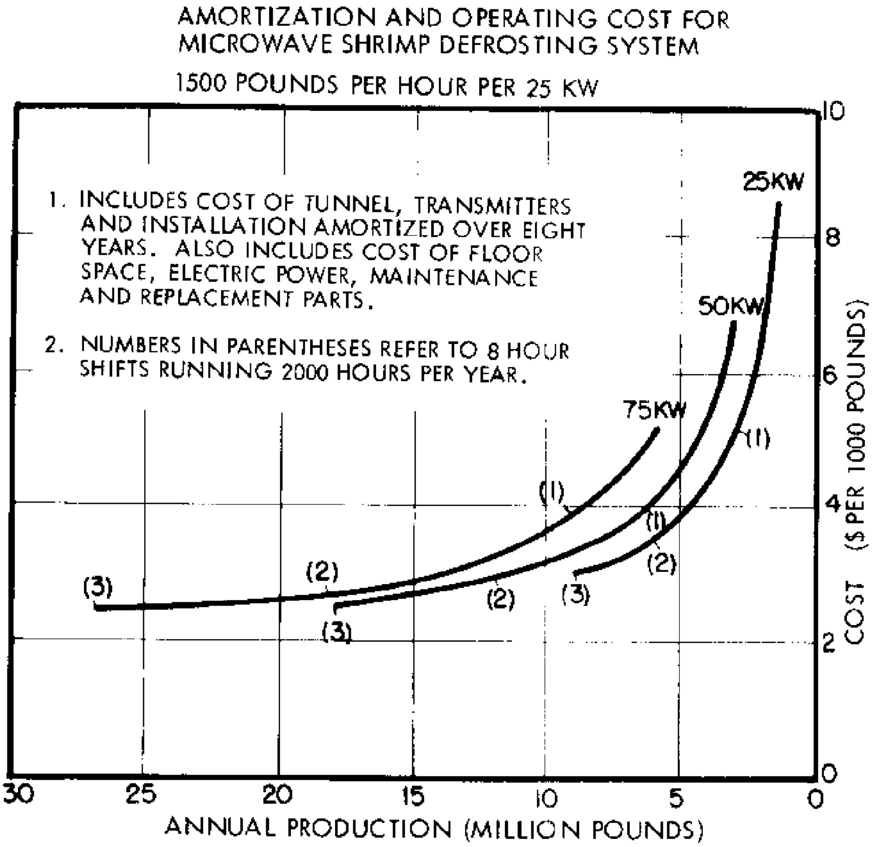

Fig. 5. Operating cost of microwave system.

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[4] Continuous flow tempering tunnel Model QMP 1679, Raytheon Company, Microwave and Power Tube Division, Foundry Ave., Waltham, Massachusetts 02154

ing cost is $8.87 per 1,000 pounds, which is less than either air-or water-defrosting. The writers' estimate of drip loss for a microwave system is 2% or $30 per 1,000 pounds. Additional operating cost data are shown in Figure 5. For a 3 million-pound-per-year plant, it is estimated that a microwave system would save $48,540 per year compared with a water-defrosting system and $101,340 per year compared with a chilled air-defrosting system.

CONCLUSIONS

It is concluded that microwave defrosting is particularly suited to the defrosting of raw, headless shrimp for the following reasons: (1) Microwave defrosting would allow compliance with the present GMP guideline for raw, headless shrimp regarding the requirements of temperature and packaging removal. (2) There is improved production control resulting from rapid in-line processing. (3) Water usage is reduced substantially alleviating waste disposal problems. (4) Defrosting takes place within the carton eliminating the need to remove the carton and increasing handling efficiency after thawing. (5) Ice requirements are reduced because there is no "temperature overshoot." (6) Bacteriological control and quality control are improved. (7) Wholesomeness, as evidenced by moisture/protein ratio, is retained. (8) Total defrosting cost is reduced compared with air or water defrosting.

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Rock Shrimp Quality as Influenced by Handling Procedures[1]

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INTRODUCTION

The shrimp processing industry in Florida represents greater than 70% of the total economic value of Florida's processed seafoods. In recent years, however, the volume of shrimp landings in Florida has decreased (Anonymous, 1972); consequently processors are relying heavily on imported shrimp to meet consumer demands.

Increasing demands for shrimp products have caused the commercial exploitation of *Penaeus* shrimp to approach optimal levels, and interest in harvesting other types of shrimp has been renewed. Rock shrimp *(Sicyonia brevirostris)* is a member of the family Penaeidae but possesses a tough ridged outer shell that until recently has been difficult to process mechanically. The characteristic flavor of fresh rock shrimp is similar to that of spiny lobster. Data concerning commercially exploitable concentrations of rock shrimp indicate that several promising areas are located in Florida coastal waters (Cobb, 1971). Recent innovations in machinery design have made commercial processing feasible. In 1971, 360,000 lbs of rock shrimp were landed, compared to less than 3,000 lbs in previous years (U.S. Dept. Commerce, 1971).

Little information is available concerning handling, storage and keeping quality of rock shrimp. Traditionally, penaeid shrimps have been headed prior to iced storage, based on the observation that this practice effects a significant reduction in microbial load. The head of freshly landed shrimp carries approximately 75% of the microbial load while representing only 40% of the total weight (Fieger and Novak, 1965). Thus, heading will lower the initial total microbial count; however, spoilage organisms are found in the surface slime layer and in the intestine as well. During iced storage, the psychrophilic spoilage organisms multiply rapidly causing degradation of protein which results in the production of off-flavors and odors. Heading the shrimp prior to storage exposes tissue, causes the content of the gut to spill and triggers enzymatic changes. This process causes a larger portion of the tissue to be available for microbial attack. Thus, if a long storage period is anticipated these consequences should be considered.

Some commercial fishermen have thought it necessary to head and freeze rock shrimp within 24 hours of catch to prevent rapid quality deterioration. Significant structural and biochemical differences between soft shelled and rock

[1] Florida Agricultural Experiment Station Journal Series No. 4708

shrimp indicate that different handling practices may be required. This study monitored changes in certain quality determinant parameters and also provided information concerning the spoilage pattern of rock shrimp.

METHODS

Rock shrimp were obtained from both the Cape Canaveral area and from Apalachicola, Florida. The shrimp were shipped to Gainesville in ice, and analyses were started within 36 hours of catch. Approximately half of each shipment was headed before storage. The shrimp were washed in cold tap water, placed in baskets, iced and stored at 35F for the remainder of the experiment. Analyses were performed at 48-hour intervals.

Samples for bacteriological analysis were prepared by homogenizing 50g of shrimp with 450 ml phosphate buffer (pH 7.2) for 2 minutes in a Waring blender. This homogenate was used to inoculate the following media: standard plate count agar (SPC), nutrient agar containing 0.5% gelatin for enumeration of proteolytic organisms, trypticase soy broth containing 10% sodium chloride (10% TSB) for staphylococci and lauryl sulfate tryptose broth (LST) for coliforms.

Total plate counts were conducted using the serial dilution technique. Pour plates were prepared with SPC agar and gelatin agar using 1 ml aliquots of the buffered homogenate. Duplicate SPC plates and gelatin agar plates were incubated at 22C for 5 days. Analyses for coagulase positive staphylococci and coliform organisms were conducted using the AOAC methods (Association of Official Analytical Chemists, 1970).

Samples for total solids and protein analyses were prepared by grinding approximately 200g of shrimp, including shells, in a Hamilton Beach meat grinder with a 5/16 inch plate. Total solids and total Kjeldahl nitrogen were determined using AOAC procedures (Association of Official Analytical Chemists, 1970).

The ice melt (drip) from 500g of shrimp and 1 kg of ice was collected in a 4l beaker. Mercuric chloride was added to retard microbial growth. The solids content of the drip was measured by weighing the residue from evaporation to dryness of duplicate 10 ml aliquots at 105C. Protein content of the drip solids was estimated by ninhydrin analysis (Denman and Diamond, 1966).

The change in the gross weight of the shrimp during storage was also monitored. Numbered tags were attached to the tails of the shrimp. Excess moisture was removed from the surface of the shrimp with absorbent paper. The weight of each individual shrimp was recorded. Twenty headless and 20 heads-on shrimp were used for this measurement.

Organoleptic evaluation of the shrimp after 1, 7 and 14 days was accomplished using a 15 member panel. Samples for use in the taste panels were prepared by splitting the shrimp through the belly, removing the legs, deveining, flattening and washing. Shrimp were then electric oven broiled for 4 minutes and presented to the panelists. The samples were coded using random numbers. Four shrimp, 2 heads-on and 2 headless were used in each trial. A hedonic scale from 1 to 9 was used, with 9 being assigned the most acceptable. Taste panel scores were evaluated using analysis of variance.

RESULTS

The data presented in this paper are representative of the information obtained in the five studies conducted. The results of initial analyses indicated that the microbial quality of the fresh rock shrimp was acceptable according to current industrial microbiological guidelines. The level of indicator organisms was also within these limits.

Initial aerobic plate counts were slightly higher for the heads-on shrimp. However, by the second day a reversal of this situation had occurred. As seen in Figure 1, the counts for the headless shrimp increased initially at the faster rate and remained higher throughout the rest of the storage period. The rapid increase in the number of proteolytic organisms in the headless shrimp during the fourth to eighth day of storage is also of particular interest. Coagulase positive staphylocci were not isolated from these samples. The level of total coliform organisms varied among the samples from < 3.0 to 1100 org/gram. These counts decreased during storage.

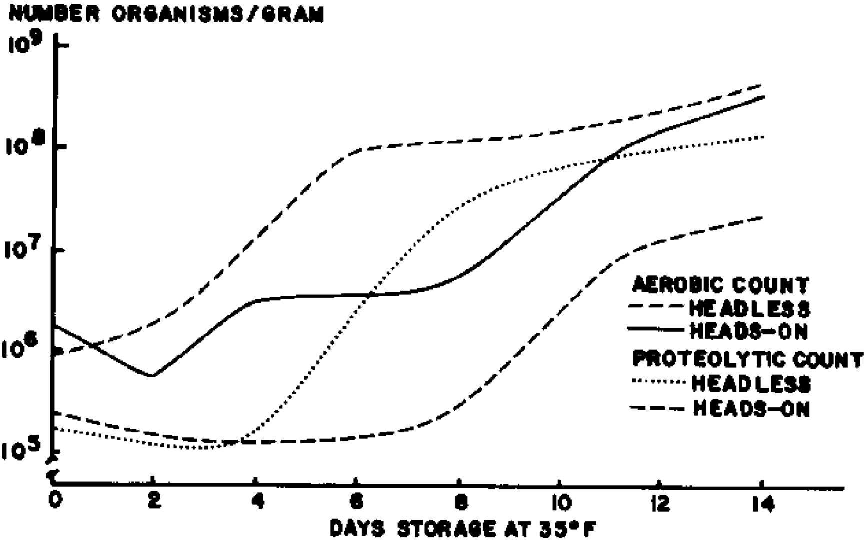

Fig. 1. Growth of microorganisms on iced rock shrimp.

The loss of total solids occurred at a more rapid rate in the headless shrimp as seen in Figure 2. The shrimp stored with the heads-on maintained a solids level that was as much as 2% higher than that of the headless shrimp during the prime quality period. Proximate analysis of fresh rock shrimp indicates the following composition: moisture, 75%; protein, 16.5%; lipid, < 0.1%; ash, 5.5% and carbohydrate, 1% (by difference).

Monitoring of weight gain, loss of solids and water uptake provided a description of the events occurring during storage. These measurements, which it is recognized are empirical in nature, are represented graphically in Figure 3. During the time in which the total solids decrease sharply, a concomitant increase in weight due to water absorption is observed. Also, within the time of maximum

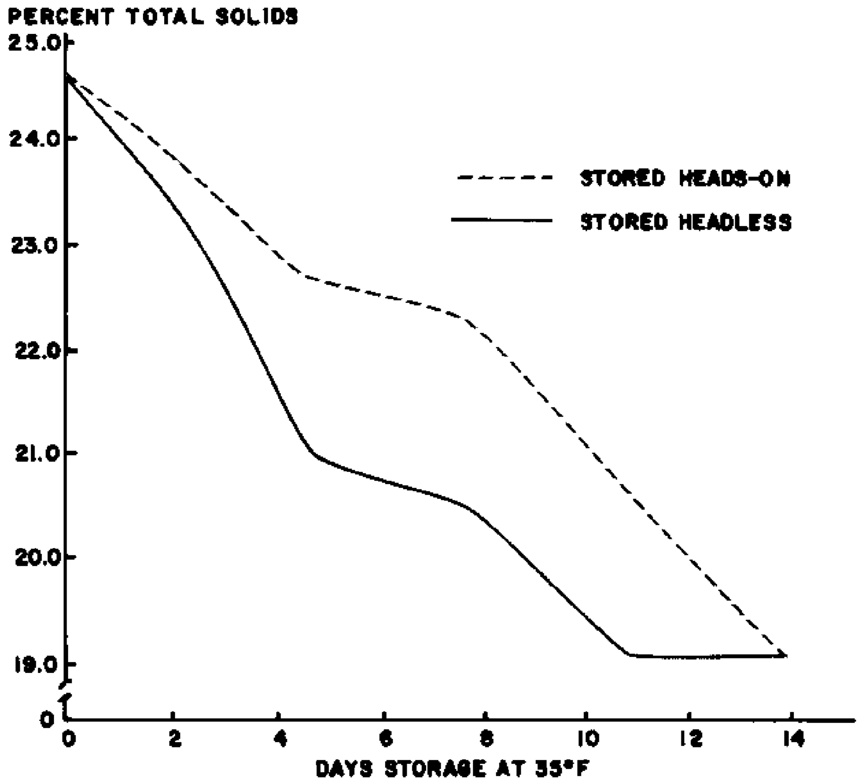

Fig. 2. Observed changes in total solids of rock shrimp during storage.

compositional change the accelerated bacterial growth phase occurs, and loss of soluble material is rapidly taking place. Analysis of material in the drip throughout storage indicated that it was 80 to 90% protein.

Taste panel data are presented in Table 1. Shrimp stored with heads-on received higher scores from the panelists throughout the 14 days of storage with significant (P $<.10$) differences noted for flavor and overall preference.

DISCUSSION

The handling of rock shrimp prior to iced storage plays a significant role in their keeping quality. From data presented in the microbiological analyses, it appears that heading these shrimp prior to storage will effect a more rapid increase in the number of spoilage organisms. It is of some significance that, upon extended storage, proteolytic organisms comprise a greater proportion of the total population in headless than heads-on shrimp. It was also observed that, during iced storage, the heads of rock shrimp darkened rapidly; however, the flesh was not affected appreciably. In stored headless shrimp, exposed flesh often becomes discolored within a few days storage, markedly affecting their appearance.

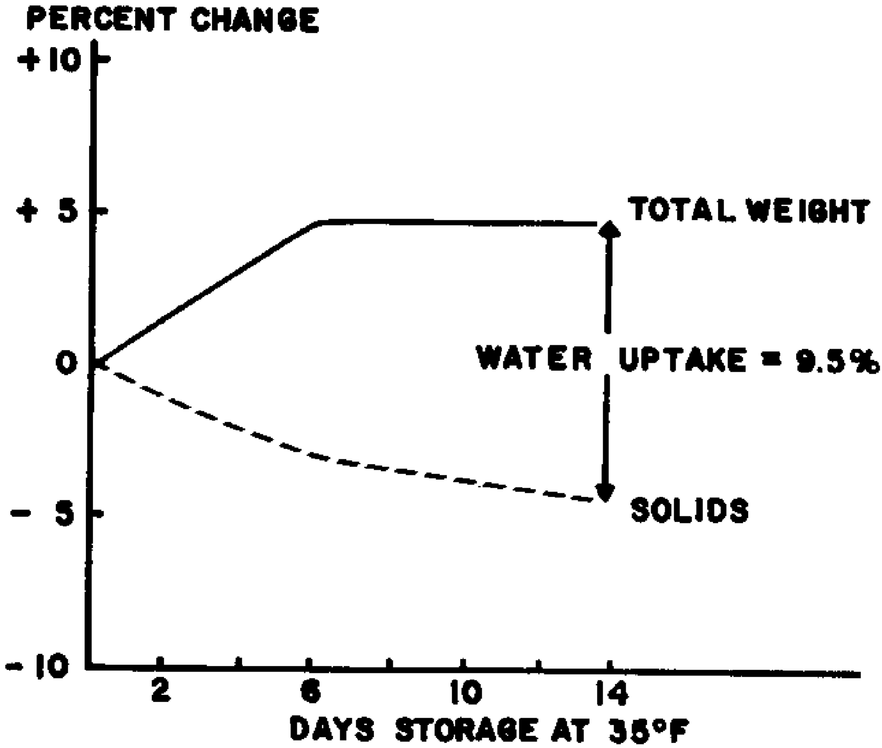

Fig. 3. Summary figure for weight change in headless rock shrimp stored in ice.

The decrease in total solids is the result of both leaching of soluble protein and water uptake by shrimp protein. As shown in Figure 3, the apparent increase in weight due to water uptake amounted to approximately 5%. However, when solids loss is subtracted there is in reality about a 9.5% water uptake. Drip solids accounted for about 95% of the actual solids weight lost from the shrimp. This could be calculated from both total solids data and solids recovered in drip. Inherent error in these measurements makes accurate calculations difficult; however, it has been demonstrated that an actual loss of solids does occur and is associated with storage time and microbial growth. The level of solids present in shrimp is a parameter that reflects many of the changes that have occurred during storage and may be a rapid means of determining relative quality. Since the magnitude of change is dependent on the combined actions of microbial and enzymic alterations rather than being a selective indicator, it may prove useful as a rapid check of quality. Unpublished data on studies conducted on other species of shrimp indicate that the simplicity of the solids determination test may lend itself to use within the industry.

A significant difference in flavor and in overall acceptability between headless and heads-on shrimp could be detected by the panelists. This consistent preference for rock shrimp stored with heads-on supports other trends presented in the study.

Table 1. Mean sensory panel scores for rock shrimp stored in ice with heads-on and heads-off.[1,2]

Storage (days)	Texture on	Texture off	Flavor on	Flavor off	Overall on	Overall off
1	7.7	7.4	7.2	6.7	7.2	6.9
7	6.9	6.8	6.5	5.8	6.6	6.0
14	5.5	5.0	4.2	3.8	5.3	4.7
Mean	6.7a	6.4a	6.0a	5.4b	6.4a	5.9b

[1] Mean scores for each attribute followed by the same letter do not differ significantly at ($P < .10$).

[2] Scale: 9 = like extremely, to 1 = dislike extremely

SUMMARY AND CONCLUSION

Rock shrimp, when stored with heads-on, had lower total counts, fewer proteolytic organisms, maintained higher solids content and greater organoleptic acceptability. When headless shrimp were evaluated, using these parameters, they showed a pattern of more rapid quality deterioration. From these findings, it can be concluded that storing rock shrimp with heads-on prior to processing within reasonable time limits tends to aid in quality retention rather than accelerating quality deterioration.

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An Innovative State-Federal Concept In Managing Fisheries Resources

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Today I am going to talk about the State-Federal Fisheries Management Program being developed by the National Marine Fisheries Service (NMFS) in cooperation with the states. Over the past year and a half, the program concept has been discussed at the annual meetings of the Atlantic States Marine Fisheries Commission, American Fisheries Society, Gulf States Marine Fisheries Commission, International Association of Game Fish and Conservation Commissioners, National Fisheries Institute, Pacific Marine Fisheries Commission and other organizations.

As Congressman Downing stated yesterday, this program is intended to enhance cooperation between the states and the federal government. Also, the program is designed to assist the states in the development and implementation of management plans for various fisheries. With input from the states, industry and other user groups, the program has been modified considerably since its inception.

The basic recurring theme in the relationships between the coastal states and the federal government, as they relate to marine fisheries, is that of uncertainty -- uncertainty as to jurisdictions, uncertainty as to obligations and uncertainty as to responsibilities. Actually, there is additional uncertainty in many of the fisheries, uncertainty as to the amount of domestic and foreign fishing effort and uncertainty as to what amount of fishing pressure many of our fisheries can withstand.

Traditional concepts are of little value today as we seek solutions to management problems created by significantly increased fishing effort and modern fishing techniques. For many years the states have been concerned with attempts to manage fisheries resources whose natural migratory paths transcend state and federal boundaries. Now this issue is being confronted in a way which is as unexpected as it is dynamic; as novel as it is consistent with today's realities. This approach is prompted by recognition of the responsibilities the federal government shares with the states for fisheries management. The states' responsibilities, conveyed by Title II of the Submerged Land Act of 1953, do not extend beyond the territorial seas except to govern its own citizens on the high seas.

The federal responsibilities are much broader and are grounded in the unique overall relationship created by our system of federal government. The federal interest comes from a recognition -- long implicit, more recently explicit -- that there is a direct federal interest in certain fisheries and the resources upon which they are based. Viewed another way, the time has come to acknowledge one fundamental truth in our thinking about fisheries management. It is that the states and the federal government do not occupy polarized positions on fisheries management. The federal interest and the state interest are not mutually exclusive. We see the respective roles of the states and the federal government in fisheries management as being entirely complementary.

The Office of State-Federal Relationships in NMFS was established to provide a focal point at which the creative abilities of the states and the federal government could be coupled to develop synergistic and truly dynamic fisheries management systems. Applied to certain resources, these systems would function for the ultimate benefit of the states and for the citizens of the United States.

We are breaking new ground. In addition to the partnership concept already mentioned, we are exploring innovative management systems which take into account not only the biological requirements of the resources, but the economic and social well-being of people dependent upon those resources for recreation and livelihood. This means that, in addition to concentrating on the biological imperatives, we must also identify and work toward optimum social satisfactions in each such fishery. This represents a sharp break from past management practices.

We no longer believe that we can fully discharge our responsibility by solely insuring the survival of certain living marine resources. Too often we have permitted the fishermen to fend for themselves within the constraints devised by fisheries managers. It is clear that the former policy has often resulted in marginal incomes, depletion of resources, allocation and jurisdictional conflicts, and the squandering of economic resources that could have been more profitably employed elsewhere in our economy.

Some state fisheries administrators have expressed concern that the federal government is preparing to preempt state control in the territorial seas. Both Director Roedel and I are keenly sensitive to this concern. Both of us have held responsible positions in state fisheries management programs and we well know how some states might view such a federal initiative. It would not likely meet with broad acceptance – nor should it necessarily. The states are in a position to make management decisions which, for good or ill, will impact upon recreational opportunities for thousands and in some cases hundreds of thousands of saltwater anglers – and affect the incomes and well-being of commercial fishermen, shore workers and others engaged in supporting industries.

In the main, such decisions tend to have strong political overtones. Where the resource is only of local importance, we would contend that the federal responsibility, if any, is not as great. However, in those instances where the resource transcends political boundaries, where decisions taken by one state impact upon neighboring states, where international competition exists or where marine fisheries products significantly enter interstate commerce, the federal government's responsibility to all citizens of the United States becomes paramount. It is here that shared decision-making becomes imperative. It is in these circumstances that the state-federal partnership program comes into play.

A cardinal tenent in our thinking is that any management plan likely to provide the social and economical benefits that we believe should accrue must embrace the complete geographic range of the resource. In those cases where the resource is exploited by foreign fishermen on the high seas, it may be essential that appropriate allocation systems be devised by quota or otherwise to insure that United States fishermen derive appropriate benefits from the management system.

I should point out, however, that there is an often overlooked aspect to this problem of international allocation. It is one thing for us to go to a foreign government asking for controls on their fishermen when we have no management plan of our own; it is another when we have an established system and can show that the foreign intrusion is jeopardizing that system. I don't mean to overstate this point – in some cases it might not make any difference at all – but a fishery under sound domestic management lets the other fellow know that we attach considerable importance to that particular fishery.

It is obvious, in my judgment, that any management plan must be based upon sound scientific evidence. Unfortunately, in too many cases, this evidence has not been sufficiently developed and serious data gaps exist largely because we have failed to invest the monies necessary to obtain the desired information. We now realize, however, that we can no longer afford the luxury of waiting until all the known gaps are filled before developing management plans. Events are moving much too fast. Fishing effort proliferates and more and more fisheries become depleted. Foreign competition both on the fishing grounds and in the market place is intensifying. This means that we must develop our plans with existing data and be prepared to modify them as new information becomes available. This, in a way, underscores the inherently dynamic character of the marine fisheries in the last quarter of the 20th century.

It is our hope that data needs can be filled in part by another related state-federal program utilizing grants under the Commerical Fisheries Research and Development Act (Public Law 88-309), recently extended, and the Anadromous Fish Act (Public Law 89-304). We believe that grants-in-aid authorized by these acts should be directed whenever possible toward obtaining knowledge required to the continuing refinement of management plans. This will mean that the states will be in a much stronger position, either singly or cooperatively, to perform their management responsibilities.

Among the goals we have identified in the State-Federal Fisheries Management Program are: (1) resource protection from natural or man-related depletion; (2) the development in time of management systems for at least all major fisheries; (3) the allocation of resources between competing users; (4) improving interstate and federal cooperation where a common stock ranges across state or federal boundaries; and (5) identifying appropriate social and economic gains from resource utilization by taking an integrated multi-disciplinary approach to management.

Much remains to be done. We are presently engaged in the cooperative development of a multistate management plan for the American lobster from North Carolina to the Canadian border. At almost the same time a similar plan – again of a multistate character -- is being worked out on the west coast for Dungeness crab. Other fisheries are being evaluated on a priority basis in the NMFS Regions by the states in cooperation with our Regional Directors. Simultaneously, research into the social and economic returns from a number of fisheries is being conducted. We hope to discover what reasonable potentials may exist, but which have not been realized because of defects in past and present management systems.

These defects are widely recognized. In general, they stem from two basic root causes. I have already touched on one of these – the problem which the Stratton Commission termed "splintered jurisdiction." It is here that the most cogent argument can be made for the recognition of an independent national interest in marine fisheries, whether recreational or commercial or both.

However, there is a second and perhaps equally compelling problem to be faced. Fisheries resources are not inexhaustible. Unfortunately, it seems to us that the willingness on the part of far too many people to commit economic resources to the utilization of our limited marine resources may be endless.

The plain fact is that in nearly every fishery – not all but certainly most – the earnings of fishermen and other segments of the industry are slowly but surely being eroded simply because too many people with too much gear are competing for limited resources.

It has been suggested that one solution would be to improve the environment – to increase, through biological or environmental manipulation, the productivity of a given fishery resource. In the short run, an increase in productivity will obviously generate better recreational opportunities and greater earnings. But as surely as night follows day, a seemingly inexorable expansion of effort will invariably be attracted into such a fishery until the newly enlarged resource base is again in distress through overexploitation and other factors.

A rational way of approaching this problem, as we see it, is by developing controls on access to the resource – by limiting entry to the fishery where such limitation is needed and seeking ways of reducing current levels of effort without interfering with efficiency when such a reduction is clearly indicated.

It is difficult – but not impossible – to meet the philosophical arguments against limited entry. We have heard it said that the commercial fisheries are almost the last bulwark of the free enterprise system that has so greatly contributed to the strength of the United States. The argument runs that any United States citizen has an inherent right to invest where he wants to – and to go broke if he must.

This argument breaks down, however, in those cases where the additional investment causes economic hardship to all previous investors. And this is the heart of the matter. If the impact of each subsequent investment fell only upon that investor, a state of equilibrium would soon be achieved, as tends to be the case in other fields of economic activity.

Precisely because this does not – indeed, cannot – occur naturally in the fisheries under our present open entry system, it is absolutely essential that ways be devised so that the fishing industry becomes more closely analogous to other industries in our society.

So much for philosophy. We propose to translate concepts into an action program through a series of carefully designed steps: (1) Discussions (currently in progress) between state and federal experts for the purpose of selecting fisheries on a priority basis in need of management. These discussions would take place while key individuals in the various user groups would be kept informed on the discussions taking place; (2) Creation of policy and technical committees for each such fishery to be managed. The policy committee would be composed of state and federal fisheries administrators while the technical committees would be composed of a mix of scientists and technicians. We are presently involved in such committees in the New England region for American lobster and are beginning this phase on the west coast for Dungeness crab; (3) The committees would consult further with various user groups for the purpose of developing optimum – and practical – management goals and practical plans for achieving these goals; (4) The policy committee would have primary responsibility for selecting that management plan which would best achieve identified goals; (5) The management plan would be cooperatively implemented by the states and the federal government with financial support through federal management grants of up to 100%.

Once policy committees for developing and implementing high priority fisheries management plans are created, we anticipate that federal funding under this program would be available for: (1) evaluation of existing regulations from the standpoint of biological and socio-economical factors; (2) collection and analysis of additional information needed for solving the two root problems I have already mentioned; (3) further development and implementation of management plans; and (4) continued improvement of regulations and their enforcement.

During the past 2 years, approximately 14 contracts dealing primarily with the socio-economic aspects of fisheries management have been granted to state agencies and various universities. The three interstate marine fisheries commissions (i.e., Atlantic States Marine Fisheries Commission, Gulf States Marine Fisheries Commission, Pacific Marine Fisheries Commission) have received small contracts for the purpose of improving communication and coordination between the states and between the states and the federal government.

I have previously mentioned development of an 11-state American lobster management plan. A surprising consensus was reached at the last meeting of the policy committee on this species and we think that within a reasonable period of time both the inshore and offshore stocks could be harvested under a management plan which takes into account the two root problems which have already been discussed.

As to the future, we are counting rather heavily on several legislative proposals. The first of these is scheduled to be introduced in the next Congress and would, among other things, provide the federal government with authority to promulgate and enforce regulations in the contiguous fisheries zone and, as far as United States citizens are concerned – and foreign fishermen whose governments have agreed to it – seaward of the contiguous fisheries zone.

We are also preparing legislation designed to encourage the states to enter into cooperative management plans with the federal government and which would provide funding for both the development and implementation of fisheries management plans. As an indication of the way this program is unfolding, we are already proceeding with the plans, even though the required legislation remains to be enacted.

Other legislative input may involve specific authority for limiting entry and we expect to participate, as some states have suggested, in developing a Uniform Model Fisheries Act for consideration by the states.

Secretary of Commerce Peterson, NOAA Administrator Dr. Robert White, and NMFS Director Philip Roedel all place great importance on this program. They believe and we believe that new initiatives in fisheries management are essential if we are to preserve the resources for future generations and restore the economic health of all our coastal recreational and commercial fisheries.

SEA GRANT SESSION

WEDNESDAY – NOVEMBER 29, 1972

Chairman - R. B. Abel, *Director, National Sea Grant Program, NOAA, Rockville, Maryland*

Estimating Abundance of Sardine-like Fishes from Egg and Larval Surveys, Eastern Gulf of Mexico: Preliminary Report [1]

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INTRODUCTION

Reports of apparent abundance of sardine-like fishes in the Eastern Gulf of Mexico and their possible potential for commercial fisheries often have appeared in discussions of fishery potential (Bullis and Carpenter, 1968; Bullis and Thompson, 1970; Fuss, Kelly and Prest, 1969; Klima, 1971; Wise, 1972). Only the Gulf menhaden presently supports a large commercial fishery; record catches in recent years may have exceeded the sustainable yield for that species (Chapoton, 1972). Other sardine-like fishes that might have potential for reduction or foodfish fisheries include thread herring, round herring, Spanish sardines, scaled sardines and one or more species of anchovies. No good estimates of stock size are available for any of these fishes, although some of these stocks may exceed Gulf menhaden in abundance (Bullis and Carpenter, 1968).

My research to assess clupeoid populations in the Eastern Gulf is based on seasonal surveys of planktonic eggs and larvae. Distribution and abundance of these stages will reflect adult distribution and abundance because eggs and larvae are planktonic for only a few days after being spawned. Rearing experiments demonstrated that clupeoid eggs hatch from 20 to 45 hours after spawning at temperatures found in the Eastern Gulf. Presence of eggs and newly hatched larvae in plankton catches, therefore, suggests proximity of adult spawning con-

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centrations. Adult biomass estimates from egg abundance can be obtained (Ahlstrom, 1968) if the mean fecundity, mean size and sex ratio of adults are known.

My objectives are to determine commercial potential of clupeoid species that are presently virtually unexploited by estimating biomass of the populations and, what may be as important, annual fluctuations in biomass. Spawning areas and seasons will be examined to determine where and when exploitable quantities of adults may be available to a commercial fishery. I hope that a good understanding of the basic biology of these stocks will lead to effective management techniques when the stocks are fished.

BACKGROUND

The survey began as part of a cooperative investigation during 1970-1972 of physical, chemical and biological phenomena in the Eastern Gulf of Mexico (EGMEX) (Rinkel, 1971). Ichthyoplankton sampling became a specific objective of EGMEX in May 1971. Cooperators included the Florida State University System's Institute of Oceanography (SUSIO) and the National Marine Fisheries Service (NMFS). This survey has served in many respects as a pilot program for development of the NMFS Marine Resources Monitoring, Assessment and Prediction Program (MARMAP).

A grid of 185 stations, mostly spaced at 15-mile intervals and on transects 15 miles apart, was designed for 1971 surveys (Fig. 1). Stations extended from the 5-fathom line to the 100-fathom line, with a few stations over deeper water. Five cruises in 1971 sampled as many stations as possible within the limits of avail-

Table 1. Cruises and number of stations sampled in Eastern Gulf of Mexico during 1971 and 1972 egg and larval surveys

Cruise Month	Number of Stations
1971	
February	20
May	123
June-July	31
August	150
November	88
1972	
February	32
May	30
June	13
September	34
November	50

Eastern Gulf of Mexico Ichthyoplankton Sampling Stations.

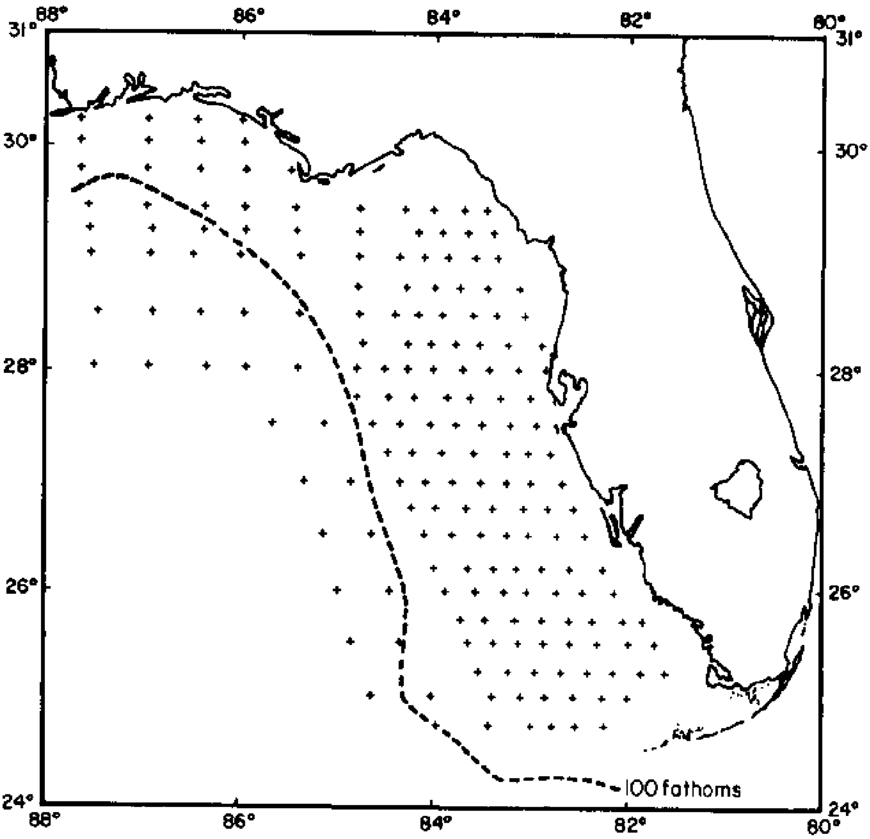

Fig. 1. The sampling grid used to determine distribution and abundance of eggs and larvae of sardine-like fishes in the Eastern Gulf of Mexico during 1971.

able vessels and time (Table 1). Three of the 1971 cruises were extensive; these were in May, August and November. Two additional cruises, February and June-July, covered smaller parts of the grid. Fewer stations were sampled in 1972 on 5 cruises because transects were spaced at 30-mile intervals, and most stations were spaced 30 miles apart. Only data from 1971 cruises were incorporated into this report.

METHODS

A Bongo net plankton-sampler (Posgay, Marak and Hennemuth, 1968) has been used to collect ichthyoplankton. Double oblique tows of paired 60-cm Bongos with 333 and 505-micron-mesh nets from near bottom to surface, or from 200 m to surface at deep stations, were made at a ship speed of about 2 knots. The gear was lowered at a wire release rate of 50 m per minute and retrieved at 15 m per minute. A flow meter inside the 505-micron-mesh Bongo sampler was used to determine volume strained during tows. Preserved eggs and larvae were removed from plankton collected in the 505-micron-mesh net after samples were brought to the laboratory. A 1-m, 505-micron-mesh ICITA plankton net was substituted for the Bongo net at a few stations during 1971 cruises.

Clupeoid eggs and larvae were identified and counted. Numbers at each station during each cruise were reported as numbers under $100m^2$ of sea surface using the technique of Sette and Ahlstrom (1948). Catches at stations of different depths are directly comparable when reported in this manner. Sette and Ahlstrom (1948) outlined a method of integrating over time and space to estimate total abundance of eggs or larvae represented by a station during a particular cruise. Their method was used to obtain an estimate of thread herring eggs spawned during the time period represented by the May 1971 cruise.

RESULTS

THREAD HERRING

Thread herring *(Opisthonema oglinum)* spawn during spring and summer months. Prest[2] studied maturity and fecundity and concluded that adults were ripe from April to August. Fuss *et al* (1969) implied a similar spawning season. My egg and larvae collections confirm their results. Eggs and larvae were common in collections made during May, June-July and August but did not occur in February or November.

Most thread herring eggs were collected within 40 miles of shore (out to about the 20-fathom line), but some occurred at distances up to 75 miles from shore (depth about 30 fathoms) (Fig. 2). The smallest size classes of larvae (≤5.00 mm) reflected the egg distribution (Fig. 3) and may be better indicators of spawning areas than eggs because they are less than 4 days old and because they are less "patchily" distributed than are eggs. Distribution of all thread herring larvae in 1971 was more widespread than that for eggs or larvae ≤5.00 mm (Fig. 4). Larvae occurred as far as 105 miles offshore (depth about 75 fathoms), but were most common within 55 miles of shore (depth about 25 fathoms).

Most adult spawners apparently inhabited areas closer than 40 miles from shore during the 1971 spawning season. Kinnear and Fuss (1971) made highest gill net catches of adults less than 9 miles from shore near Tampa Bay in 1969 and 1970. A significant number of adults occurred farther offshore in 1971, based on my egg and larvae distribution data, but most probably were within 20 miles of shore in the Eastern Gulf. A seasonal north-south migration of adult thread herring occurs (Kinnear and Fuss, 1971) in which northerly migrations occur during spring and southerly migrations occur in fall, apparently in response to seasonal temperature changes. Nevertheless, many eggs and larvae

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[2]Prest, K. W., Jr. (unpublished typewritten manuscript). Fundamentals of sexual maturation, spawning and fecundity of thread herring *(Opisthonema oglinum)* in the Eastern Gulf of Mexico. National Marine Fisheries Service, St. Petersburg Beach, Florida.

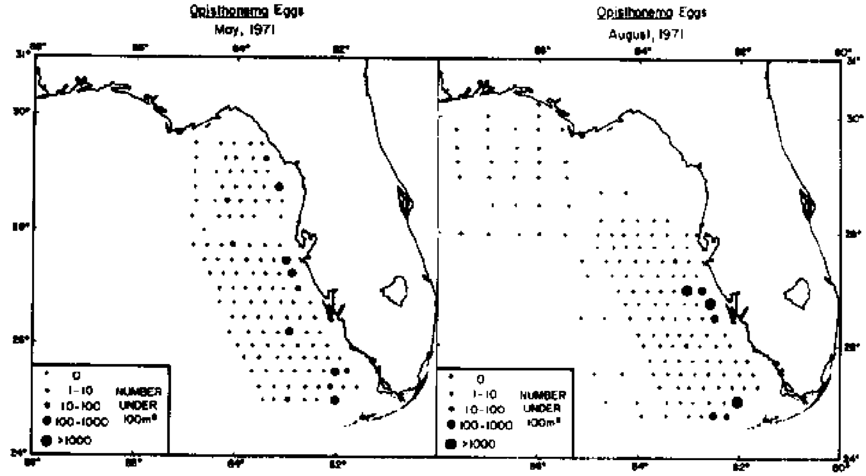

Fig. 2. Distribution of thread herring eggs in the Eastern Gulf of Mexico during May and August, 1971.

occurred south of Tampa Bay in both May and August (Figs. 2, 3 and 4), indicating that much of the adult population was distributed between Ft. Myers and Tampa Bay, even in summer months.

I have estimated thread herring biomass based on the egg distribution observed during the May 1971 cruise. The estimate is preliminary because it is derived from data representing only a part of one spawning season. Basically, the estimating procedure is that outlined by Ahlstrom (1968). I have considered the 1971 spawning season as extending from April 1 to August 31. Within the

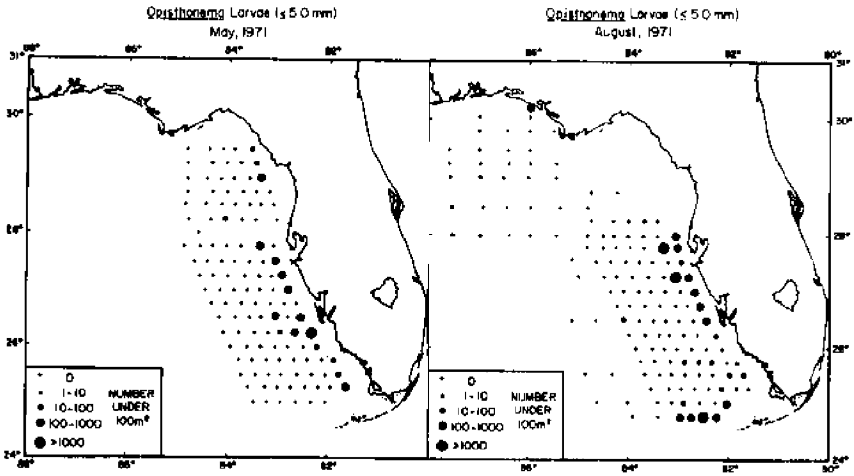

Fig. 3. Distribution of thread herring larvae ≤5.00 mm in the Eastern Gulf of Mexico during May and August, 1971.

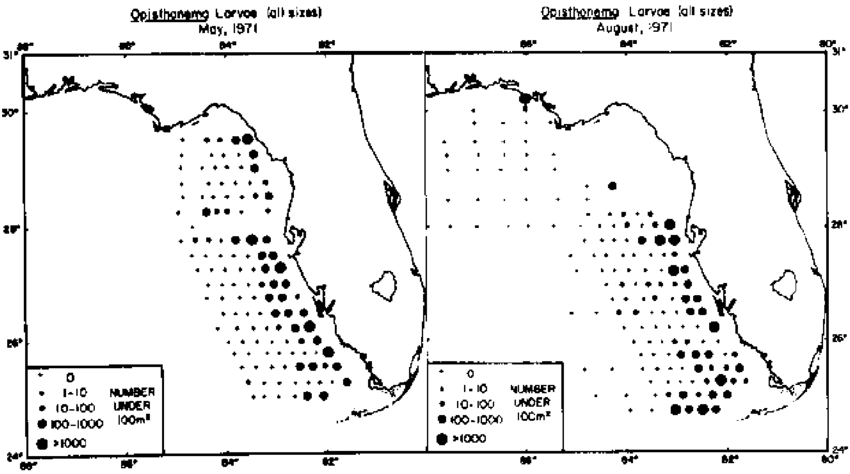

Fig. 4. Distribution of thread herring larvae of all sizes in the Eastern Gulf of Mexico during May and August, 1971.

season, I have assumed that frequency of spawning by the population more or less follows a normal distribution. In this case, the May cruise represents 73.5 days, or 31% of the area under a normal curve encompassing a spawning season of 153 days. Prest's[2] data gave mean fecundity of thread herring as about 30,900 and mean adult weight about 65 g. I assumed that the sex ratio was one to one. The estimated number of spawned eggs was 226.65×10^{11} south of Tampa Bay, but only 25.01×10^{11} north of Tampa Bay during the period represented by the May cruise.

Estimates of adult biomass were 308,600 metric tons south of Tampa Bay and 34,000 tons north of Tampa Bay in May. I feel that these estimates, though preliminary, are conservative because egg abundance probably increased in areas shallower than 5 fathoms where I did not sample.

ROUND HERRING

Eggs of round herring *(Etrumeus teres)* occurred commonly in February and November, and rarely in May at stations where depths exceeded 20 fathoms (Fig. 5). The very distinctive larvae were common in February, May and November at stations deeper than 20 fathoms, except for one catch at a shallow station (Fig. 6). Fore (1971) reported eggs of this species from December to March in the northern Gulf. Some spawning may have occurred in the Eastern Gulf at stations deeper than those included in the survey, but the November distribution data suggest that most spawning, and therefore adult concentrations, may be confined to the survey area (Fig. 5).

The abundant eggs and larvae of this species, particularly at stations where depths ranged from 30 to 100 fathoms, indicates a large biomass of adults that might be exploitable. Little is known at present regarding biology of this species and no estimates of adult biomass have been made.

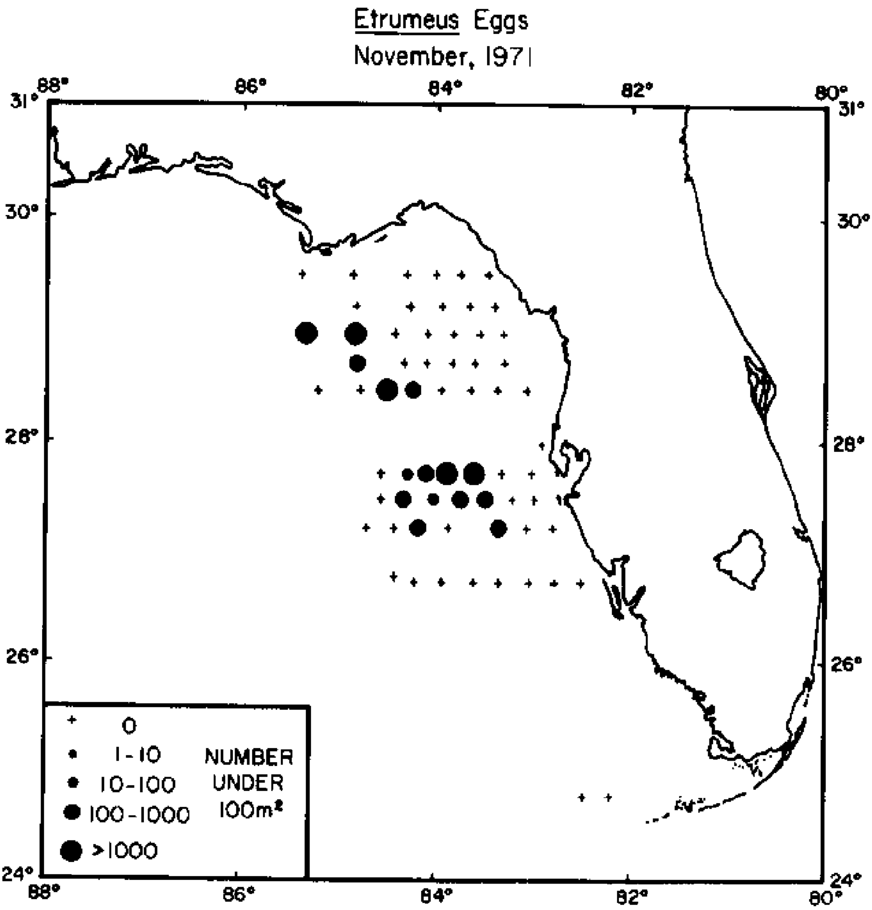

Fig. 5. Distribution of round herring eggs in the Eastern Gulf of Mexico during November, 1971.

SCALED SARDINES

Scaled sardine *(Harengula pensacolae)* eggs and larvae occurred together with thread herring in May, June-July and August. They occurred only at stations nearest to shore and were not common in 1971. Most spawning in 1971 apparently took place closer to shore than the innermost stations of the grid. Although scaled sardines may be common, abundance estimates probably will be possible only when sampling stations are extended closer to the coast.

SPANISH SARDINES

Data from 1971 are in preliminary analysis stages. Eggs and larvae of Spanish sardines *(Sardinella anchovia)* were common in February and November, and a few occurred in May. Most spawning apparently occurred during winter and fall.

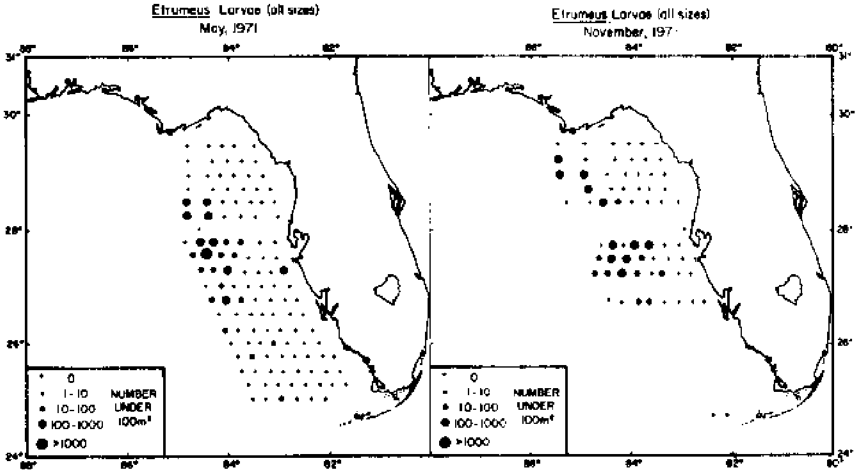

Fig. 6. Distribution of round herring larvae of all sizes in the Eastern Gulf of Mexico during May and November, 1971.

Eggs and larvae appear to be more widely distributed than those of other clupeid species in the Eastern Gulf.

ANCHOVIES

Larvae of anchovies, perhaps of several species, occurred in catches from all cruises in 1971. Eggs occurred rather uncommonly; elliptical anchovy eggs may have been extruded through meshes of 505-micron-nets. I also believe, based on laboratory rearing experiments, that some species of Gulf anchovies have spherical eggs and that such eggs have not been identified in our catches. Distribution

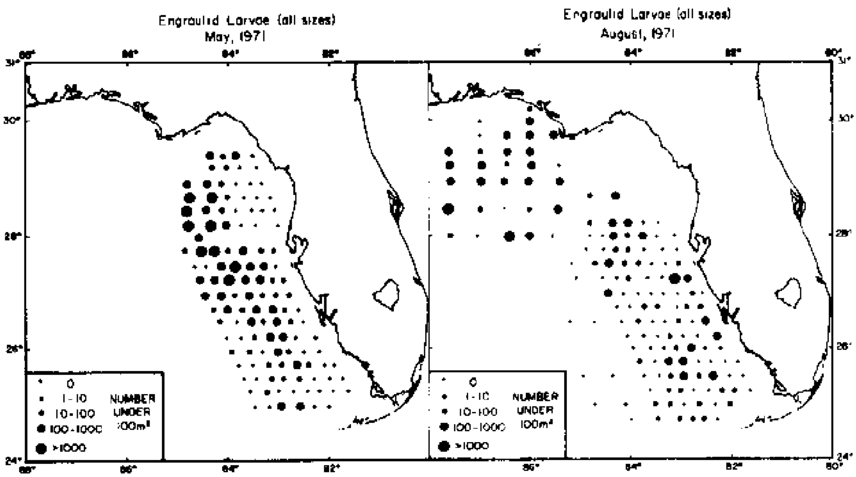

Fig. 7. Distribution of larval anchovies of all sizes in the Eastern Gulf of Mexico during May and August, 1971.

of larvae was widespread (Fig. 7) and they were abundant, particularly at stations deeper than 20 fathoms. Larvae were common even at depths of 100 fathoms or more. This suggests that a significant part of anchovy stocks in the Eastern Gulf lives well offshore.

At this time it is impossible to estimate abundance of the stocks because I cannot specifically identify larvae. It has been suggested that anchovy stocks may be the largest unfished potential resource in the Gulf (Bullis and Carpenter, 1968). Larval catches attest to the abundance of anchovies, but the relatively high fecundity of adults, coupled with small body size, may be misleading. Total biomass of adults possibly is not as great as larval catches suggest.

OTHER CLUPEOIDS

A single menhaden larva *(Brevoortia* sp.) was collected in November near Tampa Bay. Yellowfin menhaden *(Brevoortia smithi)* eggs and larvae should be common in winter in some parts of the Eastern Gulf (Turner, 1969), but my February and November cruises did not sample those areas in 1971.

A few unidentified clupeid larvae were collected. Some of these could be dwarf herrings *(Jenkinsia* spp.).

SUMMARY AND CONCLUSIONS

Assessment of distribution and abundance of eggs and larvae promises to be a good technique for evaluating fishery potential of sardine-like fishes in the Eastern Gulf. Preliminary analyses have demonstrated that areal distribution, spawning seasons and presence of spawning concentrations of adults can be quickly determined. Biomass estimates and yearly fluctuations in stock size will be possible. The same techniques can be applied to assess species other than clupeoids. Snappers, groupers and mullets are examples of fishes that can be studied by this kind of survey.

I hope that reliable assessments of population size and yearly fluctuations will lead to development of well-managed and productive commercial fisheries for presently underutilized clupeoid populations. Present legal restrictions make it difficult to utilize some of the sardine-like fishes that are within 9 miles of the Florida coastline. Thread herring fall into this category. Data from egg and larvae distribution in 1971 indicated that many adult thread herring were beyond the 9-mile state boundary, at least during the spawning season. Also, round herring and anchovy larvae were common well offshore, suggesting the presence of large adult populations that might be exploited by midwater trawls.

ACKNOWLEDGEMENTS

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Descriptive Characterization of Mass Autumnal Migrations of Spiny Lobster, *Panulirus argus*[1]

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INTRODUCTION

Perhaps the most striking aspect of the life history of spiny lobsters *(Panulirus argus)* is the phenomenon of mass single file movements (Herrnkind and Cummings, 1964; Herrnkind, 1969, 1970; Herrnkind and McLean, 1971). The event involves both nocturnal and diurnal movements of thousands of lobsters in chain formations (queues) across open shallow areas devoid of lobsters at other times. The movement lasts only a few days, during which all queues travel in the same general heading. The event occurs in autumn, usually after a period of stormy weather and seems to be localized according to climactic conditions. Mass queuing is reliably reported from the Florida Keys, Boca Raton, Bimini and Grand Bahama (Herrnkind, 1969). Only one-way treks have been observed and the movements presently appear to be emigrations of lobsters from certain areas to as yet undetermined destinations.

These mass migrations are unusual in several respects. First, the mode of movement in formation is unique among benthic crustaceans. Species such as the King crab *(Paralithodes camtschatica)* and some other spider crabs, the anomurans *Pleurocodes* and *Coenobita* (terrestrial), as well as some ocypodids (terrestrial and semi-terrestrial), move *en masse* and form groups but apparently do not travel in formation (Bainbridge, 1961; Allen, 1966; Herrnkind, 1972). Movements of other "lobsters," e.g., *Homarus americanus* and various palinurids, may involve clustering and travel by individuals in proximity, but queues or similar arrangements are reported only for *Panulirus argus* (Lindberg, 1955; Bainbridge, 1961). Second, the other known migrations and wanderings of *Panulirus argus* involve variable solitary movements causing shifts in the population over periods of months (Dawson and Idyll, 1951; Sutcliffe, 1952, 1953; Buesa, 1969). Such movements typically occur at night, the lobsters remaining in seclusion by day. Third, the latter movements are often associated with inshore-offshore migrations of adults during the reproductive season in the spring, whereas mass migrations occur after the main reproductive period (Allen, 1966). Hence, the functional significance of the event is not immediately apparent.

The literature on this phenomenon is sparse. Crawford and DeSmidt (1922) mention movement of *Panulirus argus* in "trains" but do not cite the source of

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this observation. Sutcliffe (1952) was told of a migration of considerable magnitude that occurred at Bermuda one autumn in the late 1940s, and he in turn suggested that it might be comparable to a migration occurring at Bimini in October 1950, as reported to him by C. M. Breder, Jr. Aside from such vague references possibly indicating occurrence of mass movements, the volumes of literature on this species included no adequate characterizing data until our recent reports. The documented occurrence of mass migration, a brief description and a photograph of a queue, was published by Herrnkind and Cummings (1964). The tactile mechanism associated with queue maintenance and evidence for an internal Zugunruhe was reported by Herrnkind (1969). More recently, the pathway and orientation vectors were described for a mass migrating population off the west coast of Bimini in 1969 (Herrnkind and McLean, 1971).

In spite of the paucity of scientific information, we found that lobstermen in migration areas have known about the phenomenon for many years and capitalize on it by making large catches. For example the lobstermen at Bimini actively monitor the past migratory pathway through the fall, and during a mass movement catch 500-1,000 lobsters (estimated) per bully-netter per day. This compares to a typical good daily catch of 100-150 at other times of the year. Some of the anecdotal infomation provided us by these individuals was valuable in focusing our present research in that region.

The absence of scientific information on mass migration is attributable to the following reasons. The earlier authors mentioning the event appartently presented only anecdotal descriptions and did not, themselves, witness it. Furthermore, trapping studies, the common source of data on lobster population dynamics, cannot adequately detect or discriminate a mass movement since it often occurs in areas where traps are not set and even full traps give no indication of time of entry, mode of movement, directionality or magnitude. Directly witnessing the migration is hindered by rough sea conditions and high turbidity associated with its occurrence. Chance observations are further reduced by its limited duration and localization and by the fact that few scientists until recent years actually entered the marine medium to conduct observations (Herrnkind, in press).

For the past 3 years we have undertaken *in situ* and laboratory-based research aimed at characterizing mass migrations, determing causal factors, establishing its biological function and interpreting economic and conservational implications. This paper gives the general characteristics of these events drawn from direct observations in 1963, 1965 and particularly 1969 and 1971. The other research aims mentioned above are briefly discussed but will be treated more fully in a series of detailed papers presently in preparation.

STUDY AREA

Field research was conducted primarily at Bimini, Bahamas, on the extreme western edge of the Great Bahama Bank some 50 miles (83 km) east of Miami, Florida. Bimini is particularly suitable for study of mass migrations occurring off the western side of the islands between shore and the Florida Straits (Fig. 1). The surrounding waters are clear, with visibility ordinarily exceeding 20 m along the west shore and only slightly less to the east over the bank. Even after storms and periods of high winds cloud the shallow waters, the migratory pathway adjacent to South Bimini is quickly flushed by northward-flowing, clear Gulf Stream water washing over the bank edge. The unique combination of proximity to a migratory area, research facilities (Lerner Marine Laboratory), high probability of migration, water clarity and mild weather provides an excellent situation for *in situ* study of the phenomenon.

The benthic communities and substrate characteristics of the Great Bahama Bank, with special reference to the Bimini area, are treated by Newell *et al* (1959) and Kornicker (1958). In general, the area west of the islands (North and South Bimini and Turtle Rocks) is a gently sloping shelf dropping gradually from the shore or shallow bank area (2-5 m depth), then abruptly at approximately 30 m depth between 1 and 2 km offshore. Lobsters on the shelf live primarily below 6 m depth on hard substrate providing crevices or under isolated coral heads mostly at depths of 10-20 m. The extensive and heavily fished bank population resides mainly in the seawhip (Plexaurid) and sponge beds, although lobsters may inhabit any exposed rock shelves and undercut *Thalassia* banks. We have not observed lobsters by day over open sand, sparse grass beds or benthic *Sargassum* except at migration time. Most of the shelf area over which mass movements were noted consists of these typically uninhabited bottom types.

The hydrographic conditions of the shelf area, according to past studies and our observations, are influenced by the conservative characteristics of the Gulf Stream and the more variable water mass over the shallow bank. Water clarity, temperature and salinity vary according to tidal phase, wind direction and other climactic factors. The waters of the shelf and bank area near Bimini during mild weather in late summer and early fall generally have high clarity (visibility in excess of 20 m), temperatures about 28C (83F) and salinities near 35 parts per thousand (°/oo), the highest salinities being found in the Bimini lagoon outflow and over the bank (Kornicker, 1958). According to Newell and Imbrie (1955), the Great Bahama Bank water flows generally westward with current vectors varying with tides and displacement, or channeling, of water flowing around the islands. Periods of high winds and thermal perturbations have a rapid and marked influence on the shallow bank. Heavy wave turbulence increases turbidity and sediment disturbance, while the dynamics of heat exchange result in considerable fluctuation in water temperature, especially as compared to the Gulf Stream.

METHODS

Our field research was designed to monitor the lobster populations adjacent to Bimini concurrently with hydrographic and climactic conditions from the premigratory period in early fall through a mass movement (usually in late October - mid November) and subsequently for several weeks. In the premigratory period, we surveyed the general region to determine the distribution of the resident populations and characterized them by number, number per den, size frequency, sex ratio, molt condition, reproductive state and degree of fouling by epifauna and eiflora. As many individuals as possible were tagged with sphyrion type back tags for later indeptification and released in the area of capture.

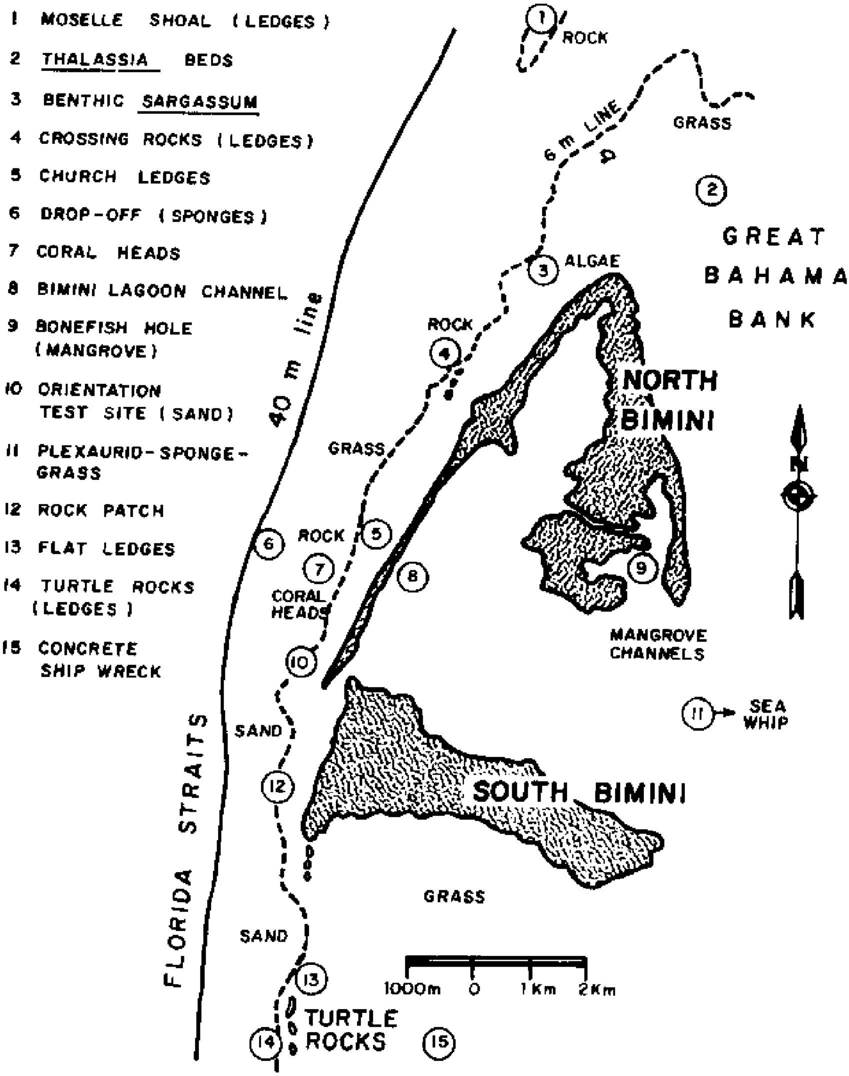

Fig. 1. Bottom characteristics in the Bimini region and areas (1-15) frequently sampled for spiny lobster in 1969 and 1971.

Environmental conditions were monitored by constant recording thermographs (General Oceanics and Ryan) and current sensor (General Oceanics) emplaced on the bottom by divers at such locations as the past migratory pathways, suspected pathways and source areas, and the edge of the shelf in deep water (40 m). Daily thermometer casts were made in the Bimini lagoon and surf.

Specific locations chosen to grid the area were checked on a periodic 4-7 day basis throughout the fall to document any changes in population distribution or condition. The sphyrion tags allowed recognition and monitoring of individual movements while an advertised reward program provided for further information through local divers and lobstermen. Ordinarily we merely recorded the number of a resighted, tagged lobster but did not capture or physically disturb them. Throughout the fall specimens were collected and sacrificed for gut content and hemolymph analyses.

Survey, capture and tagging were conducted exclusively by diving techniques to assure a thorough sample in selected areas and to facilitate behavioral observations. The techniques resemble those described by Cooper and Herrnkind (1971). During daylight, lobsters were visually located (by closely examining the substrate) then captured by tail-snare to avoid injury (to both lobster and diver). When convenient, lobsters were measured and tagged underwater and immediately replaced in their dens. Otherwise, they were placed in mesh bags for measurement and tagging at the surface and subsequent release in the general capture area.

Additional survey outside the selected area was accomplished by boat-towing an observer on a diving plane (Kumpf and Randall, 1961). The plane allowed a snorkler to travel 3-4 knots and dive with little effort to 10 m. Deeper depths down to 30 m were covered by towing a diver with SCUBA. The dive plane technique was especially valuable during mass movements and when water clarity was reduced or surface ripples precluded observing through the air-water interface. Spotting lobsters in dens was facilitated by the ability to control both depth and horizontal scope when operating the plane.

The onset of a mass migration was determined from visual observations of queues moving during daylight. During the periods of probable massing, divers surveyed the general area beginning at dawn, keeping in communication with Bimini lobstermen, who usually dispersed and monitored the shallower depths to 5-6 m (within range of their bully-nets). Upon occurrence of mass queuing, we recorded the number of lobsters per queue and its compass bearing, as well as the location, depth, substrate type, temperature, visibility and general behavior. Samples of the migratory group were tail-snared, measured, sphyrion-tagged and released. Behavior and interesting events were photographically documented by 35mm underwater camera whenever possible.

Some migrants were sonic-tagged and tracked as far as possible to determine the pathway at night and in deep or turbid water. Each saddle-shaped transmitter pulsed a 70KHz signal at an individually identifiable periodicity detectable up to 250 m by diver-carried or surface-operated directional receiver (Smith-Root). The general technique is given by Herrnkind and McLean (1971) and further elaborated in Herrnkind *et al* (in prep.). The tracking program was just initiated and results are not included in this paper. However, the method is potentially significant because, by sonic telemetering migrants over long duration (30-day tag life), we hope to determine the population movement presently escaping investigation. Knowledge of resultant changes in population distribution and structure is necessary to interpret the functional significance of the event to the species.

DESCRIPTIVE CHARACTERIZATION

PREMIGRATORY PERIOD

Figure 1 shows the main areas surveyed regularly during the early fall along the shelf area west of Bimini where past mass queuing was observed (Herrnkind and Cummings, 1964; Herrnkind and McLean, 1971).

The region is mostly open sand, sparse grass, benthic *Sargassum* or hard substrate with few ledges, and lobsters were not observed by day in these habitats. Some rocky areas in shallow depths (5-8 m) providing ledges were occasionally inhabitated by a small number of lobsters (areas 4, 5, 12 on Fig. 1). Several areas of coral heads and rock outcrops 10-20 m in depth were inhabited at this time, but the regions were relatively confined (totaling approximately 20 hectares) and we estimate they contained only a few hundred lobsters on any sampling day. The main channels in the Bimini lagoon had a small population of young mature lobsters while juveniles were found in the shallow sand flats and mangrove areas. The migratory pathway was relatively devoid of both lobsters and suitable habitat, especially in depths less than 10 m.

Numbers increased in sparsely populated locations in early October some 1-3 weeks prior to mass queuing. This is shown in Figure 2 for two areas (5 and 12 on Fig. 1) several kilometers apart off the west shores of North and South Bimini. These increases occurred both during periods of uninterrupted mild weather (1969) and during periods of intermittent, brief storms (1971). Lobsters moved in by night and during the crepuscular hours, queues being observed at these times. Thereafter, large clusters of lobsters (up to 70 individuals per den) were noted in areas formerly containing few or none. The recently arrived immigrants sometimes emerged from dens by day under provocation of capture and formed queues. More typically they retreated into the crevices, the common response of lobsters other than mass migrants. While we cannot accurately estimate the numerical increase in the population for the total area, it was certainly manifold. Additionally, the behavior suggests a propensity for queuing and daytime locomotion not seen during the preceding period and more typical of the mass movement.

MASS MIGRATION

Severe squalls lasting several days with high winds from the northerly quadrants and cool temperatures occurred duing late October-mid-November. Mass queuing was observed after such storms in 1961, 1963, 1969 and 1971 off Bimini (and 1965 off Boca Raton, Florida). In all cases, queues were seen on the shelf west of North and South Bimini in those areas where water clarity permitted. The lobsters were observed to move southerly, generally along shore, across depths ranging from 5-20 m in 1963, 2-10 m in 1969 and 1971, and as deep as 40 m in 1961. Figure 3, a composite scatter diagram of queue headings taken in 1969, shows a strong southerly direction over a 10 km distance during a 4-day period (see Herrnkind and McLean, 1971, for further details). Queues followed a shallow S-shaped track over distances of several hundred meters, thus accounting for some of the apparent deviation from the resultant southerly path. Despite the essing and gross deviations of queues and individuals dispersed by bully-

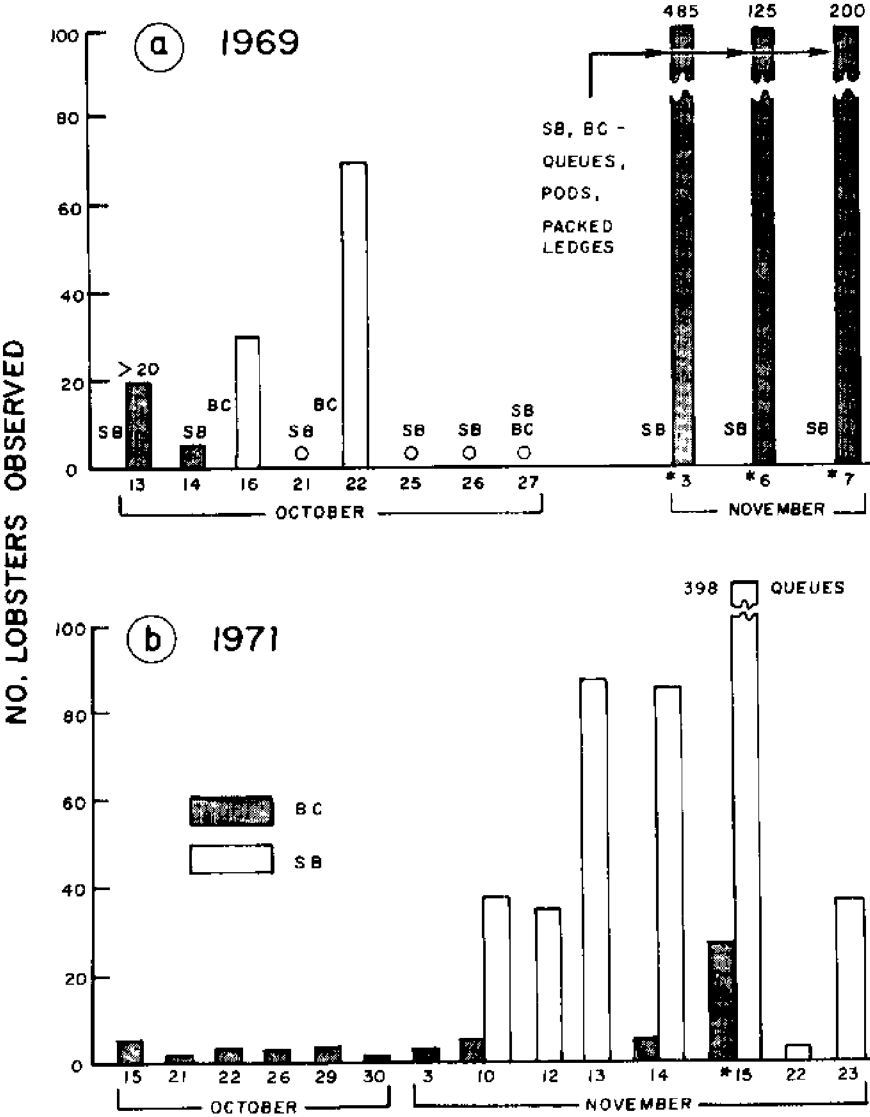

Fig. 2. Numbers of spiny lobsters observed in selected pathway sample areas during autumn 1969 (a) and 1971 (b). Asterisk indicates dates when mass daytime queuing was observed. SB – South Bimini patch reef (12 on Fig. 1). BC – Church ledges (5 on Fig. 1).

netters, all 1,638 lobsters comprising 230 queues and 39 individuals were observed within a narrow corridor some 400 m wide for 5-6 km as they passed Bimini.

The bulk of the migrants (98%) moved in queues rather than individually as shown in the frequency plot in Figure 4. Most solitary lobsters were recorded near bully-net operations which caused fragmentation of queues and subsequent

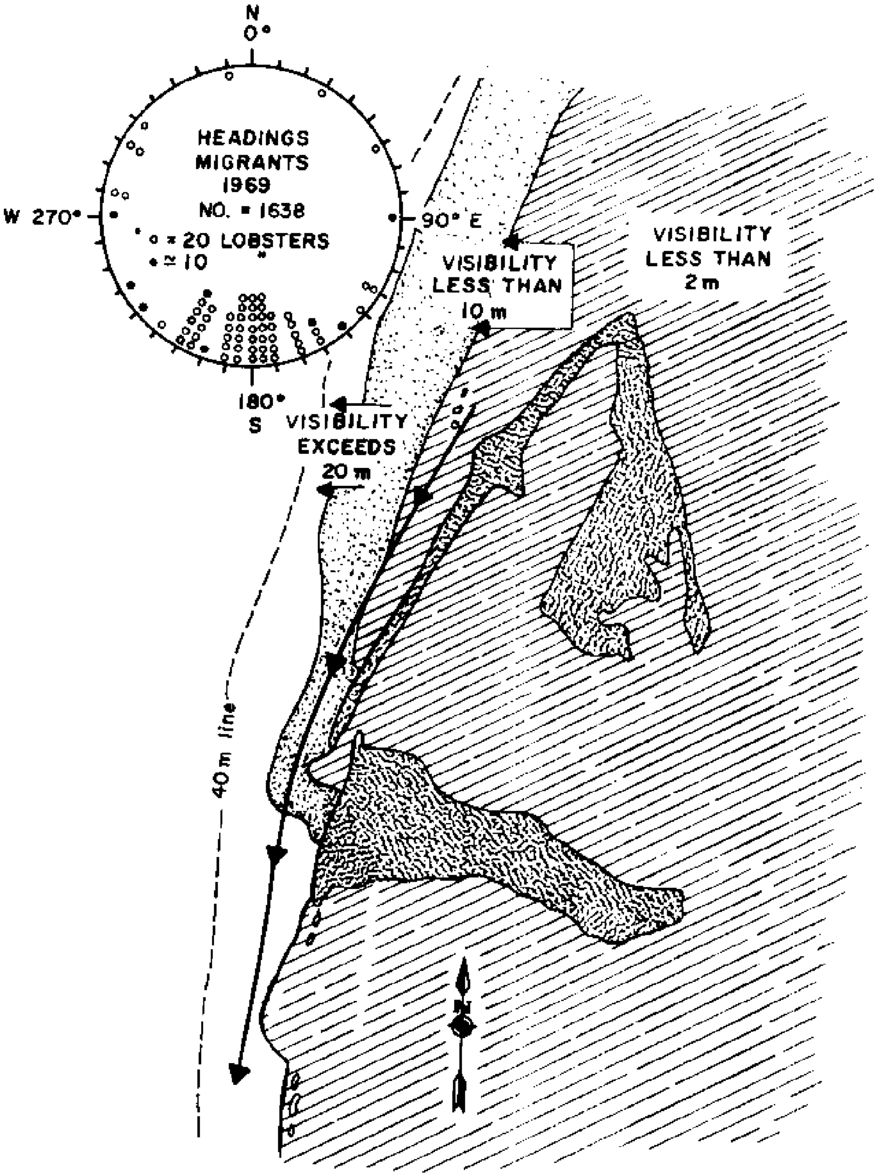

Fig. 3. Migratory pathway (arrows) observed in 1969 (including portions observed in 1961, 1963 and 1971) in relation to Bimini and the principal water masses, as defined by turbidity characteristics, at the time of mass migration. The scatter diagram gives the compass headings recorded for migrants observed in 1969 (n 1638).

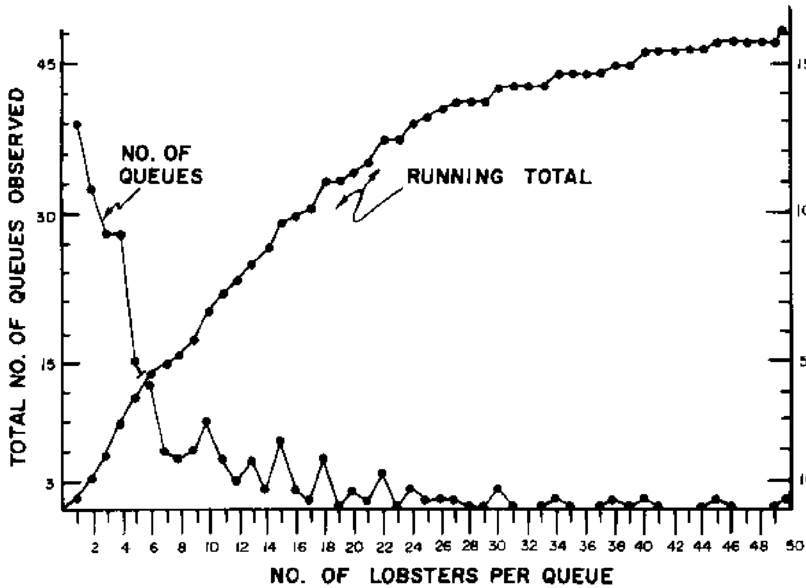

Fig. 4. Frequency profile of number of spiny lobsters per queue observed in 1969 (left scale) and the cumulated number of spiny lobsters represented (right scale). Total number of queues plus solitary migrants = 230; total number of individuals = 1638.

brief dispersal. As many as 65 lobsters were observed in a single queue (1971) and 34 queues of 13 or more individuals made up 18% of the queues but approximately 50% of the population on which we were able to record data in 1969. The higher frequency of smaller queues accounted for the remaining 50% of the total population as queues less than 13 individuals; i.e. 82% of the queues. Queuing, therefore, was the major mode of movement, the larger queues occurring with lower frequency. Yet large queues were not infrequent and represented a significant proportion of the emigrants (20% of all moving lobsters travelled in queues of 25 or more individuals).

When not queuing, migrants either formed large congregations (pods) in areas devoid of cover or packed into any available crevices. During 1969, for example, data were recorded on 2,365 lobsters, 1,638 (69%) of which were observed as queues (including 39 solitary moving lobsters), 449 (19%) under ledges, 265 (11%) in pods and 13 solitary resting individuals. Apparently, the quiescent periods do not last more than a few hours, since any pod was observed only once although repeated surveys were made throughout the day. In addition, queues entered ledges already packed with lobsters, some of which emerged, formed new queues and moved off. Stable congregations that did not emerge by day, even under provocation, occurred more frequently toward the end of the movement. At that time lobsters were found only in dens rather than in pods in open areas. In summary, the bulk of the population passed through the area as queues, although some lobsters established apparent residency, especially toward the end of the movement.

No specific attempt was made to measure the total number in past migratory populations and we can only offer an estimate based on our counts in the field and the catch by Bimini bully-netters, the latter reported to us verbally by several of them and by a commercial wholesaler (we witnessed the catches prior to shipment but did not make counts). The lobstermen claimed catches of 500-1,000 lobsters per boat per day over a 4-day period (3,4,6,7 November 1969), while the wholesaler estimated a total shipment of 20,000 lobsters for that period. This latter estimate seems reasonable since a catch of 500 lobsters per boat, with up to 13 boats fishing each day (from our notes), over 4 days gives a figure near 20,000 lobsters. We know the bully-netters fished only from daylight until late afternoon, approximately 10 hours, but the migration occurs at night as well. Also, we counted 256 lobsters over a 2-hour period directly down the pathway from the fishermen and 338 lobsters in a similar period in an area unfished by them. Obviously large numbers either escaped capture while amidst the lobstermen, moved through the area outside the fishing period or moved by outside the fished region. Consequently, we suggest the lobstermen fished less than half the migratory period and likely missed at least half of those lobsters present in the area observed during the fished period. Thus, an estimate of 100,000 lobsters seems appropriate although it might be orders of magnitude low if the movement occurred over the large regions we were unable to monitor. Hopefully, our present tagging program and the cooperation of the lobster wholesalers will permit more reliable future estimation.

Duration of the observed daytime mass queuing varied from approximately 5 hours (1971) to 4-5 days (1969). However, the actual starting time could not be determined because the point(s) of origin was not ascertained and the turbid water conditions north of Bimini prevented visually backtracking along the migratory pathway. The final stages of past movements, at least over the 10 km distance between Crossing Rocks and North Turtle Rocks, was associated with decreasing occurrence of queues. Additionally, an increasing number of lobsters resided by day under nearby ledges at this time. Apparently, the number in the pathway area decreased and/or those remaining ceased diurnal locomotory activity. The true termination of mass queuing also cannot be established, since movement may continue past the southernmost point we have tracked queues (i.e., 1-2 km south of South Bimini).

Samples of migrants for characterization by biological condition were taken either from queues, pods or crevices during the main period of daytime movement in areas known from preceding surveys to be otherwise uninhabited. Data taken on 200 lobsters in 1969 and 1971 are given in Figure 5 and Table 1. The size frequency over both years shows a range in carapace length (measured from between the rostral horns to the posterodorsal margin of the cephalothorax) of 55-126 mm, and a relatively symmetrical distribution around means of 84.6 mm (1969) and 82.1 mm (1971). The larger individuals tended to be males, and the only lobsters over 110 mm were a queue of five captured in 1969. Leader lobsters from queues (n=39) showed the same size frequency distribution and sex ratio as the total group (Fig. 5a) and were morphologically indistinquishable from the followers. Overall the migration lacked both young juveniles, typical of

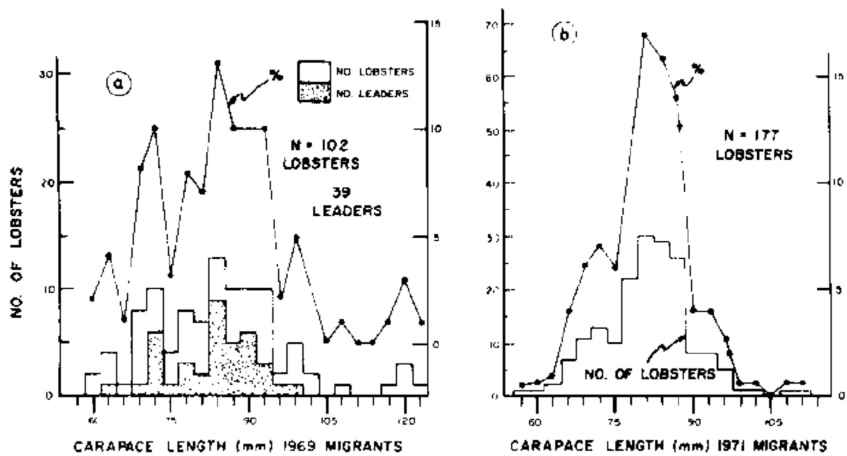

Fig. 5. Size frequency distribution of carapace lengths (measured from between the rostral horns to the posterodorsal margin of the cephalothorax) plotted as 3 mm intervals for 102 migrants in 1969 (a) and 177 migrants in 1971 (b). Shaded portion of 1969 migrants (a) indicates size frequency of queue leaders (n = 39).

the Bimini lagoon and Bank area, and older matures common to deeper reef habitats (Sutcliffe, 1952; Cooper and Herrnkind, 1971). Rather, most were individuals of initial reproductive age (Sutcliffe, 1952).

The sex ratio for the migrant sample was not significantly different from 1:1 either in 1969 or 1971. Only one female with spermatophores or eggs was taken from these collections (or observed in queues), although some were found in the pre-migratory build-up. Ecdysial state (molt or intermolt) classified by the carapace condition was also recorded. Pre-molt lobsters showing a dark line and flexing along the ventrolateral cephalothoracic margins, and post-molt lobsters with still flexible carapaces were considered in the molt category. Lobsters with hard carapaces resisting flexure when grasped firmly were considered intermolts. The migratory group showed a significant portion (20%) of recent and incipient molters.

Color notes and photographs revealed nearly the full range of variation reported for the species; i.e., from light tan through brownish-red to dark purple. The extremes of either light or dark color did not make up a large proportion of the samples. One striking color variation consisting of a violet hue noticeable over the entire dorsal and lateral carapace and appendages was recorded with variable frequency both during the premigratory period and from queues. We have not yet determined whether this violet cast is specific to any particular populations at other times or represents a peculiarity of fall migrants. As we obtain further samples from various populations before and after migration, we hope to correlate color, fouling organisms or some other biological feature with such attributes of mass migrants to infer their possible origin.

Table 1. Migrant sex ratios, carapace length, reproductive condition and molt state (1969 and 1971)

Year	♂	CL mm	♀	CL mm	♂+♀ CL mm	Eggs or Spermat	Pre- or post-molt	Inter-molt	Total
1969	53(52%)	87.9	49(48%)	81.1	84.6	0		–	102
1971	89(50%)	84.1	88(50%)	80.0	82.1	1(0.6%)	36(20%)	141(80%)	177

GENERAL BEHAVIOR

A number of behavioral aspects including the striking queue formations charactize the mass movements. Lobsters in queues, especially in open areas, may move continuously for at least several hours. The locomotory rate was estimated from tracking studies to be about 1 kilometer per hour over distances of at least 1-2 km over unobstructed bottom topography. When moving rapidly, the queue members usually maintained single-file formation with physical contact by the antennular inner rami and/or the anteriormost pereiopods, as described for queues in laboratory pools (Herrnkind, 1969). A line retained its integrity through turns analagous to a railway train, futher reflecting the close contact between individuals. Breaks in rank occasionally occurred, resulting in either increased locomotory rate of the trailing individuals, who remained in line and eventually re-established contract, or divergence in pathways of the separated groups.

Disturbances by a diver or obstruction in the path caused piling up of queue members into a pod. As this occurred, whole lengths of queues sometimes moved abreast to give a double or triple-file appearance. Groups at rest in areas devoid of ledges were seen in rosette formations, the members facing outward with abdomens in contact. Pods and rosettes did not immediately disperse as individuals unless physically scattered; instead, queues formed as lobsters began to move away. Leadership of queues generally changed both during pod disruption and queue-splitting, yet queues in the area retained the appropriate heading. Apparently, a number of individuals, perhaps all, are capable of the necessary orientation.

We witnessed feeding of emigrants by day although they probably fed nocturnally as well. At times, queue members fed while marching by manipulating the food object with the anterior pereiopod pair while walking on the remaining posterior pairs, presumably retaining alignment by antennular contact and/or vision. The food in each case was probably recently obtained from the substrate. For example, holothurians and asteroid starfish common to the open sand were often carried by lobsters moving through those areas. Otherwise, lobsters milled about briefly in sea grass and algal beds apparently searching for food, although we didn't chance to see actual feeding at such times. Stomach content analysis also showed recently ingested material in a significant proportion of migrants The range of items was typical of the normal diet but reflected the biota of the pathway and included polychete, pelecypod, gastropod, crustacean and echinoderm material (n=29).

ASSOCIATED PHYSICAL CONDITIONS

Mass migrations typically occurred following frontal storms in an area according to our observations, reliable reports and island legend. Since such atmospheric disturbances modify the shallow water environment where migrations appear (and perhaps originate), both meteorological and hydrological conditions before and during the migratory period are of interest. Air and water temperatures were obtained from Lerner Marine Laboratory daily records and from our thermographs. Underwater visibility as an indication of turbidity was estimated by divers using a measured line.

Weather, in late September and early October, prior to population increases in the pathway and adjacent areas, was characteristically mild with air temperatures in the mid 80's (F) and with light winds predominately from the east and south quadrants. Our records from Bimini show the shallow waters (3-30 m) were generally calm with few large swells, temperatures in the low 80's (F) and useful diver visibility exceeding 20 m even in the lagoon and bank areas, which are usually slightly more turbid than the shelf area. Influx of lobsters to the pathway area occurred during such conditions in early October 1969. Build-up occurred during intermittent brief periods of squalls and gusty winds in late October 1971; the latter conditions being more typical for this period than earlier in the month. During squalls, wind comes mainly from the northerly quadrants, and higher velocities cause chop over the bank and larger waves seaward of Bimini. Turbidity usually increases, reducing visibility to 5 m or less on the bank as well as on the shelf where bank water is carried by tide, wind and currents, and where surge action stirs the substrate (Fig. 3). The turbid condition lasts only a day or so and is least apparent to the south and west of the islands.

The stormy periods we observed immediately prior to mass queuing lasted at least several days. Sustained winds from the NE and NW often exceeded 15 mph (22km/hr), and air temperatures dropped as much as 10-15F for several days. Sea conditions included heavy chop on the bank with intense wave action along the west shores, carrying onto the fringe of the bank north and south of Bimini. At such times, water visibility was less than 1 m. With return of mild weather and light breezes came the initial observations of daytime queuing in pockets of clear Gulf Stream water washing over the shelf along the southwest shore of North Bimini (Fig. 3). Water temperature drops of up to 5C also occurred on the bank and shelf during the storms as shown in Figure 6. Cold water was especially noticeable below thermoclines that formed at this time west of the islands in depths of 5-40 m.

The period following the onset of mass queuing varied from mild and calm to moderately stormy and was often followed by another storm within a few weeks. This pattern became characteristic of the late fall and winter. We have reports of several mass movements occurring in some regions between September and December but have not witnessed more than one major fall movement at Bimini.

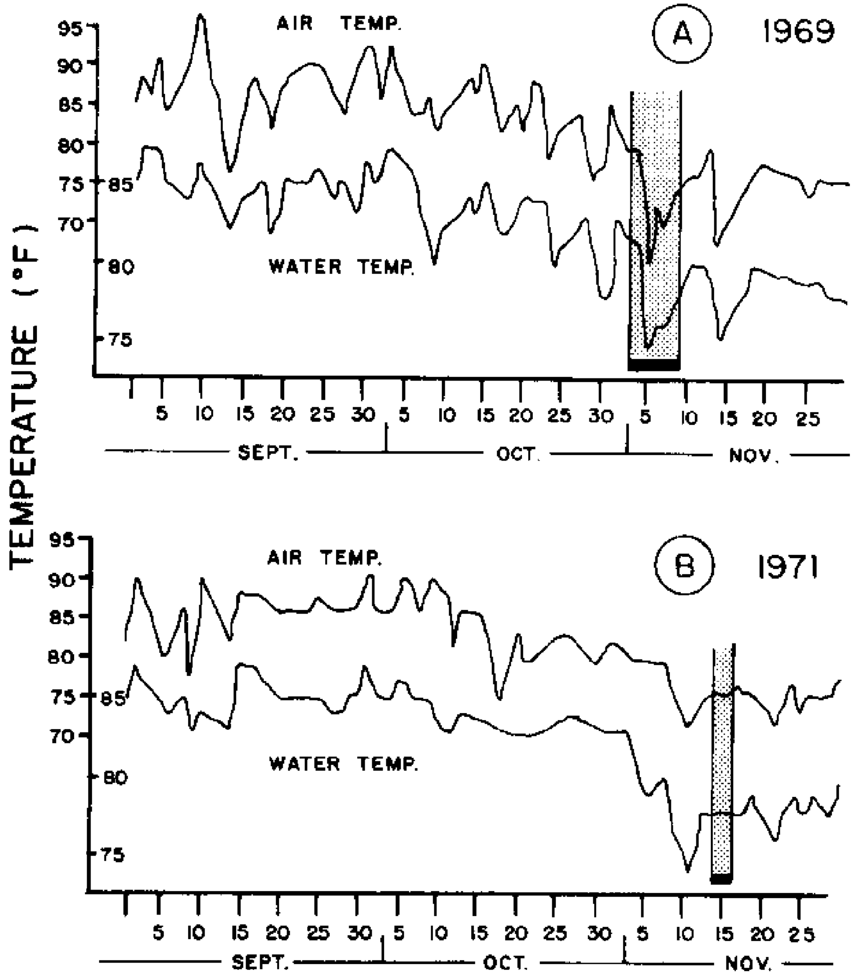

Fig. 6. Daily air temperatures (upper line each graph) and water temperatures (lower lines) plotted for the 3 month period preceding and including observed mass queuing (shaded area) in 1969 (a) and 1971 (b). Water temperatures were taken in the surf along the west shore of North Bimini contiguous with the migratory pathway.

DISCUSSION

The major sequential events of the mass migratory phenomenon may be summarized as follows: An influx of lobsters to the shelf area west of Bimini occurs during nocturnal movements over several weeks in October, causing a manifold increase in local population size. A severe autumnal squall causing high water agitation, increased turbidity and a temperature drop on the bank and shelf area, is followed by appeareance of up to 100,000 migratory lobsters. The migrants off Bimini are observed to move almost exclusively in queue formations, day and night, southward along the shelf area. The mass migration lasts up to 5 days, most lobsters moving through the area but some taking up at least temporary residence. The aspects bearing discussion are: (1) the change in population distribution in the region, (2) the apparent nexus with autumnal storms, (3) the significance of sociality to the mass migration, (4) the localized nature of the migratory direction and (5) the economic and conservational implications.

The autumnal pattern seems to involve two possibly related phases: first, a gradual movement of lobsters into the shelf region over several weeks, increasing both the population number and density in confined areas of suitable habitat; second, a synchronous mass movement including those lobsters from the previous period still residing in the pathway at the time but not excluding recruitment from as yet undefined areas. Certainly the pathway area population prior to the initial influx period was too small to generate the mass migrant group. The resultant effect in the pathway adjacent to Bimini following the migration is at least a temporary increase in population size made up of remnants of the migrant group; most migrants having emigrated from the area. Assuming no adult return movement (although lack of observations does not disprove occurrence of such an event) a significant seasonal redistribution of the local adult population occurs over an area of at least 20 km^2, but likely much larger.

We cannot as yet define and prove the functional significance of the mass migration and resultant population shift, but some inferences may be drawn. Reproductive aggregation is apparently not the immediate function. The frequency of occurrence of females in reproductive condition was low in the pathway throughout the fall and less than 1% for the mass queuing samples. Additionally, timing of mass migration mismatches the reported spring-summer reproductive period for other areas of similar environmental conditions, e.g., in Florida and Bermuda (Sutcliffe, 1953). Unless there exists an undiscovered winter breeding period or area, we suggest the mass movement affects reproduction only in an indirect, but perhaps crucial, way.

The area's potential reproductive population is increased, since a large number of young mature lobsters are redistributed along the shelf in habitats characteristic of adult habitation (Sutcliffe, 1952) and at a location adjacent major oceanic currents where larval release likely occurs (Allen, 1966). Such relocation occurs also in the U.S. Virgin Islands under quite different ecological conditions (Herrnkind and Olsen, 1971, unpublished report). There, the juvenile habitats are devoid of lobsters over 80 mm carapace length (c.l.), whereas the reefs from shore out to 20 m depth show a paucity of lobsters under 80 mm c.l. Obviously the life history of the Virgin Island lobsters includes a shift in habitat from the nursery areas to the reefs at about the age of sexual activity. We are presently sampling the reef (adult) and shallow bank (nursery) areas near Bimini to establish the general characteristics of those populations and to determine whether mass movements produce a similar effect.

The correlative evidence suggests that autumnal frontal storms trigger and synchronize the mass migratory population, but occurrence of influxes during preceding calm periods indicates the storms are not necessarily the only stimulus for migration. Other information implicates a probable change in internal state and other causal factors associated with migratory behavior. For example, lobsters in the field, and others taken from the migration and placed in laboratory pools, continued diurnal and locomotory activity under non-storm conditions. Queues off Bimini in 1969 and 1971 continued migrating in clear warm water, mostly of Gulf Stream origin. Lobsters captured from queues off Boca Raton, Florida, in 1965 continued daytime locomotion and frequent queuing for several weeks in an indoor pool (Herrnkind, 1969). Lobsters collected at other times remained active for only several hours. In a recent study, we found the duration of diel locomotory activity varies seasonally, probably in response to shifting photoperiod (Kanciruk and Herrnkind, in press). Such long term factors as photoperiod, gradual thermal change, nutrition and population density effects are now under study as possible influences on Zugunruhe.

Present information does not rule out the possibility that the physical disturbances from storms stimulate both queuing and a long lasting Zugunruhe. However, it is necessary to discriminate between stimuli evoking migration and stimuli evoking queuing, a behavior also exhibited under certain non-migratory conditions (although number of individuals, duration and orientation of queues in the latter case are much less impressive). We plan to test the effect of storm-related factors including sharp temperature changes, severe water agitation, decreased light levels and increases in suspended particles in the laboratory and, whenever possible, in the field.

The behavior of mass migrants shows an extremely strong tendency for sociality, even for a species congregative at other times. Lobsters living on reefs, for example at St. John, U.S. Virgin Islands, typically reside by day in specific dens with one or more other lobsters (Cooper and Herrnkind, 1971; Herrnkind *et al.* in prep.). Yet, nocturnal feeding forays as well as occasional long distance movements are performed solitarily, and single resident dens are not infrequent. The excessive sociality during mass migration is demonstrated by the close physical contact during queuing, resistance by grouped lobsters to a separation when disturbed by divers or bully-netters, and the strong tendency to reform queues or pods after forced dispersal. This is reflected in the fact that solitary lobsters made up less than 3% of observed migrants in open areas.

It presently appears that queues, pods and rosettes serve a protective function (Herrnkind, 1969). Additionally, queues possibly provide a mechanism assuring appropriate orientation of the entire population, facilitating establishment of congregations immigrating into areas low in population density. The strong social tendency at this time provides the necessary basis for these, or any other, consequential group behavioral adaptions.

The observed migratory pathway in 1961, 1963, 1969 and 1971 was southerly although the depth range and area covered varied somewhat among these years. Reports from other areas also suggest local directionality repeated at each migration; e.g., northward along the southeast Florida coast (Herrnkind and Cummings, 1964; Herrnkind, 1969) and westward at Grand Bahama (B. Rose, personal communication). No clear pattern of offshore or onshore movement has emerged, but all observed pathways included a definite along-shore component. Regardless, the differences in direction from place to place, and the slight year-to-year variability of the pathway at Bimini, suggest local guideposts rather than regional navigation cues. Our orientational research is presently focused on hydrodynamic cues such as current and wave surge since lobsters can orient accurately without vision and must do so during much of the migration (Herrnkind and McLean, 1971). Mechanisms involving visual cues (landmark, polarization and astronomical-compass orientation), magnetic cues, topographic gradients, kinesthesis, inertial guidance or chemotaxis are under scrutiny but seem less likely to operate under the known range of migratory conditions.

The economic and conservational implications are obviously important in each locality presently fishing the migrations. The Bimini lobstermen bully-net daily catches up to tenfold that normally caught at other times; i.e., 3 or 4 migration days are equivalent to a month's work. Diving lobstermen also make large catches as one of us (Herrnkind) observed off Boca Raton in 1965 when two free divers took over 200 lobsters in 1 hour. Hence, the catch per unit effort is exceedingly high for net, gig and snare capture methods where lobsters are actively sought. The process is further facilitated by the strong congregative behavior of the migrants. While the mass queuing may last only a few days, the population during the preliminary influx period and the remaining migrants are congregated in large groups, facilitating capture, and are available over periods of up to a month. The influence of the fall migration is therefore more extensive than suggested by its short duration.

The mass migrations are reportedly fished throughout the Bahamas (Herrnkind and Cummings, 1964) as are apparently similar movements in British Honduras (Allsopp, 1968). It seems likely the localized occurrences are weather dependent but cover the distributional range of the species in areas with appropriate ecological conditions. Also, the massive redistribution of lobsters may be consequential to the existing fisheries the remainder of the year and certainly for the month-long period bracketing mass queuing. Taking these points into consideration, the total migratory catch may reflect a significant component of the total spiny lobster fishery. Overfishing the mass queuing migrants could possibly result in regional depletion. Moreover, the phenomenon is a regularly occurring one of massive proportions and it is therefore reasonable to assume that its function (whatever) is of considerable importance to the species. If concentrated unregulated fishing occurs at this time, it might detrimentally influence the migration function, and thereby adversely affect the population as a whole.

In our opinion the potential economic and ecological implications of this phenomenon are not recognized by most marine scientists and fisheries experts. Hopefully the information and discussion presented here will serve to increase interest in the further research of mass migrations within the milieu of lobster population dynamics and behavior. We believe the coordination of broad based fisheries research techniques with the *in situ* and laboratory methodology partly elaborated here is necessary to ultimately elucidate this problem.

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A Long Line (Set Line) Retrieval System[1]

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ABSTRACT

The efficiency of certain pot and trap fisheries can be increased by utilizing a longline (set line) system. Longline systems have certain inherent advantages when pots or traps are fished in deep water, in fisheries where rough or stormy weather is a common feature and where a large amount of gear must be efficiently handled.

A longline system can be defined as attaching pots to a long ground line at intervals suitably spaced for the particular fishery. The ground line is attached to anchor lines at each end. The anchor line, in turn, proceeds to the surface where it is buoyed. Extensive sea trials along the Oregon Coast have demonstrated that Dungeness crab pots can be rigged in a longline system for approximately 55% of the cost of individually-buoyed gear. The savings increase as the fishery proceeds into deeper water. Working efficiency is increased as the gear can be retrieved more rapidly than individually-buoyed gear in any depth exceeding 10 to 12 fathoms. If vessel steering and engine controls are installed at the gear-hauling station, it is possible to reduce the crew by one member. Gear loss has been radically reduced and fishing time is optimized because buoys and longline systems have a great deal more buoyancy than is possible with individually-buoyed gear and, hence, longline gear can be retrieved in conditions of adverse current that preclude recovery of individually-buoyed gear. Continued field experience dictates that additional savings are possible as the gear can be more lightly constructed than the traditional individually-buoyed gear.

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[1]Complete details of this fishing method are described in: A Long-line (Set-Line) Crab Pot System by R. Barry Fisher, 1970, Circular of Information 630, Agricultural Experiment Station, Oregon State University, Corvallis, Oregon.

Quality Control – A Solution to Fish Inspection

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What would happen to our seafood industries if the Wholesome Fish and Fisheries Product Act became effective tomorrow? The possibilities are limited only by one's imagination as to the final wording. Certain vessels would not be allowed to engage in commercial fishing; those that were might lose their catch to seizure because of unsanitary practices. Fish houses might be forced to close their doors because of improperly constructed facilities. Some processing operations might not meet inspection requirements while others that did would find themselves in a supply shortage. The picture painted can be very grim.

This is only hypothetical thinking because if the Wholesome Fish and Fisheries Product Act (S. 2824) were passed today, its enforcement would be at least 2 years in the future. There is probably more time than that involved because all sources indicate the bill is virtually dead for this year.

This paper is not another shouting of "wolf" or a scare tactic to promote quality control. Its purpose is to present some of the basic factors affecting quality and how they can be dealt with in daily operations. Quality control should be a way of life in or out of the hovering shadow of fish inspection. If everyone in the fishing industry, from harvester to consumer, were aware of factors that might affect the quality of the product and practiced quality control on a daily basis, the eventual passage of the Wholesome Fish and Fisheries Product Act would be token in nature. In this sense, quality control would be the solution to fish inspection.

The seafood industry has many problems, each complimenting the other. The harvester must spend more time at sea to reach a break-even point. Processing in many cases still involves a large hand labor force, and the human factor complicates a quality control program. Existing marketing channels are complex; this increases the number of times a product is handled and the time before it reaches the consumer. Retail stock rotation or turn-over is often inadequate, and consumer confidence dwindles each time mercury or botulism scares are publicized.

All phases of the industry have one common goal – to supply a product at a profit. Poor quality seafoods can directly affect this goal in several ways: (1) Failure of certification by inspectors could result in the banning of individuals from the harvesting, processing or marketing of seafoods; (2) Products of poor quality are subject to seizure and destruction; (3) Consumer acceptance is dependent on a consistently high quality product; and (4) Possible human illness from a contaminated product could lead to legal complications.

The quality of a product can be judged in many ways, including uniformity of size, color, texture, weight and other criteria. The most noticeable and offensive indications of loss of quality are discoloration, off-odors and off-flavors.

These organoleptic quality changes include: (1) enzymatic changes caused by the breakdown of certain substances by enzymes that occur naturally on the product; (2) oxidative reactions such as rancidity and melanosis (dark discoloration) and (3) spoilage from growth of bacteria – the most important single factor causing quality deterioration.

In the seafood industry we are concerned with two groups of bacteria: those causing food spoilage and those causing human illness. Spoilage bacteria thrive on available nutrients and water present in food products. As these bacteria use the nutrients, they produce waste products often resulting in a bad odor and/or bad flavor of the product. There are three major factors that determine the shelf-life (time a product is in storage before it spoils from bacteria). These factors are the number of bacteria present on the product, the type of bacteria present and the temperature of storage.

Figure 1 shows the influence of number of bacteria on product shelf-life. The product with the higher initial bacterial count will usually have a shorter storage life. There are many steps in the harvesting and processing procedures that can influence the number of bacteria present on a product.

The length of time a catch is in the net can have two effects on quality. First, long trawls can result in physical destruction of the product, thus providing for an early invasion into the deep tissues of bacteria living on the slime or skin. Second, if fish are stressed or excited before death, their body chemistry changes and they go through the process of *rigor mortis* sooner. The keeping quality of a catch that has gone through early *rigor mortis* because of stress may be shorter than the catch that was not excited.

The first surface with which a catch comes into contact after removal from the net or line is the deck. If this surface is not in good repair and not adequately cleaned, it can be a major source of bacterial contamination. The deck surface where shrimp or fish are landed should be of an easily cleanable material. Wooden surfaces soak up slime and water, creating a natural place for bacteria to hide and multiply. Decks should be scrubbed clean with a detergent and sanitized with 200 parts per million (ppm) chlorine solution at least once a day. The deck should be rinsed adequately before and after each catch.

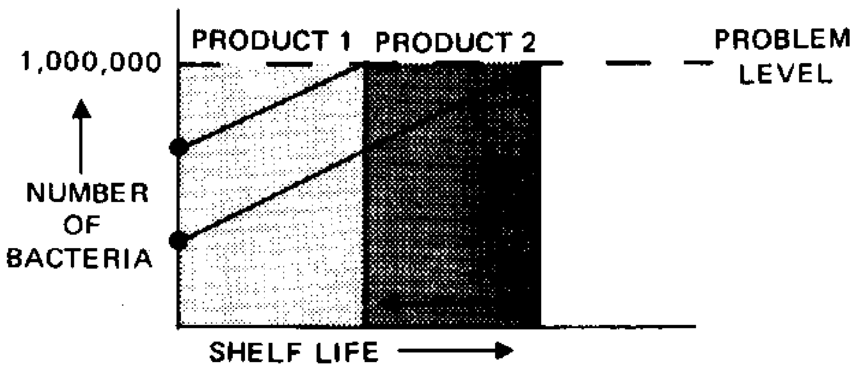

Fig. 1. The influence of bacterial number on a product's shelf-life.

In the case of shrimp, removal of the heads as soon after catching as possible is an important factor in the storage life of the product. The head carries about 75% of the total bacteria found on shrimp. If the shrimp are not headed immediately, these bacteria are transmitted to the surface of the tails where they then invade the tissue. Captains should insure that new deck hands are familiar with the proper heading technique. If front legs are left on or the contents of the head are mashed on the tail, the shelf-life of the shrimp is significantly reduced.

Some reports indicate that as much as 75% of the bacterial count can be reduced by washing. Headless shrimp from Gulf waters are reported to contain 51,000 bacteria per gram. After thorough washing with sea water, this count can be reduced to 7,400 per gram (Green, 1949).

Any delay from time of catch to refrigeration will result in the loss of shelf-life time. Temperatures in the Gulf of Mexico and Caribbean are usually quite warm. Shrimp should be headed and iced immediately. Research data (Feiger *et al*, 1958) show that after 11 days of storage on ice, shrimp exposed to the air (79-84F) for 2 hours before being iced had a bacterial count three times higher than those iced immediately. Shrimp exposed to the air for 6 hours before being iced had counts seven times greater than those iced immediately. In many instances, it is difficult to head and ice shrimp immediately. Bacterial growth could be reduced by placing ice on the pile of shrimp while on the deck. The time on deck has also been shown to be an important factor in the percentage of shrimp with black spots. After 11 days storage, shrimp on the deck for 0, 2 and 6 hours exhibited 14, 55 and 98% shrimp with melanosis, respectively.

Holds used to store seafoods are probably as varied in design and construction as are the many boats fishing Gulf waters. Under new regulations, holds will probably be required to have false bottoms to prevent contamination of seafood by bilge water and to be constructed of nontoxic material that facilitates cleaning and sanitizing. Most vessels have wooden or concrete holds, neither of which is easy to clean. Ideal hold-lining materials such as stainless steel, fiberglass, epoxy-coated plywood and plastics are expensive and hard to put in old boats. A simple way to cover the inside of the hold is with polyethylene film. The material is readily available, inexpensive and easy to install. It protects the product from the wood and protects the hold from moisture. The 6-mil polyethylene (which should be Food and Drug Administration approved) is simply stapled in, then ripped out at the end of each trip.

There are many sources of bacterial contamination in a processing plant. Each step in the processing procedure can lead to some type of contamination. Raw products entering processing plants already have a certain bacterial population. This population may be small or large depending on the conditions and time from harvest to unloading. These bacteria can be left on equipment and can multiply using available food and water residues on the equipment. Despite the quality of the next raw product, it can become contaminated. Shedding of bacteria from arms and hands, coughing, sneezing, speaking and breathing contributes to the bacterial counts of air samples around workers. The number of people in an area and the extent of their physical activity also affects the count.

Airborne contamination has received little attention in non-sterile products because of the difficulty in identifying the source. Researchers (Heldman and

Hedrick, 1971) have shown that bacterial counts in air samples increased almost four times when fans were first turned on. After the fan had run for 35 minutes, the counts returned to normal. Flooding of floor drains that had not been used for 12 to 15 hours significantly increased the airborne bacterial level in the area around the drain.

Airborne materials other than bacteria can present problems. Two researchers (Thompson and Farragut, 1969) investigated the incidence of green discoloration in raw breaded shrimp and found that metal particles from air contamination were causing the problem. This incident emphasizes the importance of plant location. In this case, the amount of metal dust in the air was related to wind direction and location of the plant.

Regularly scheduled cleaning and sanitizing operations will eliminate large numbers of bacterial contaminants from hold surfaces, equipment or processing areas. Regardless of what is cleaned or what sanitizer is used, this simple four step operation should be followed: (1) pre-rinse – to remove large particles of food waste or slime, (2) clean – scrub wash with a detergent, (3) rinse – apply suitable sanitizing agent and (4) rinse – if the sanitizer is corrosive to metal, it should be removed with a final rinse.

The past statements have been about factors leading to the contamination or addition of bacteria to a product. Although a high bacterial number does not always indicate a poor quality product, generally the higher the bacterial count the more rapid the spoilage. In some cases, large numbers of organisms could be present and if they were inert, the product would still be of an acceptable quality.

Figure 2 shows the influence of bacterial type on shelf-life. Many of the typical spoilage bacteria are capable of growing even at refrigeration temperatures. When "cleaned" shrimp were inoculated with either a coryneform or pseudomonad organism, the spoilage patterns were very different (Cobb and Vanderzant, 1971). The rapid growth of the pseudomonad at refrigerated temperatures and subsequent spoilage at 11 days is compared to the slow growth of the coryneform and an extenuation of the shelf-life by 10 days. In a study of pond-raised shrimp and Gulf of Mexico shrimp (data in print), results indicate that the typical spoilage organisms *(Pseudomonas)* are not a part of the normal flora. Most of the quality problems arise from bacteria that originate from human beings, the equipment and tools used, poor-handling practices and storage at too high a temperature for too long a time. By applying fundamental knowledge about these bacteria, their number can be kept at a minimum. This can be accomplished by avoiding the addition of more bacteria to a product, and/or by proper handling and refrigeration techniques.

Types and numbers of bacteria fluctuate with changes in temperature and salinity. Differences in bacterial populations may be noted as water temperatures become warmer or cooler. Bay catches may be composed of different bacteria than Gulf catches because of differences in salinity and pollutants.

Poor quality wash water or ice are contamination sources. Bacteria in ice are already accustomed to cold temperatures (referred to as psychrotrophic bacteria) and can produce off-odors and off-flavors at refrigeration temperatures.

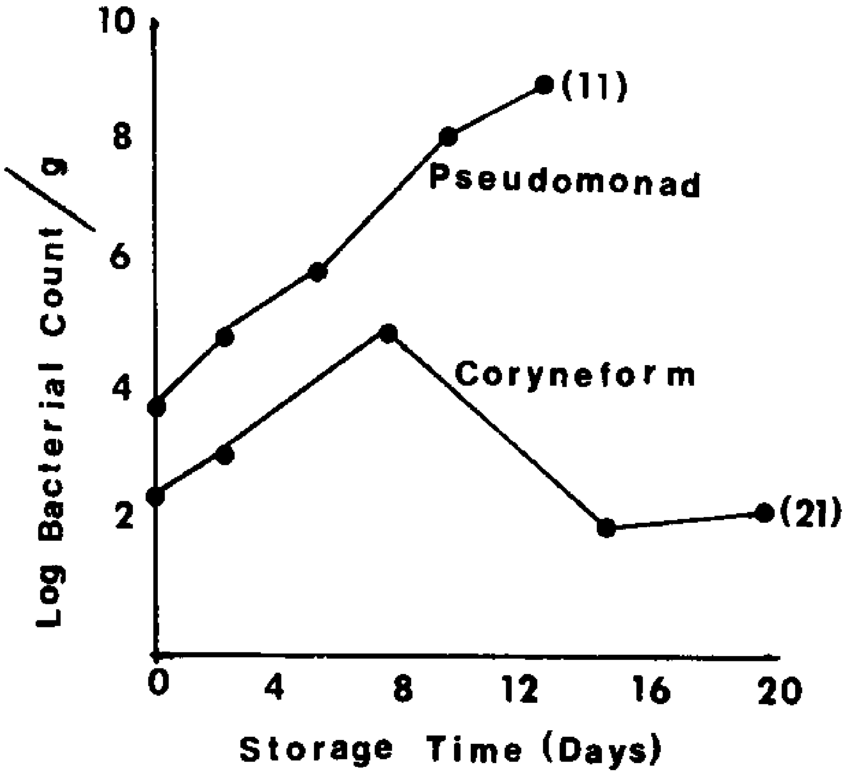

Fig. 2. Bacterial counts of shrimp inoculated with a pseudomonad and a coryneform bacterium.

The third important factor influencing the ultimate storage life of a product is temperature of storage. Figure 3 shows the effect of different icing rates on shelf-life. The product with good icing (for example, 1 pound of shrimp stored in 2 pounds of ice) will last three times longer than the product stored at a poor refrigeration temperature (such as 2 pounds of shrimp per 1 pound of ice).

Proper icing procedures can be a valuable asset in prolonging the quality of seafoods. Ice can prevent bacterial build-up in four ways: (1) It lowers the temperature and slows the growth rate of most bacteria; (2) It lowers the salt content of the product and eliminates some bacteria that require salt for growth; (3) It provides a continuous washing that removes bacteria and slime, and (4) Melting ice appears to reduce the level of discoloration.

When shrimp are placed on ice, they are sometimes placed in layers. These layers should be as thin as possible. The best way to ice shrimp is to mix shrimp with ice, using twice as much ice as there is shrimp (Carrol, 1968). If the melting ice is allowed to flow through many layers of shrimp, the bacteria washed off the top layers will accumulate on the bottom. One study (Green, 1949) showed that bacterial counts on top layers increased only two times while the counts in

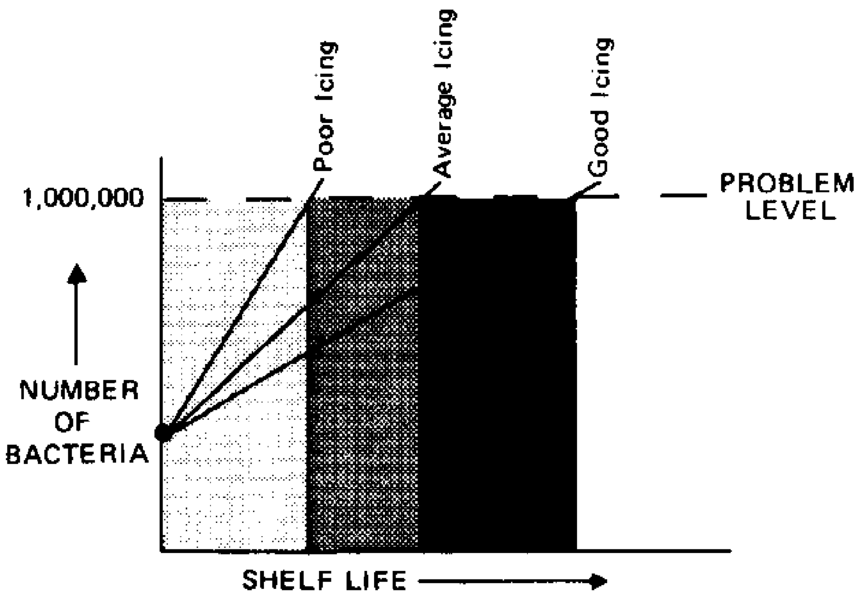

Fig. 3. The effect of storage temperature on the shelf-life of a seafood product.

bottom layers increased 1,000 times. (The water draining from the bin contained 23 billion bacteria per gallon). Ice should be used in adequate amounts on floors and walls to prevent the product from touching these surfaces.

The following substances when added to ice were no more effective than commercial ice of a good quality – chlortetracycline, tannic acid, sodium bisulfite and ascorbic acid-citric acid (Fieger *et al*, 1956). The use of either crushed or flaked ice, coupled with improved handling practices, will improve the keeping quality of shrimp or fish as much or more than the use of any of the above mentioned additives.

In subtropical and tropical waters such as the Gulf of Mexico or Caribbean, insulation of holds should be considered a must. Besides a considerable savings in ice, seafood storage in insulated vessels requires less labor. On long trips the amount of re-icing is reduced. Work on insulating ice bunkers and fish holds (Angel, 1972) indicates that shrimp from an insulated vessel were of a higher quality than those from an uninsulated vessel. The insulated vessel also consumed 67% less ice than the other vessel.

Freezing is probably the best tool we have for preserving food products. Unlike other methods of preservation, changes in physical and chemical properties by freezing are minor. Spoilage of frozen products is usually attributable to autolysis, or breakdown of enzymes in the fish tissue (Burgess *et al*, 1967). Bacterial growth is inhibited below about 15F whereas autolysis may still proceed at a slow rate at -20F. A good quality frozen product is determined by: (1) quality of the fresh product, (2) freezing time and rate, (3) storage temperature, (4) packaging material, (5) time of storage and (6) type of fish or seafood.

All deck-hands, vessel captains, processing plant employees, managers and owners should be aware of the various factors that determine the quality of the seafood they are handling. The Texas Agricultural Extension Service, through the Sea Grant Program, tries to accomplish this task by providing newsletters to the commercial fishing industry, by conducting workshops on quality control for commercial fishermen and processing plant employees and by supplying bulletins on quality control.

If the entire seafood industry practiced the basic principles of quality control and produced a perfect product, would our problems be solved? No! There is one final important step. Regardless of the quality of a seafood product, if it is mishandled or abused in the home or institution, the blame will rest with the industry. Our quality control program should therefore extend to the user through consumer education.

Mishandling in the home or institution can lead to two types of problems – spoilage and food poisoning. For example, if a good quality frozen product is thawed improperly, spoilage off-flavors and odors can be produced before cooking. It is convenient for a housewife to place frozen fish out to thaw before she leaves for work and prepare it when she returns 9-10 hours later. This could be prevented if the housewife were informed that the best way to thaw frozen seafoods is under cold running water just before preparation.

Current information on the place of acquisition of food-borne illness (U. S. Dept. Health, Education and Welfare, 1971a) shows the home and food service establishments to be the main areas of food poisoning problems. In the majority of cases, food poisoning could have been prevented by proper handling of the food. Good examples are two recent outbreaks of gastroenteritis involving seafoods. On the Atlantic Coast, 320 persons attending a picnic became ill from eating crabs contaminated with the bacterium *Vibrio parahaemolyticus* (U.S. Dept. Health, Education and Welfare, 1971b). After the crabs were steamed, they were placed in a truck with baskets of live crabs being placed on top. The steamed crabs were probably free of the disease bacterium, but were contaminated by the raw crabs. The warm temperature of the cooked crabs was ideal for the rapid multiplication of the organism. Another more recent incident (U.S. Dept. Health, Education and Welfare, 1972) involved 600 persons at a "shrimp boil" on the Gulf coast. The incriminated shrimp were boiled, then stored at ambient temperatures for 5-6 hours before being served. The raw shrimp contained a small number of *V. parahaemolyticus*. If large quantities of shrimp were being boiled at one time, the internal temperature of the shrimp may have been too low to destroy the bacteria. During the several hours that the shrimp were held at ambient temperatures prior to eating, *V. parahaemolyticus*, with a generation (dividing) time as short as 20 minutes, would have had ample time to multiply to levels high enough to cause illness.

Incidents like these can be avoided by educating the food-handler in the home and food service establishments. The following guidelines should be observed with any food product: (1) Cooked foods should not be exposed to warm temperatures for long periods of time; (2) Cooked foods should be stored in clean containers; (3) Cooked foods should not come in contact with the raw product; and (4) Areas such as cutting boards should be thoroughly cleaned after raw products have been processed and before cooked products are processed.

The passage of a "fish inspection" act is inevitable. The results of such legislation on the seafood industry will depend on the industry's willingness to meet the challenge of producing the highest quality product. Few people would deny the need for such a law, but most are handicapped in their attempt to provide the quality assurance needed in the day of "consumer protection." The conscientious vessel captain is often paid the same price as is paid for the poorer quality catch. The processor is plagued with the problem of maintaining the quality of the raw product received. With some raw products, there is no margin of error. Who should be responsible for the quality of seafood products? We can't blame the consumer for mishandling, but we can make the consumer aware of proper handling procedures. The processor states that the problem is at the boat level; however, it is impossible for any inspection system to monitor the activities of individual vessels. Ultimately, processors will pay harvesters prices related to the quality of their seafood. This has been and is still impossible because simple, reliable tests for the determination of freshness are non-existent. A test that may be used in determining the quality of shrimp is being developed. The test, based on a ratio of Total Volitile Nitrogen and Amino Nitrogen, requires about 20 minutes, is approximately 85% confident and can be conducted at the fish house (Cobb, B. F. III, personal communication).

Fish inspection is still a few years in the future. There is time to prepare, and the harvester and processor should work together towards the production of a consistently high quality seafood product. Quality control today produces a higher quality product tomorrow and will solve many of the problems that could be associated with a fish inspection law.

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Effect of Sanitation Procedures on Bacterial Levels in Blue Crab Processing Plants

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The seafood industry needs additional effort on the control of microorganisms. During the processing of crabmeat, there is a possibility that large numbers of bacteria may be brought into the plant on the raw product and by the workers. Also, a serious increase in bacteria can occur if adequate sanitary practices are not used throughout the plant. This laboratory has previously made studies on the level and types of microorganisms occurring in commercial crabmeat. However, a detailed study of in-plant levels needs to be accomplished. Once the levels have been established and problem areas identified, methods of control can be established.

This investigation involved the examination of the microbial level and an appraisal of the in-plant sanitation conditions at various points throughout the processing cycle. The object of this study was to establish levels of microbial organisms found in the finished product and throughout the processing operation.

MATERIALS AND METHODS

The microbiological sampling techniques involved sampling the finished product, personnel hands, equipment and utensils throughout the plant. Sterile swab tubes containing 10 ml of polypeptone diluent plus antifoam were used for collecting samples for total microbial numbers from the equipment, utensils and personnel. Each sample was taken during plant operations by swabbing the same location for each replication between the hours of 10:00 and 11:00 a.m. each sample day. Variations were held at a minimum by sampling the same areas for each trial throughout the study. Location of samples were labeled alphabetically as shown in Figure 1. Swab samples represented an area of approximately 8 in^2 with the exception of areas F (hand samples), N (faucet handle) and Q (knife). The hand samples were taken on a 4 in^2 area using the palm of the worker. The faucet handle samples were taken on a 4 in^2 area covering the four prongs, top and bottom. The knife samples were taken on a 4 in^2 area of the blade and were taken from the same worker whose palm was swabbed.

Enumeration of total bacterial numbers was made by removing 10 ml of swab tube diluent and placing into 90 ml of polypeptone diluent (1:10 dilution). Standard plate counts were determined using plate count agar according to standard methods of the American Public Health Association (1967). Incubation was for 48 hours at 35-37C.

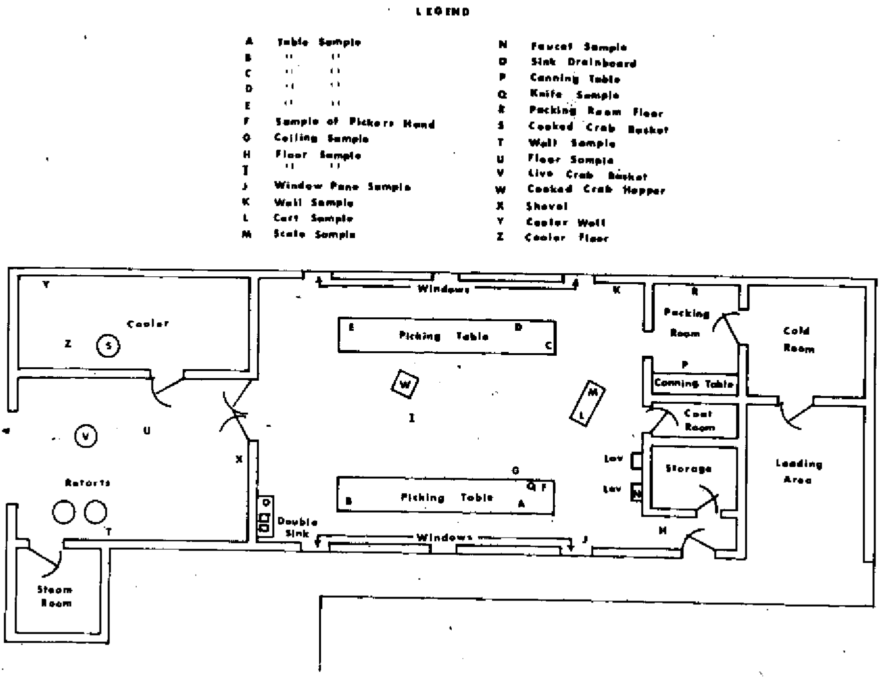

Fig. 1. Schematic design of sampling locations in a blue crab processing plant.

Sampling procedures varied for whole crabs, crab claws and "special" and claw crabmeat. Samples were taken of whole raw crabs upon arrival at the plant and whole cooked crabs after an overnight chill (approximately 18 hours). Whole crabs were placed separately in sterile "whirl-pak" bags using sterile tongs, packed in ice and delivered to the laboratory within 2 hours. One hundred ml of sterile polypeptone diluent was added for each crab, and the bag shaken 25 times. A 25 ml aliquot was removed and mixed with 225 ml of diluent (1:10 dilution).

Samples of whole cooked claws were taken after removal from the crab during the picking operation. Claw samples consisted of 10 average sized whole claws selected from the production container. Each sample was placed in a "whirl-pak" bag packed in ice and delivered to the laboratory within 2 hours. One hundred ml of polypeptone diluent was added, and the bag shaken 25 times. A 25 ml aliquot was taken and mixed with 225 ml of diluent. Total bacterial numbers were determined as described above.

The samples of blended claws were handled as above, except upon arrival at the laboratory 200 ml of diluent were added to the claws and homogenized in a Sunbeam blender for 2 minutes.

Samples of "special" crabmeat and clawmeat were taken at three points in the process: (1) meat as it was being picked, (2) meat that had been picked 30 minutes and (3) meat which had been chilled for 4 hours. Each of these samples

Table 1. Total Bacterial Numbers for Equipment in Blue Crab Processing Plant[a]

Sample Area	Code	Sample Date[b] Nov. 19	Dec. 7	Feb. 23	May 1	May 3	June 7	June 13	June 14	June 20	June 21	June 27	Range
Table Picking	A	850	150	46	120	32	1,200	100	7	170	100	190	7 - 1,200
Table Picking	B	1,200	38	570	160	250	150	210	50	130,000	120	2,500	38 - 130,000
Table Picking	C	940	95	170	140	820	80	120	65	1,300	3,100	1,500	65 - 3,100
Table Picking	D	920	350	310	500	190	60	3,700	20	120	11,000	16	16 - 11,000
Table Picking	E	12,000	470	560	150	650	28	170	37	110	1,100	64	28 - 1,200
Hands Pickers	F	720	57	900	520	47	2,000	1	1,700	3,200	190,000	1,100	1 - 190,000
Cart, Weighing	L	550	92	190	270	7	430	600	140	30,000	5,300	2,200	7 - 30,000
Scale	M	1,200	600	920	3,000	120,000	1,300	500	800	22,000	3,200	4,600	500 - 120,000
Table, Packing	P	11,000	3	260	12,000	2	750	40	1,400	280	110	75	2 - 12,000
Knife, Picking	Q	930	2	230	75	2	870	2,200	400	1,600	33,000	3,000	2 - 33,000
Crab Cook Basket	S	18	140	0	5,200	0	12,000	0	330	110	1,300	480	0 - 12,000
Live Crab Basket	V	220,000	600	-	-	-	-	-	-	-	-	-	600 - 220,000
Crab Cook Hopper	W	250	210	3,600	-	3,200	0	3,000	43	17,000	-	2,600	0 - 17,000
Shovel, Cook Crab	X	160	620	250	670	1,500	960	140	1,500	1,700	-	41	41 - 1,700

[a]Numbers are organisms per in^2

[b]Nov. and Dec. were in 1971 and remaining dates were in 1972

was taken from the same can. Samples were removed aseptically from the center of the can for each examination.

To prepare the meat for bacteriological examination, one part of the meat was blended with nine parts of diluent for 2 minutes and analyzed as previously stated (American Public Health Association, 1967).

A routine cleaning procedure for the plant was conducted at the end of each working day. The procedure was to remove all debris from the area, and the floor was swept. A clean crab cart was filled with a mixture of water and detergent, and used to wash the tables and equipment. After cleaning, the small equipment was dipped in a 200 parts per million (ppm) chlorine solution. The remaining detergent mixture was placed on the floor. The floor was scrubbed and the tables and floor rinsed with cold water. At the beginning of each day, the picking tables were rinsed with a 200 ppm chlorine solution.

Table 2. Total Bacterial Numbers for Facilities in Blue Crab Processing Plant[a]

Sample Area	Code	Sample Date[b] Nov. 19	Dec. 7	Feb. 23	May 1	May 3	June 7	June 13	June 14	June 20	June 21	June 27	Range
Ceiling, Picking Room	G	-	12	0	45	12	0	1	0	0	10	0	0 - 45
Floor, Picking Room	H	>370,000	11,000	>370,000	>370,000	>370,000	17,000	17,000	8,000	>370,000	>370,000	>370,000	8,000 - >370,000
Floor, Picking Room	I	300,000	87,000	21,000	300,000	190,000	300,000	>370,000	>370,000	>370,000	>370,000	>370,000	21,000 - >370,000
Window, Picking Room	J	17	410	5	8	2	1	1	0	3	0	0	0 - 410
Wall, Picking Room	K	62	1	25	2	61	30	2	0	0	0	2	0 - 62
Faucet Handle	N	30,000	>750,000	13,000	-	>750,000	>750,000	>750,000	>750,000	>750,000	>750,000	>750,000	13,000 - >750,000
Sink, Picking Room	O	11	8	4	9	0	11	20	0	10	76	2	0 - 76
Floor, Packing Room	R	19,000	47,000	1,700	1,400	41,000	10,000	110,000	12,000	>370,000	140,000	310,000	1,700 - >370,000
Wall, Cook Area	T	21	20	8,400	14	5	0	1,100	180	6,300	810	140	0 - 8,400
Floor, Cook Area	U	10,000	>370,000	31,000	270,000	>370,000	200,000	>370,000	210,000	>370,000	-	>370,000	10,000 - >370,000
Wall, Cooler	Y	0	0	3	3	0	0	0	0	0	-	1	0 - 3
Floor, Cooler	Z	-	140,000	>370,000	22,000	91,000	1,700	200,000	2,000	22,000	-	15,000	2 - >370,000

[a]Numbers are organisms per in^2

[b]Nov. and Dec. were in 1971 and remaining dates were in 1972

For comparative purposes, two additional studies were conducted.

In the second experiment, total bacterial numbers were taken on commercially harvested live whole crabs after transfer to the pilot processing laboratory. Crabs from the same lots were cooked and counts taken on the cooked whole crabs and the meat from selected samples of the same cook lots. Bacterial samples on the whole crabs were taken by rinsing each crab in 100 ml of sterile polypeptone diluent as described previously. Also, samples from crabmeat were prepared and analyzed as described previously. Total bacterial numbers were expressed as count/g.

In addition, a third experiment was conducted to determine the types of bacteria in commercially processed fresh and frozen crabmeat. The fresh crabmeat was stored for 2 days at 0C. Crabmeat stored for 1 day at 0C was frozen and stored at −29 ± 2C for 77 days. This sample was then thawed at 0C and stored for 1 day prior to analysis. All samples were analyzed for total bacterial counts, psychrophiles, coliforms, anaerobes, yeasts and molds by the technique of American Public Health Association (1967).

RESULTS AND DISCUSSION

The data shown in Tables 1 and 2 indicated that most areas sampled had extremely large variations in total bacterial numbers during the sampling period. These variations can be attributed to several factors. First, there was a seasonal variation which may have been temperature or simply day-to-day variation in sanitation practices. Second, there were major differences among the areas sampled. In general, the ceiling, walls and windows were relatively low in total bacteria. However, the floors were extremely high relative to other areas of the plant. The equipment and personnel hands were moderately high when compared to the previously mentioned areas.

It is evident from the data presented in Table 3 that a large variation in total number of bacteria was present for each sample. Numbers of bacteria present on

Table 3. Total bacterial numbers for blue crabs from various stages of processing

Sample Description	Code	Sample Date (1972) May 10	May 15	May 16	May 17	May 22	May 23	June 7	June 13	June 14	June 20	June 27	Range
Whole Raw Crab Surface[a]	27		230,000						1,800,000				230,000 - 1,800,000
Whole Cooked Crab Surface (overnight chill)[a]	28	270	980	1,200	1,800	9,600	8,500	395	750	4,000	470,000	70,000	270 - 470,000
Special Meat Picking Area[b]	29		19,000	230,000	140,000	64,000	88,000	9,700		6,050	14,000	37,000	14,000 - 230,000
Special Meat Packed, 0 hrs Chill[b]	30	190,000	7,700	26,000			11,000	6,800		56,000	14,000	14,000	7,700 - 190,000
Special Meat Packed, 4 hrs Chill[b]	31	120,000	41,000	130,000	4,400		12,000	4,400		3,250	10,000	14,000	3,250 - 130,000
Whole Cooked Claw Surface[c]	32	15,000	180,000	50,000	340,000	250,000	180,000	150,000		420,000	760,000	160,000	15,000 - 760,000
Whole Cooked Claw Blended[b]	33		1,600,000	28,000	150,000		560,000	120,000	124,000	350,000	600,000	110,000	28,000 - 1,600,000
Claw Meat Packed[b]	34	8,800	97,000	62,000	120,000	12,000	9,500	26,000	12,800	31,000		38,000	8,800 - 120,000
Claw Meat 4 hr Chill[b]	35	750,000	18,000				44,000	19,000	21,000	46,000	51,000	10,000	18,000 - 250,000

[a]Numbers per crab

[b]Number per gram

[c]Numbers per ten claws

the whole raw crab were high when compared to the cooked product. This indicates the importance of maintaining restricted areas for separating raw from cooked products. The reason for a higher number of bacteria occurring in the special meat from the picking area than that from the packing area is not evident. Since this situation was found in 9 of the 11 trials, it was attributed to either the type of sampling or a bacterial injury condition. Further research is needed to clarify this point. It is evident that the whole cooked claws are a potential source of contamination and special procedures are needed to reduce the surface contamination.

Data in Table 4 indicated that numbers of bacteria from live whole crabs, cooked whole crabs and fresh picked crabmeat were relatively high for laboratory processing conditions when compared to the results in Table 3. These data suggest that the ability to routinely reduce the level of fresh picked crabmeat below 50,000/g would be extremely difficult.

The results for types of bacteria in fresh and frozen commercially processed crabmeat are presented in Table 5. In this particular study, all types enumerated were at a relatively high level, with psychrophiles and coliforms being especially prevalent. As would be expected, the freezing effect reduced numbers except for anaerobes. It is possible that conditions developed during the thawing of the frozen sample, and the 1-day storage afterward, resulted in the growth of some anaerobes.

It is beyond the scope of this study to establish that the results were high or low for crab processing operations. However, the results indicate those areas requiring greater sanitary treatment. In most cases, the variation was extremely high among sampling dates for a specific sample area. This too would indicate that there is need for increased emphasis on sanitation, since there is the potential, under commercial operating conditions, for reducing the bacterial numbers to a level near the low reported for each sample area. Also, the data indicated that extreme cross-contamination occurred and the segregation of processing operations would probably improve this condition.

Table 4. Total bacterial numbers for live and cooked crabs and crabmeat processed under pilot laboratory conditions.

	$\bar{x}$	r
Live whole crabs	4.5×10^8	(1.6 - 7.4)
Cooked whole crabs	1.8×10^4	(.09 - 5.7)
Crabmeat, fresh picked	4.1×10^4	(2.5 - 5.8)

Table 5. Distribution of bacterial types in fresh and frozen commercial crabmeat.[a]

Type	Fresh[b]	Frozen[c]
Total bacteria count	1.9×10^4	1.2×10^4
Psychrophiles	9.6×10^3	9.2×10^3
Coliforms	3.5×10^2	3.1×10^1
Anaerobes	7.2×10^2	3.6×10^3
Yeasts and molds	2.5×10^1	5.4×10^1

[a]Each mean represents 6 samples analyzed in duplicate. All samples were taken from uniformly mixed lot.

[b]Crabmeat stored 2 days in iced condition ($\sim 0^\circ$C).

[c]Crabmeat frozen after 1 day in iced condition and stored 77 days at $-29 \pm 2^\circ$C; thawed and stored 1 day in iced condition ($\sim 0^\circ$C).

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Total Utilization of Fishery Products

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We can no longer tolerate either discarding as a waste and pollutant or reducing to low-grade animal feed the majority of the some 70 million metric tons of fishery products annually removed from the sea. This waste and pollution starts on the fishing boats, where soluble components end up in the bilge and are subsequently discharged into harbors adjacent to fish plants. A similar problem exists with solubles in the discharge water from processing plants. Not only do solubles create an unacceptable pollution problem, but they represent a valuable proteinaceous food material that should be recovered. Likewise, much of the solid waste currently being reduced to low-grade animal food or discarded as a waste product can and should be upgraded to human foods or high-grade animal feed components.

These problems are prevalent in all areas of our industry from the large processing complexes to the small "family" operations. Hence, the problems

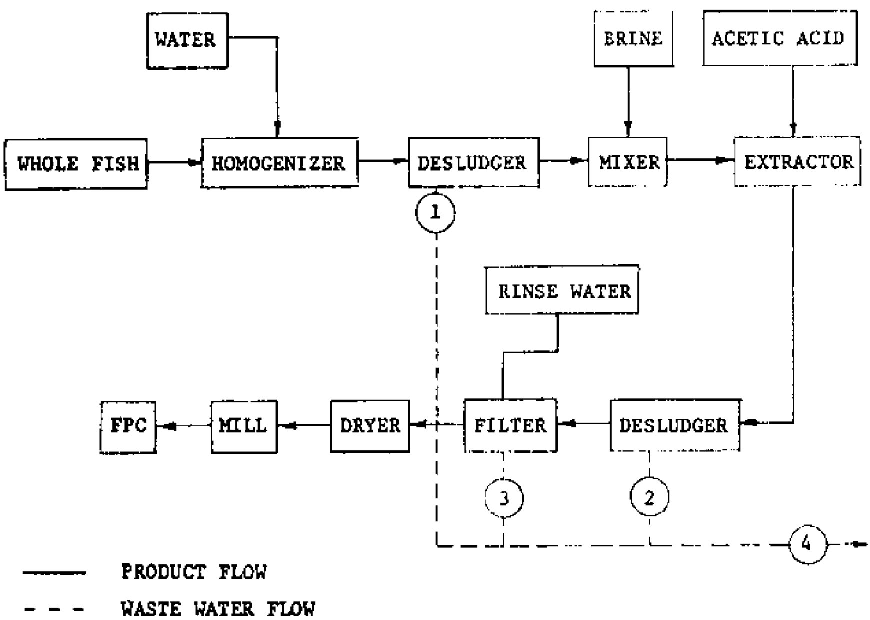

Fig. 1. Effluent streams from acidified brine process.

facing those of us encouraging the total utilization of fishery products is to develop economic techniques for handling large quantities of waste continuously, as well as smaller quantities on a batch basis.

At the University of Washington we have been involved in the development of four basic techniques for handling "waste" or, as we prefer to call it, secondary raw materials from processing plants. Since the group attending this meeting is primarily concerned with shellfish waste, I will merely mention the first three processes and dwell primarily on the fourth technique, that of processing shellfish waste.

Figure 1 is a flow sheet of the brine-acid process, the details of which have been previously reported. It consists primarily of extracting homogenized fish "waste" with an acid-brine solution in an effort to remove undesirable components, including the lipid fraction. The solid residue is then dried in a vacuum rotary dryer yielding a high-protein content meal that is nonfunctional in nature. Current research in this area is being directed towards improving the extraction technique so that a higher percentage of lipid can be removed from the waste, thus resulting in a low-fat protein product.

The other approach to processing fish "waste" has been a controlled enzyme hydrolysis, a flow sheet of which is shown in Figure 2. This technique (also previously reported) involves the solubilization of protein materials through a controlled acid-enzyme hydrolysis. Following subsequent separation of undesirable components by membrane filtration, the material is spray-dried. The brine-acid process results in approximately 15 lb of concentrated protein per 100 lb of waste, while the enzyme technique results in 12 lb of completely soluble protein per 100 lb of waste.

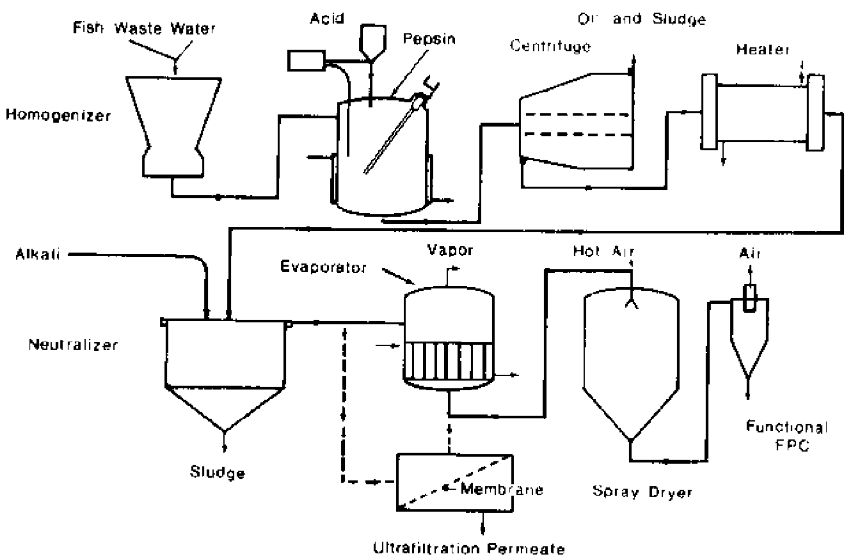

Fig. 2. Functional FPC from fish waste.

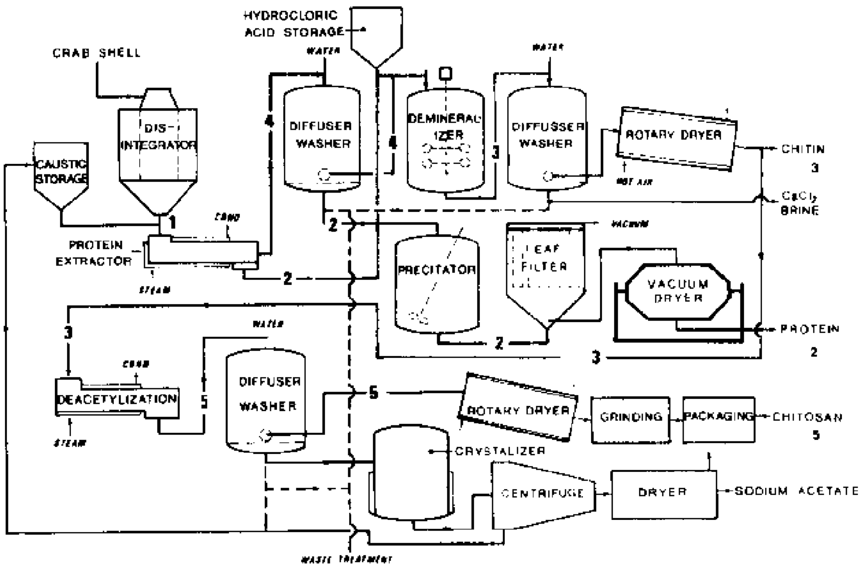

Fig. 3. Chitosan process flow diagram.

The above two processes yield a highly contaminated waste water, and major efforts are currently being directed towards commercializing a technique for treating this effluent in order to make it acceptable for discharge into the environment. By combining several techniques, including flocculation, trickling filtration, carbon absorption and membrane filtration, we can reduce the contamination in highly polluted effluent streams (i.e. 70,000 ppm) to levels acceptable for discharge. We have just completed a pilot plant for obtaining information necessary to commercialize the two "waste" processing procedures. An effluent treatment facility is included in the pilot operation.

During the past year, the Sea Grant program at the University of Washington has entered into a cooperative program with Food Chemical and Research Laboratories, Inc., Seattle, Washington, to commercialize their process for producing chitin and other by-products from shellfish waste. As shown in Figure 3, the chitosan process consists primarily of a caustic extraction to remove the proteins from the shell, followed by a hydrochloric acid extraction to produce a calcium chloride brine from the calcium salts normally found in the shell. The remaining material, commonly called chitin, is the structural material that holds the shell together. Depending on the species of crustaceous shell, chitin can vary from 15 to 25%, while protein varies from 25 to 40% and calcium carbonate varies between 40 and 55%. Chitin can be deacetylated to produce a modified natural carbohydrate polymer, 2-deoxy-2-amino glucose. There are many known and potential uses for both chitin and chitosan in the food, chemical and pharmaceutical industries.

Research in the College of Forestry, University of Washington, has shown that both products greatly improve the wet strength properties of newsprint and

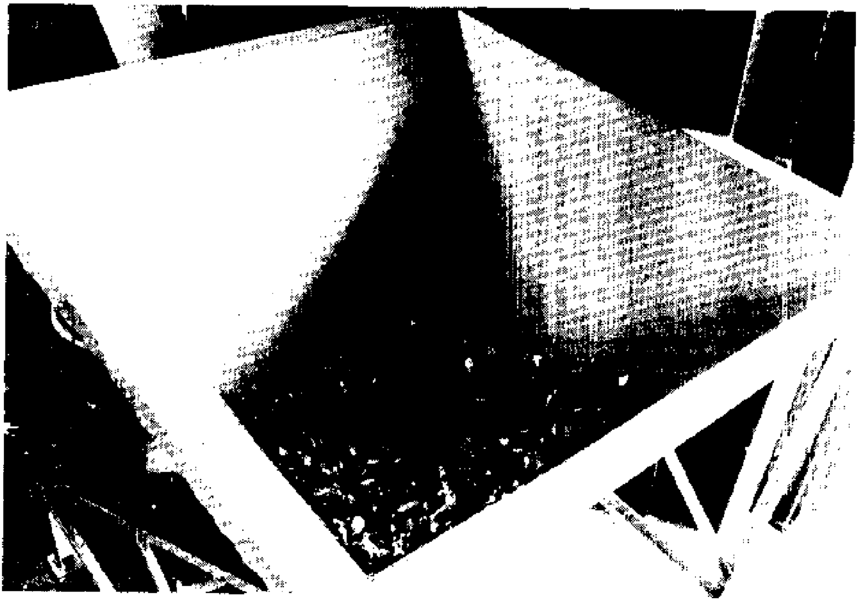

Fig. 4. Incoming shell.

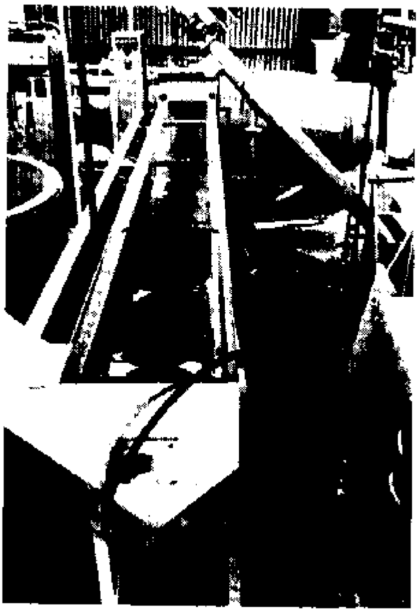

Fig. 5. Ground shell.

Fig. 6. Protein extractor.

other papers. They are also superior coagulants and coagulant aids in the treatment of water supplies, sewage and waste waters. There are many other specialized uses in the thickening and emulsification of food and other industrial products that either have been or are currently being investigated.

The Food Chemical and Research pilot plant in Seattle, Washington, is capable of processing several hundred pounds of shellfish per day, producing a chitosan product of the following properties: less than 2% ash; 8% or greater nitrogen (dry basis); soluble in acetic acid, viscosity of 12 centipoises in 1% solution of one-half normal acetic acid at 25C ± 10%.

The process begins when the incoming shell is conveyed from a hopper (Fig. 4) into a grinder. This results in a coarsely ground material that is satisfactory for further extraction and processing (Fig. 5). The ground shell is extracted in caustic in a trough screw conveyor, as shown in Figure 6. This solubilizes the protein so that the resulting solid contains only calcium salts and chitin. The solid is then placed in a wooden tank where the added hydrochloric acid extracts the calcium chloride as a soluble brine, leaving only chitin as a residue (Fig. 7). Following washing and basket centrifugation, the chitin particles are dried in a rotating drum dryer. This primary product is then ground to the desired particle size and packaged for market or further processed to produce chitosan by deacetylation. This step is carried out in a screw conveyor containing hot caustic solution (Fig. 8).

Through a cooperative effort between the Oceanographic Institute of Washington and Food, Chemical and Research Laboratories, Inc. (sponsored by Sea

Fig. 7. Demineralizer.

Fig. 8. Deacetylizer.

Grant), sample quantities of chitin or chitosan may be obtained upon request. Our department has a limited supply of the fish proteins prepared from the acid-brine and enzyme processes.

The forthcoming year should yield results of particular interest to your industry. Our pilot plant program will yield information on the cost of commercial plants and on the economics of "waste" processing.

Chairman – J. W. Gehringer, *Regional Director, Southeast Region, National Marine Fisheries Service, St. Petersburg, Florida*

Large Volume Stackable Fish Traps for Offshore Fishing

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INTRODUCTION

Fish traps account for a very significant proportion of the catch from coralline tropical seas, where the presence of coral reefs precludes or severely restricts the use of trawls or other nets. In the coralline portion of the Western Atlantic Ocean and of the Caribbean Sea, only a very small proportion of the area of shallow water is trawlable, and the greatest proportion of fishing effort is devoted to fishing by means of traps, hook-and-line and spears.

Antillean fish traps have previously been described and illustrated by Munro, Reeson and Gaut (1971). The commonest type of trap is in the form of a double chevron or Z, with two down-curved "horse-neck" entrance funnels, and measures 183-229 cm (72-90 in) long, 122 cm (48 in) wide and 61 cm (24 in) deep, with an overall volume of 1.4-1.7 m^3 (48-60 cubic ft). The framework is normally constructed of mangrove or other sticks and is covered by wire mesh having a maximum aperture of 4.13 cm (1-5/8 in). There is some regional variation in design, size and method of construction according to local tradition or preferences.

The use of traps is advantageous in that traps require little maintenance and can easily be repaired if superficially damaged. A substantial proportion of the catch is normally represented by reef fishes such as Scaridae (parrot fish), Acanthuridae (surgeon fish), Palinuridae (spiny lobsters), Mullidae (goat fish) and Chaetodontidae (angel fish), which cannot easily be caught by other means, and other groups such as Balistidae (trigger fish) which are not readily taken on hook and line.

Low density fish stocks can be economically exploited by means of traps where other methods are uneconomical or have become uneconomical through overfishing.

The disadvantages of the traps presently in use in the Caribbean region relate to the fact that they have evolved for use from small open boats or canoes operating near shore under circumstances where several traps will be carried to sea on a small boat and set in a suitable location. Such traps are then hauled and reset at will and are not normally returned to shore except for purposes of repair. As such, a fisherman operating a fleet of approximately 20 traps has to make up to 10 trips to the fishing grounds in order to set his entire fleet; his mobility is therefore severely limited and he cannot easily move to new fishing areas. Similarly, in the event of storms or hurricanes he is totally unable to withdraw his fishing gear.

As a result of the low mobility of the fishermen and the continuous operation of the traps, most nearshore shelf areas in the Antilles are probably severely over-exploited and yield less than the potential maximum sustainable yield. The over-exploitation of nearshore stocks by means of traps leads to hook-and-line fishing becoming increasingly uneconomical causing even more fishermen to adopt the use of traps. However, such over-exploitation is confined to areas within the normal operating range of small outboard-powered craft, and the fish stocks of substantial areas of coralline shelf or oceanic banks lying beyond the operating range of small craft are very lightly exploited or completely unexploited. These areas include most of the extensive Nicaragua-Honduras shelf (about 20,000 sq miles), the large oceanic banks such as Pedro Bank (2,344 sq miles) and Rosalind Bank (1,441 sq miles), many small oceanic banks in the western Caribbean, the Saba, Barbuda and Anguilla Banks of the eastern Caribbean, various banks lying to the north of Hispaniola and the extensive shallow areas of the Bahamas.

In Jamaica, over the past few years, several 10-20 m (33-65 ft) vessels have been introduced and exploit the Pedro Bank by means of traps. The mobility of the vessels is highly restricted. The carrying capacity is around 20 traps, but upwards of 100 traps can be hauled and reset in a day. To set a fleet of 200 traps the vessels must make around 10 trips from the home port, and in order to move the fleet of traps to a new fishing area, a similar number of trips must be made. In the case of the above-mentioned vessels, the areas in which they operate lie no more than 60-100 miles from the home port and, despite their restricted mobility, they would appear to be operating on an economical basis.

Other vessels have attempted to extend operations to the more productive Rosalind Bank, 200 miles from Jamaica (Kawaguchi, 1971), or to parts of the Honduras shelf, up to 300 miles from Jamaica. These efforts have not had significant success. The trap-carrying capacity of such vessels is insufficient, and all of the traps can be hauled and reset within a few hours. The remainder of the day is then spent line fishing, which, although promising in some areas, yields very variable results (Kawaguchi, 1971).

Wolf and Chislett (1971) showed that trap fishing in the Caribbean gave consistently good results in many areas. However, it may be deduced from their results that the trap-carrying capacity of the fishing vessel poses a major obstacle to economic success, or that the profitability of the operation could be increased several times by carrying more traps. For example the *Alycon* and *Calamar,* twin

25-m (81-ft) exploratory fishing vessels of the UNDP/FAO Caribbean Fisheries Development Project, carried a maximum of only 24 Z traps. In contrast their hauling capacity when operating traps in deep water (110-146 m; 60-80 fm) amounted to 30-40 traps per 8- to 10-hour day. Wolf and Chislett (1971) therefore suggested that such vessels should haul each trap twice daily in order to maximize their catch. However, their results show that the greatest catch per trap is obtained when baited traps are soaked for 2 to 3 days, a fact confirmed by recent tests conducted on Pedro Bank (Munro, in press). In order to maximize the daily catch, the *Alycon* and *Calamar* would therefore have had to carry 60-120 traps, depending upon whether 2-day or 3-day soaks yielded the greater margin of profit.

Previous investigations (Munro *et al*, 1971; Munro, in press) have shown that the magnitudes of trap catches relative to any particular soak are determined by relative rates of ingress and escapement of fishes, and that these rates are influenced by factors such as conspecific attraction, moon phase or the corresponding tides, composition of the fish community, configuration, size and structure of traps and presence or absence of bait.

It has been shown that escapement rates from Antillean traps amount to about 12% per day, and that catches stabilize when the number of fishes entering the trap is balanced by the number escaping. Also, escapement via the inlet funnels is proportional to the area or volume within which fishes are contained, or inversely proportional to the number of entrance funnels and the size of the inlet apertures. Escapement is probably a result of random movements within the traps, particularly at night. Therefore, catches are proportional to the size of traps when the number and size of entrance funnels remains constant. The size of entrance funnel inlets should be restricted to the greatest extent practicable. Non-return devices to prevent escapement have been tested, but all reduce the rate of entry into the traps and thus reduce catch rates to below that obtained without such devices.

The circumstances outlined above led to the conclusion that stackable traps were required if trap fishing was to prove economically profitable in the Caribbean area and, in so far as possible, such traps should incorporate desirable characteristics of traditional Antillean traps: large size and twin, down-curved, "horse-neck" funnels, plus inexpensive construction and high durability.

STACKABLE TRAPS

CONSTRUCTION

The basic solution to the problem of developing stackable Antillean traps has been derived from the fact that the traditional S-trap can be split through the vertical-longitudinal axis into identical halves. If the outer dimensions of one-half a trap are reduced to smaller than the inner face of a vertical-longitudinal split through the trap, then one half can be rotated through 180° and stacked inside or on top of the other half.

Two designs have been developed and tested: the stackable "Dollar"- or split-S-trap, derived from the Cuban S-trap (Buesa Mas, 1962), and a stackable

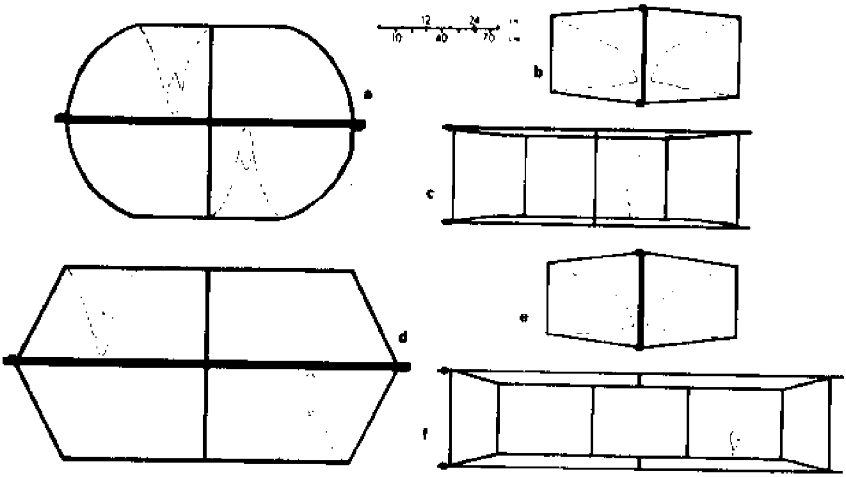

Fig. 1. Configuration of stackable traps. Plan (a), end (b) and lateral (c) views of split-S or Dollar-trap. Plan (d), end (e) and lateral (f) views of Hexagonal-trap.

Hexagonal trap based in turn on our experience with the Dollar-trap. Both designs are shown in Figure 1. To date, the frames of the stackable traps have been constructed of 1.27 cm (1/2 in) box-section steel. The frames are welded throughout and all ends are sealed. The box-section steel possesses very high structural rigidity.

The assembled Dollar-trap is 183 cm (6 ft) in length, 122 cm (4 ft) in overall width and 61 cm (2 ft) deep at the center. The sides taper to 51 cm (20 in) high, giving a 5 cm (2 in) taper on each side. The corners of the trap are gently curved to maintain the sigmoid shape of the Cuban S-trap.

The Hexagonal trap differs from the Dollar-trap in length and taper. The trap is 244 cm (96 in) in overall length and at the sides tapers to 46 cm (18 in) in height. The curved corners of the Dollar-trap have been replaced by a 117° angle.

Figure 2 illustrates how the traps can be split and the halves stacked. Each half has an asymmetrical horse-neck funnel constructed as shown in Figure 3, and therefore has a fixed upper and lower surface and similarly a fixed right or left side. In our traps the half sections have been joined by fitting the central rectangular frame of each half with two projections at the right hand side (when viewed laterally) and two small pieces of 1 in box-section steel on the left hand side of the frame. Each spike has a small hole drilled vertically about 1-1/4 inches out from the outer margins of the central rectangular frame. When two trap halves are paired the spikes pass through the piece of 1-inch box-section at each corner, thus lending support at all corners of the central rectangular frame. The two halves are then locked in position at any corner by means of a locking pin. The locking pin is merely a 7.6 cm (3 in) galvanized nail with about 15 cm (6 in) of galvanized wire attached below the head of the nail.

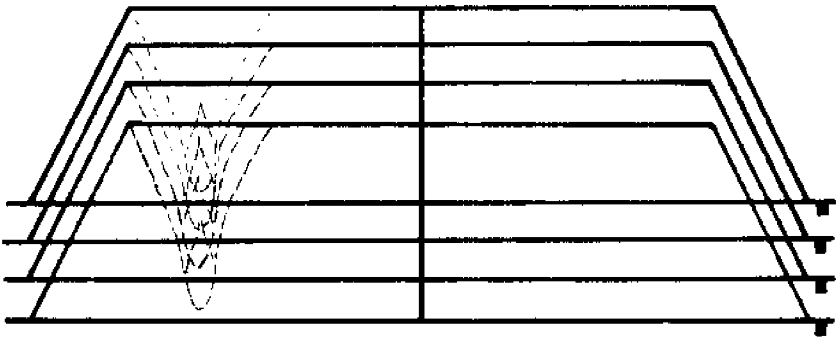

Fig. 2. Stacked Hexagonal-trap frames. Twenty-one frames can be stacked in the space normally occupied by two traditional Antillean traps.

The completed Dollar-trap weighs 20.9 kg (46 lb); the Hexagonal trap 24.5 kg (54 lb). The half sections weigh only 10.5 and 12.3 kg (23 and 27 lb), respectively, and can easily be handled by one man even under severe weather conditions. The weight of the Dollar-trap is approximately equal to that of the wood and wire Antillean Z-trap (44 lb), but the weight in water is greater because of the absence of a buoyant frame work. As a result, the stackable traps rest more firmly on the bottom and are less readily displaced by waves and currents.

The stackable traps have to date been covered with 3.18 cm (1.25 in) galvanized chicken-wire mesh, which is the traditional material for Antillean fish traps. However, the use of other materials is possible, particularly PVC coated wire and rectangular welded wire mesh.

COMPARATIVE PERFORMANCE

The performance of Dollar-traps and Hexagonal traps was compared at a series of 31 stations on Pedro Bank and on the South Jamaica Shelf between February and October 1972. The mean catch per Hexagonal trap was 2.41 kg

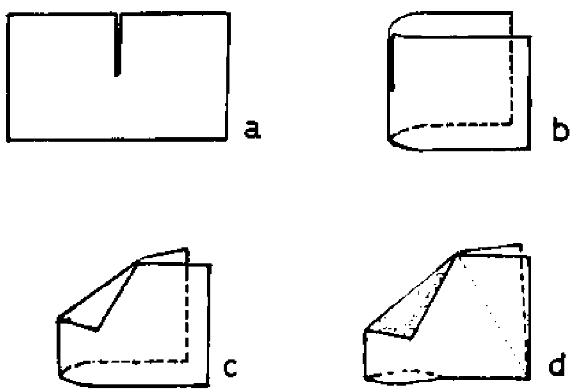

Fig. 3. Details of construction of a horse-neck funnel; the rectangle of wire (a) measures 109 x 61 cm (43 in x 24 in) and is cut and folded as illustrated (b-d).

compared with 2.00 kg/trap for Dollar-traps. A one-tailed "t" test of the departure of the catch rates of Hexagonal traps from the mean catch rates of Dollar- and Hexagonal traps combined, showed Hexagonal traps to be significantly better than the Dollar-traps ("t" = 1.697, P + 0.05), and the best estimate of the difference is + 20.5%.

Munro (in press) has shown that catch rates in Antillean traps are proportional to the area covered by the traps, and that the relative efficiency of Dollar-traps per unit area was about 21% less than that of Antillean traps. The catch rates in Hexagonal traps suggest that this proportionality has been maintained and that the catching power of the stackable traps is about 25% less than that of wooden-framed traps of equivalent size. There is no satisfactory explanation for this difference at the present time.

HANDLING TIME

The time required for preparing, baiting and shooting an Antillean or a stackable trap does not differ substantially but the physical effort required is less in the case of the stackable traps. The time required to haul traps to the surface is proportional to the depth at which they are set and also does not differ. However, emptying and stowing a stackable trap requires only 30 seconds; the trap is placed on its side, one-half removed and stacked and the other half upended and emptied into a fish box, rotated in the process and similarly stacked. In contrast, Antillean traps require up to 3-1/2 minutes to empty and stow depending upon the size of the catch. This results in the ship having to wait until the crew is ready to retrieve the next trap, in contrast to the stackable traps where the limiting factor is the speed with which the vessel can approach successive trap buoys. Consequently, stackable traps require fewer crew to handle the operation and the crew actually has time to rest or organize affairs on deck between successive traps.

Our results suggest that a professional crew could easily haul and reset 120 traps in a 10-hour working day, and any remaining time could be devoted to line-fishing on an opportunistic basis.

COSTS

The cost of the completed prototypes has been about J $20.00 (US $24.00) for the Dollar-trap and J $17.50 (US $21.00) for the Hexagonal trap. The cost of materials for the Hexagonal traps is greater than for the smaller Dollar-traps, but the labor costs for Dollar-traps are greater. Large scale production techniques would reduce labor costs to some extent. Materials and costs are given in Table 1.

The life of a trap in continuous operation with no protection against rust is conservatively estimated at 12-18 months. Plastic or other coatings on the wire and frame would undoubtedly reduce rusting and greatly extend the life of the trap.

CARRYING CAPACITY AND OPTIMUM SOAK

Catch per trap is related to the soak and, in the case of baited traps, reaches a maximum shortly before the bait in the trap is exhausted (Munro, in press).

Table 1. Materials and costs for construction of prototype stackable Dollar and Hexagonal traps (Jamaican Dollars = 1.2 U.S. Dollars)

Item	0.5 in box section steel		1.25 in 18G wiremesh		Labor and Supervision		
Cost per unit ($J)	0.07/foot		0.023 sq ft		2.10/hour		
	ft	$	sq ft	$	hr	$	Total costs
Dollar trap	81.3	5.69	86	1.96	6	12.31	$19.96
Hexagonal trap	102.0	6.58	110	2.50	4	8.42	$17.50

When the bait is exhausted, the catch declines and stabilizes when escapement equals ingress. The optimum soak is therefore a variable that depends upon the rate at which the bait is consumed, the numbers of fishes which enter the trap and the amount of bait provided. On Pedro Bank the maximum is reached in 2 or 3 days.

In order that a vessel be fully occupied, the carrying capacity should be the product of the optimum soak and the daily hauling capacity. For example, if the hauling capacity is 120 traps per day and the optimum soak is 2 days, then 240 traps should be carried. Carrying more than 240 traps will result, in this case, in the mean soak exceeding the optimum and will result in a lower catch per trap and a lower daily catch.

ECONOMICS OF OPERATION

The economics of operating such traps is dependent, as with other gear, on the construction and maintenance cost, useable life, average catch per trap, price of fish and cost of vessel operations; all of which are highly variable from place to place. However, it is sufficient to point out that vessels using Antillean traps are operating on an economical basis at the present time. If stackable traps are used on a commercial scale, the greater carrying capacity and mobility, the higher durability of the traps and the lower operating costs for vessels would appear to ensure their profitability.

The catch rates obtained on the deeper parts (>15 m) of the southern portion of Pedro Bank indicate that a mean catch rate of about 8.2 kg (18 lb) per trap can be expected when using Hexagonal traps soaked for 2 days. At current average fish prices of J $0.48/kg (J $0.22/lb), the cost of a Hexagonal trap would be paid off in 4-5 hauls or in 8-10 days of operations.

SUMMARY AND CONCLUSIONS

(1) Traps are used for fish capture in most coralline tropical seas. They offer many advantages but are bulky and the mobility of fishermen is very

restricted. Fishing vessels cannot carry sufficient traps to sustain a commercial operation in distant waters.

(2) Stackable traps, based on one of the traditional Antillean designs, have been developed and tested. Hexagonal traps yielded catches about 20.5% greater than obtained in stackable S-traps (Dollar-traps), but the stackable traps were about 25% less efficient than traditional traps of equivalent size.

(3) The trap-carrying capacity of a vessel is increased six to seven times and the handling time and physical labor is substantially reduced.

(4) Over 120 traps can be hauled and reset in a day in depths of 20-50 m (10-25 fm), and a 2-day soak would appear to be optimal on Pedro Bank. The total number of traps carried should be the product of the optimum soak in days and the daily hauling capacity.

(5) The cost of a Hexagonal trap operated on the southern portion of the Pedro Bank is likely to be paid off in four to five hauls or 8-10 days of fishing.

ACKNOWLEDGEMENTS

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The Present Status of the Exploitation and Evaluation of the Fishery Resources of Venezuela

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INTRODUCTION

The fishery resources of Venezuela and their exploitation were described by Simpson (1963) and Simpson and Griffiths (1967) at a time when comparatively little study had been made of them. Since December 1967, the Venezuelan Government and the Food and Agriculture Organization have been carrying through a Fisheries Research and Development Project, the FAO acting as executing agency for the United Nations Development Program and the Ministry of Agriculture of Venezuela acting as the cooperating government agency.

This project has been able to undertake a wide range of studies of the marine fishery resources and has been able to make a first evaluation of the major resources now under exploitation. Each species or species assemblage that is the object of an important commercial fishery has been classified in terms of total catch according to whether the fishery is in a developing phase, an accelerating growth phase, a decelerating growth phase (approaching but not attaining the maximum sustainable yield), the stabilized phase (at or near the level of maximum sustainable yield) or a state of over-fishing.

The total annual catch (marine and fresh water species combined) has increased steadily though slowly during the past 2 decades as Table 1 shows. Fresh water species occupy about 10% of the total.

For a number of species that were to a large degree the exclusive basis for a fishery, in contrast to trawl fishery species assemblages, some biological work was done, mostly on growth rates, the length-weight relationship, sexual maturity and sex ratios.

Although the majority of the references are in Spanish, they usually have an English summary, and some are printed in both English and Spanish.

STATUS OF THE RESOURCES

PELAGIC RESOURCES

Sardine

Sardinella anchovia is taken by beach seine in eastern Venezuela. The annual catch, most of which is canned, has oscillated around an average of approximately 40,000 tons since 1963 (Table 2). This stabilized catch is considered to be mainly due to the relatively limited accessibility of the resource to the method. The status of the resource until 1966 was described by Griffiths and Simpson (1967).

The relative percentage of the total sardine catch originating in the Gulf of Cariaco was, until about 1965, always greater than 80%, but from 1965 onwards

Table 1. Total annual landings and values in Bolivars of fish in Venezuela (1953-1971)

Year	Catch (tons x 10^3)	Value (B^s x 10^6)	Year	Catch (tons x 10^3)	Value (B^s x 10^6)
1953	63.36	37.73	1963	97.40	56.47
1954	51.17	32.02	1964	110.41	63.66
1955	70.09	39.73	1965	119.26	69.10
1956	61.28	38.58	1966	116.79	73.86
1957	83.68	45.54	1967	113.22	71.60
1958	77.21	41.75	1968	126.18	64.25
1959	83.81	45.59	1969	134.11	102.59
1960	85.66	50.24	1970	126.33	113.15
1961	83.59	51.15	1971	139.94	130.79
1962	94.87	55.74			

this proportion declined to an average of 30-40% on an annual basis. The southeast coast of the island of Margarita, the north coast of the Peninsula of Araya and, to a lesser extent, the Carupano area on the north coast of Sucre have contributed significantly to the catch (Fig. 1). The cause of this is unknown. A long-term analysis of monthly catch and average sea-surface temperature records for the Gulf of Cariaco showed that up to about 1965 high monthly catches corresponded rather well with low average monthly temperatures. Thereafter, till about 1968, the high catches generally corresponded to months of high average sea temperature, and in recent years the earlier pattern has been partially reestablished (Martinez, ms). The long-term trend in the temperature (as well as sea-surface salinity) over the period 1954-1970 was significantly positive.

Sardine schools appeared to prefer cooler-than-average water. A strong correlation was found between the duration of the period in which the mean monthly temperature was below 24C and the annual catch in the Gulf of Cariaco. This temperature approximated the long-term average and was found to

Table 2. Total annual landings and values in Bolivars of sardines in Venezuela (1959-1971)

Year	Catch (tons x 10^3)	Value (B^s x 10^6)	Year	Catch (tons x 10^3)	Value (B^s x 10^6)
1961	23.4	2.03	1967	40.0	3.91
1962	32.3	2.80	1968	36.8	4.12
1963	35.3	3.06	1969	35.9	3.17
1964	42.1	3.29	1970	40.7	3.15
1965	43.8	3.07	1971	43.3	3.24
1966	39.1	2.64			

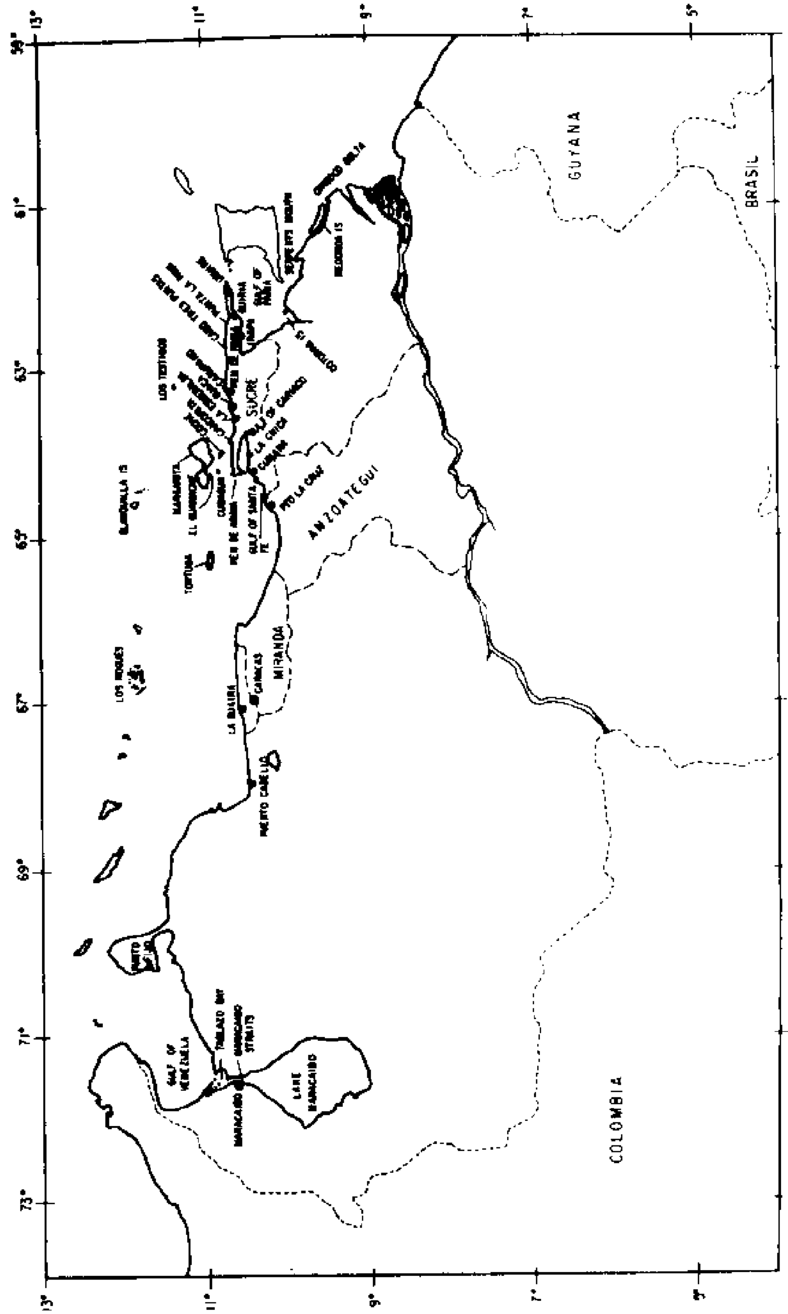

Fig. 1. Map of Venezuela showing fishing areas and geographic locations mentioned in the text.

be a key temperature in work on the west African guilt sardine, *Sardinella aurita* (Boely, 1971).

A study of wind-induced upwelling in the Gulf and its relation to other biological variables (phytoplankton and zooplankton) showed this general short-term association to be so between late 1959 and late 1961 (Simpson and Griffiths, 1971).

The fishing method is known to take the whole school most of the time, more or less regardless of school size. The apparent abundance cannot therefore be safely measured by the catch per set until it has been determined whether or not average school size is dependent on the actual abundance.

The catch per set shows monthly variations with highest values generally occurring in the spring months (typically March) and the autumn months (typically September). These are periods of maximum phytoplankton standing crops, at least in the Gulf of Cariaco, and of highest frequencies of sexually mature sardines (though the spring maximum is by far the more important) (Simpson, 1965; Simpson and Griffiths, 1971). School size may therefore reflect feeding or spawning behavior rather than population abundance, or it may be determined by both.

The seine-month was chosen as a unit of effort not dependent on stock density as is the set. The relationship between the catch per seine-month and total number of seine-months indicated that an increase in the fishing effort above 800 seine-months, which was the level in 1970 and 1971, would only cause a small increase above the 44,000 tons caught in 1971.

According to the length-frequency data, the smallest annual mode normally enters the fishery in May at a total length of about 140 mm. This size is approximately that at which the first scale ring is formed, and corresponds to 1-year old fish (Heald and Griffiths, 1967). The sardine probably attains a maximum age of 5 years; most of the catch consists of fish older than 1 year and less than 3.

The sex-ratio does not differ significantly from unity (1:1). Sexually mature specimens of a total length less than 140 mm are rare. This fact, together with the time of entry (May or later) of fish of this size into the fishery, indicates that 1-year olds do not normally participate in the main annual spawning of this species (Simpson and Gonzalez, 1967).

The egg and larval surveys made in 1968 and 1969 showed that sardine spawning was most intense along the northeast and south coasts of Margarita, around the islands of Coche and Cubagua and between Cabo Tres Puntas and Guaca to about 15 miles offshore along the north coast of Sucre (Fig. 1). Spawning in the Gulf of Cariaco was low and confined to the north coast (Lopez, 1972). Spawning intensity was very low along the Santa Fe coast and around Los Testigos Islands and virtually absent in the Gulf of Paria and along the north coast of the Peninsula of Paria, east of Punta La Pava. Spawning intensity was highest in the early and late months of the year. Lopez (1972) confirmed the findings of Simpson and Gonzalez (1967), but in addition showed an expanded area of spawning. Also, the spawning observed in the Gulf of Cariaco was less intense than that observed by Simpson and Gonzalez (1967).

Although the commercial species of sardine is considered to be *Sardinella anchovia*, the closely related species *S. pinnula* and *S. brasiliensis* have been observed and may have been caught (Heald and Griffiths, 1967). However, the taxonomy of the genus in this area is in need of revision since the existing descriptions have been based on very few specimens.

Thread herring

Opisthonema oglinum is abundant along the Venezuelan coast; it is fished by beach seine, mainly in eastern Venezuela. The annual catch of roughly 600-800 tons increased about eight times between 1965 and 1967 (Table 3). Since then the catch has been variable.

Although no effort data are available, it appears that this fishery is still in the phase of accelerating growth. The catch is almost all converted to fish meal, though some is canned as "sardine."

The study of this species is comparatively recent. The analysis of length-frequency distributions and scale rings is being undertaken to determine age, growth and total mortality. Some morphometric work is also being done. Fish with up to six scale rings have been observed but about 50% of the catch has consisted of fish lacking a scale ring.

Other Clupeids

From time to time the "sardina canalera" (*Jenkinsia lamprotaenia*) is abundant in eastern Venezuela, but there is no commercial fishery for it; it may be less accessible to the beach seines than similar species.

Anchoveta

Although the annual catch (Table 4) of *Cetengraulis edentulus* is only about one-tenth of that of the sardine it is considered potentially important since it is known to be abundant. At present it is used almost exclusively for the production of fish meal.

The fishery is sporadic, markedly seasonal (mainly June-November) and isolated (mainly along the north coast of the Peninsula of Araya). It has therefore proven difficult to obtain an adequate sampling coverage.

Females are larger than males of the same age, at least throughout the range sampled (approximately 40-165 mm). The incoming size groups apparently originate between January and March, and again between September and November. The scales of the anchoveta showed growth rings, which were observed to form normally between January and March or between September and November.

The two annual size-classes indicate two main spawnings per year, though the predominant spawning season is considered to be June-November (Simpson, 1965). The spawning of anchoveta, as that of engraulids in general in eastern Venezuela, is widespread in both time and space. The egg and larval surveys confirmed that June to November is the predominant period and that the north coast of Sucre is the predominant area (Lopez, ms).

Table 3. Total annual landings and values in Bolivars of thread herring in Venezuela (1964-1971)

Year	Catch (tons x 10^3)	Value (B^s x 10^6)	Year	Catch (tons x 10^3)	Value (B^s x 10^6)
1964	0.63	–	1968	6.50	623.4
1965	0.81	–	1969	3.85	320.1
1966	3.57	–	1970	6.58	375.8
1967	5.07	–	1971	9.13	518.2

Other Engraulids

Although relatively abundant, only one is of commercial interest at this time: the "camiguana" *(Anchoviella estauquae)*, which is sold fresh to a fairly restricted group of consumers. These engraulids are undoubtedly important ecologically. Occasional samples of camiguana have been obtained, but no systematic study has been undertaken except insofar as camiguana eggs and larvae are sampled in routine egg and larval surveys.

Yellowfin tuna

The tuna longline fishery for *Thunnus albacares* was started in the late fifties and is now a well established sector of the Venezuelan fisheries; it exploits the tuna stocks in the Atlantic Ocean and the Caribbean Sea in common with many other nations (Griffiths and Simpson, 1967). The landings of tuna for the last 10 years have fluctuated around 2,500 metric tons per year, representing a value of about 5 million Bolivars (Bs) to the fishermen (Table 5). Yellowfin occupy about 70% of the tuna landings and about 60% of the total landings of this fishery. Seventy percent of the catch is landed in ports on the northeastern coast

Table 4. Total annual landings and values in Bolivars of anchovies in Venezuela (1959-1971)

Year	Catch (tons x 10^3)	Value (B^s x 10^6)	Year	Catch (tons x 10^3)	Value (B^s x 10^6)
1959	1.47	38.09	1966	2.08	63.19
1960	2.12	55.49	1967	0.86	58.50*
1961	4.51	126.09	1968	5.42	366.03
1962	4.35	126.17	1969	4.85	288.09
1963	4.54	136.24	1970	3.92	237.31
1964	1.29	38.60	1971	3.41	196.78
1965	4.79	154.20			

*Estimate

Table 5. Total annual landings and values in Bolivars of tuna in Venezuela (1961 - 1971)

Year	Catch (tons x 10^3)	Value (B^s x 10^6)
1961	2.01	2.25
1962	3.54	4.22
1963	3.09	4.59
1964	1.94	3.28
1965	1.83	3.73
1966	3.14	4.57
1967	2.06	4.13
1968	1.98	4.01
1969	2.72	5.60
1970	2.20	4.84
1971	2.35	5.41

Table 6. Total annual landings and values in Bolivars of Spanish and King mackerels (1961-1971)

Year	Catch (tons x 10^3)	Value (B^s x 10^6)
1961	3.41	5.05
1962	3.07	4.54
1963	2.99	4.41
1964	3.90	5.61
1965	3.23	4.95
1966	3.46	5.59
1967	3.03	10.15
1968	2.66	4.74
1969	2.86	5.42
1970	2.45	4.91
1971	3.52	7.29

and sold to the canneries, the remaining 30% is landed in La Guaira for fresh consumption in Caracas.

The data from this fishery show that catch rates for tuna have declined steadily but these have leveled off at about 1.50 fish/100 hooks in recent years (Griffiths and Nemoto, 1967; Hooft and Ramos, 1972). The data indicate that the resource is probably now being overfished.

In mid-1972, several foreign purse-seine vessels fished successfully off the northeastern coasts of Venezuela and one vessel, accompanied by two chummer boats, was given permission by the National Fisheries Office to conduct fishing by this method on an exploratory basis, and in two trips caught 463 tons of yellowfin and 120 tons of skipjack (Mihara, Medina and Griffiths, 1972).

There are some indications that the stock in the Caribbean Sea is to some degree separate from the one in the Atlantic Ocean, within the areas fished by the Venezuelan fleet (Hooft and Ramos, 1972). In the length-frequency distributions, the principal modes of one area are somewhat displaced with respect to those of the other at the same time of the year, and certain modes are observed in one but not in the other area in a given quarter. Little or no fishing is done in the area of the common boundary between the two regions. There are some minor morphometric differences between specimens from the two areas.

There appear to be five or six modal sizes in the catch but it is not known whether these are year classes or whether, like the Pacific yellowfin, there are two age groups per year about 6 months apart. Little is known of yellowfin spawning in this region but gonad samples obtained in 1970 showed that sexually mature tuna were common in October and November. Because the fish is gutted at capture such information is difficult to obtain from the Venezuelan fleet.

A few samples of viscera have been obtained and show that crustaceans are probably the predominant element of the tuna diet.

Other Tunas

Albacore occupy at most 20-30% of the tuna catch, and bigeye tuna no more than 5%. The remainder of the catch, apart from yellowfin, consists of sailfishes, spearfishes and sharks. The annual catches of spear and sail fishes have increased slowly during the past decade to a level of 400-500 tons per year. The data for these species do not justify drawing firm conclusions about the state of the stocks. Blackfin and bluefin tuna are only occasionally caught.

Skipjack of 3-5 kg in weight are seasonally (October-February) abundant off the central Venezuelan coast and there is an incipient, though rather primitive, fishery for them by hook and line, with or without fishing poles (Hilders, 1972). Chum is used. This fish is entirely new to the market so that its development is very much dependent on the development of the market, though the general shortage of bait in the central region is a significant factor.

Spanish and King mackerels

There are extensive though modest fisheries for *Scomberomorus maculatus* and *S. cavalla*, the Spanish mackerel being generally predominant. The primary fishing gear is the gillnet; the secondary is trolled lines. The main fishing area is eastern Venezuela, though these mackerels are abundant at times in central and western Venezuela. These fish are mainly sold fresh for direct consumption, with local surpluses being salted.

Peak catches are observed in February and September. The annual catch of each species is usually a little less than 1,500 metric tons, though the 1971 catch of Spanish mackerel was nearly 1,900 tons. Total landings of these mackerels are given in Table 6.

Gillnets used in the fishery have mesh sizes of 3-½, 4 and 4-½ inches (stretched mesh); and catch rates, though highly variable, are between 0.3 and 1.3 fish per 1,000 m^2 per hour per gillnet set.

Sexually mature specimens are apparently not found in the Gulf of Paria, indicating that these mackerels do not spawn there.

Catch records of numerous small boats are being obtained and analyzed and some morphometric measurements have been taken. The highly dispersed nature of this artesanal fishery and the large size and relatively high value of the fish make sampling difficult.

Chub mackerel

This species (*Scomber japonicus*) is another abundant but underexploited resource with a poorly developed market. The fishery is artesanal, the mackerel being taken by handline (sometimes multiple-hook) and, incidentally, by beach seines and gillnets. The catch is extremely variable (Table 7).

This fish is sold mainly for fresh consumption, but the production of canned mackerel is increasing. No effort data are available, but morphometric measurements and some length-frequency data have been taken.

Other Scombrids

There are sparsely developed seasonal fisheries for Atlantic bonito and frigate mackerel (*Sarda sarda* and *Auxis thazard* respectively). They are usually taken

Table 7. Total annual landings and values in Bolivars of chub mackerel (1967-1971)

Year	Catch (tons x 10^3)	Value (B^s x 10^6)
1967	0.37	81.4*
1968	1.55	346.2
1969	4.05	677.2
1970	0.35	252.2
1971	1.18	710.7

*Estimated

Table 8. Total annual landings and values in Bolivars of white and grey mullets (1967-1971)

Year	Catch (tons x 10^3)	Value (B^s x 10^6)
1967	3.43	3.77*
1968	3.90	4.03
1969	3.53	4.00
1970	3.51	3.95
1971	3.49	3.88

*Estimated

by trolling. Approximately 300 tons of each species are taken annually. There are insufficient biological or fishery data to permit any analysis of this resource.

Mullets

Two species of mullet are taken by dispersed coastal fisheries with beach seines and gillnets. The annual catches (Table 8) have remained rather steady at just over 2,000 tons for white mullet (*Mugil curema*) and 600 tons for blueback (*M. liza*). Small quantities of a third species (*M. incilis*) are also taken in certain areas (e.g. Gulf of Paria). The main fishing season is November to February. Mullet are sold fresh, with local surpluses being salted.

Again, the dispersed nature of this artesanal fishery makes it difficult to obtain catch-effort data, but biological sampling in fish markets and certain landing places, particularly in western Venezuela, has been relatively good.

Bigeye scad and Rough scad

These scads are taken mainly by beach seine, gillnet and troll. Bigeye scad (*Selar crumenophthalmus*) is predominant, and rough scad (*Trachurus lathami*)

Table 9. Total annual landings and values in Bolivars of bigeye and rough scads (1967-1971)

Year	Catch (tons x 10^3)	Value (B^s x 10^6)
1967	2.50	1.21*
1968	2.05	1.00
1969	2.26	1.09
1970	1.74	1.04
1971	2.10	1.39

*Estimated

Table 10. Total annual landings and values in Bolivars of crevalle in Venezuela (1967-1971)

Year	Catch (tons x 10^3)	Value (B^s x 10^6)
1967	1.23	--
1968	1.79	1.85
1969	1.99	2.18
1970	1.58	2.00
1971	1.94	2.39

is not identified in the catch statistics. The annual catch (Table 9) of bigeye scad is between 1,000 and 1,500 tons in eastern Venezuela and between 200 and 400 tons in the central area; catches elsewhere are negligible.

Scads are known to be abundant, and the fishery could be developed substantially, especially in the central zone (Hilders, 1972). Biological samples of both species have been obtained somewhat irregularly and await analysis.

Other Carangids

The crevalle jack, *Caranx hippos*, is taken seasonally along the Venezuelan coast, principally by beach seine and trolling. The annual catch is between 1,500 and 2,000 tons (Table 10). About two-thirds of the catch is made in eastern Venezuela, one-third in western Venezuela and a small amount in the central zone. As with the scad, there is ample scope for increasing the catch in the central zone. Jack is popular locally as a food fish, mostly being sold fresh. The rather sporadic and seasonal fluctuations in abundance impede development of the fishery. For similar reasons, few biological samples or fishery statistics have been obtained for this species.

The Atlantic moonfish, *Vomer setapinnis*, is taken by trawls, beach seines and gillnets. The main fishing area is in the eastern zone; the second is in the western zone; negligible quantities are taken in the central region. Annual catches are shown in Table 11. Some biological and fishery statistics data have been obtained.

Other Perciforms

There is a seasonal coastal fishery (by beach seine and gillnet) for bluefish, *Pomatomus saltatrix*, mainly off the north coast of the State of Sucre. The annual catch is between 700 and 1,000 tons. The main fishing season is from May to August. Occasional biological samples have been taken.

Between 300 and 500 tons of sable-fish, *Trichiurus lepturus*, are taken each year by bottom and, to a lesser extent, by floating longlines and handlines, mainly in eastern Venezuela. This species is sold fresh locally. It is a consistent though minor component of the tuna longliners' catches. Fishery statistics and biological sampling have not been developed.

DEMERSAL RESOURCES–FISH

The demersal fish program began in 1968 in western Venezuela, and in early 1970 operations were initiated in the eastern region.

One hundred and twelve species of fish have been identified from the commercial catches taken in Lake Maracaibo and the Gulf of Venezuela. Although Lake Maracaibo is essentially a body of freshwater, it is connected to the Gulf of Venezuela. Because of the faunal interchange between the two areas, the Lake's resources have been included, for convenience, in the marine sector. Apart from shrimps, three species of fish predominate in the Lake fishery.

Lake curvina

Twenty-three per cent (approximately 6,000 metric tons) of all Lake Maracaibo catches (Table 12) consist of *Cynoscion maracaiboensis*. Both beach seines and handlines are used in the fishery.

Table 11. Total annual landings and values in Bolivars of Atlantic moonfish in Venezuela (1967-1971)

Year	Catch (tons x 10^3)	Value (B^s x 10^6)	Year	Catch (tons x 10^3)	Value (B^s x 10^6)
1967	1.07		1970	1.37	1.23
1968	1.94	1.38	1971	1.19	1.11
1969	1.82	1.46			

The curvina spawns throughout the year in the Bay of Tablazo and Straits of Maracaibo and enters the fishery at the end of the first year at a total length of 40 cm (Espinosa, 1972).

Manamana

Anodus laticeps, a characid, is the second most important commercial species in Lake Maracaibo after curvina, comprising about 20% (5,000 met. tons) of the Lake catches (Table 13). No significant quantities of manamana are taken outside the Lake.

The fishery is by surround net, mainly in the southern part of the Lake. This fish migrates up rivers from the Lake. There is no major river fishery, but the fishermen take advantage of the migrations into and out of the rivers. Some aspects of the biology of this species have been described (Espinosa and Gimenez, ms).

Bocachico

Prochilodus reticulatus reticulatus is a characid fish similar to the manamana and is the third most important commercial species in the Lake, accounting for about 15% (3,800 tons) of the Lake catches (Table 14).

Gulf of Venezuela trawl fishery

Two fleets operate in the Gulf of Venezuela: the Punto Fijo fleet and the Maracaibo fleet. The number of trawlers in the Punto Fijo fleet has increased

Table 12. Total annual landings and values in Bolivars of Lake curvina (1961-1971)

Year	Catch (tons x 10^3)	Value (B^s x 10^6)	Year	Catch (tons x 10^3)	Value (B x 10^6)
1961	4.36	3.28	1967	6.50	4.90
1962	4.80	3.50	1968	6.74	5.64
1963	5.37	3.96	1969	7.09	6.41
1964	5.41	4.15	1970	5.86	5.24
1965	6.14	5.07	1971	9.00	8.48
1966	7.39	5.62			

Table 13. Total annual landings and values in Bolivars of manamana in Lake Maracaibo (1967-1971)

Year	Catch (tons x 10^3)	Value (B^s x 10^6)
1967	5.12	1.84
1968	6.29	2.21
1969	9.55	3.54
1970	6.56	2.56
1971	5.03	2.06

Table 14. Total annual landings and values in Bolivars of bocachico in Lake Maracaibo (1967-1971)

Year	Catch (tons x 10^3)	Value (B^s x 10^6)
1967	1.78	0.73*
1968	3.62	1.46
1969	4.62	1.95
1970	1.94	0.96
1971	3.84	1.73

*Estimated

from 11 in 1956 to 130 in 1971. The total landings during the same period increased from 4,000 to 11,000 tons. The Maracaibo fleet started in 1962 with three vessels, increasing to 49 in 1971. Apart from trash fish, nearly all the catch of the Maracaibo fleet consists of white shrimp complemented by grooved shrimps when abundant. The Punto Fijo fleet lands a variety of species: grooved shrimps (*Penaeus aztecus, P. duorarum* and *P. brasiliensis*), white shrimp (*P. schmitti*), grunt (*Orthopristis ruber*), curvinata (*Macrodon ancyclodon*), croaker (*Micropogon furnieri*), squid (*Doriteutis plei*), curvinas (*Cynoscion* spp.), snappers (*Lutjanus* spp.), southern sennet (*Sphyraena picudilla*), Atlantic moonfish (*Vomer setapinnis*), sharks (mainly *Rhizoprionodon porosus*) and octopus.
don porosus) and octopus.

A first stock assessment has been made of this assemblage of species using commercial statistics and data from the monitoring of fishing operations (Racca and Griffiths, 1972). Biological studies of individual species have not been developed as was done for the Lake species.

The trash fish, which are returned to the sea, may constitute as much as 75% of the total catch of a given haul.

The relationship between catch per unit effort and effort is good if 3 years (1965, 1967 and 1970), known to be years of extraordinary shrimp catches (Cadima *et al*, 1972), are ignored or if the shrimp catches for each year are subtracted from catch totals. The level of effort corresponding to the maximum sustainable yield was estimated at about 20,500 days' absence from port of the Punto Fijo fleet. This value decreases to about 18,500 days' absence if the years 1965, 1967 and 1970 are not considered. If the shrimp catches are discounted, the level is at about 16,500 days' absence. The catch-effort relationship for shrimp is discussed later. The present level of trawl fishing effort in the Gulf of Venezuela is at about 27,000 days' absence from port.

Apparently not all the commercial fish species are equally affected by the fishing effort; about half (sharks, curvinas, snappers, southern sennet and Atlantic moonfish) do not individually show a definite response to the fishing effort; grunt, curvinata, croaker and squid do. The shrimps are a special case in which a response is observed but with wide variations (Cadima *et al*, 1972).

The relative percentages of grunt and shrimps in the catches have increased as the fishery developed, whereas the percentage of the remaining species has remained constant or declined slightly. The grunt resource is being fished somewhat above its level of maximum sustainable yield, though the catch-effort curve has only a very broad maximum, such that even at the prevailing high effort levels, the present annual yield is close to a maximum sustainable yield.

In the western demersal fishery, the catch-effort relationships of individual species are greatly variable. The relationship between catch per unit effort and effort for "unclassified" catch is a well-defined concave descending curve however.

Eastern Venezuela trawl fishery

The trawl fishery in Eastern Venezuela (Novoa and Cadima, 1972; Novoa, Cadima and Racca, 1972), which began in 1960, was carried out by two to three vessels until 1966. The landings consisted almost entirely of demersal fishes. The number of vessels increased rapidly after 1967 and totaled 60 in 1971. Shrimps, squids, octopus and other molluscs (especially scallops) were taken in negligible quantities prior to 1968 but increased from 15 to 37% of the total landings in the period 1969-1971, and it is probable that this percentage will increase further. There are two main base ports: Cumana and Puerto La Cruz. The Cumana fleet fishes preferentially in the area of Isla Margarita, whereas the Puerto La Cruz fleet fishes preferentially along the coasts of Anzoategui and Miranda States.

Total landings have increased from 340 tons in 1960 to 5,400 tons in 1971 but the catch per boat-month decreased from 18 tons per boat-month in 1969 to 12 tons per boat-month in 1971. It is concluded that this fishery, taking all species together, has entered the phase of decelerating growth. However individual commercial species or groups, such as Atlantic moonfish (*Vomer setapinnis*), sharks (principally *Rhizoprionodon porosus*), snook (*Centropomus ensiferus*), southern sennet (*Sphyraena picudilla*), squids (*Doriteuthis plei* and *Loligo palei*), octopus (*Octopus vulgaris*) and shrimps, are still in the development phase; corocoro (*Orthopristis ruber*) appears to have entered the stabilization phase. It should be emphasized however that the data are not yet adequate to properly define the catch-effort relationships.

Moderate increases in the fishing effort probably would produce higher total yields but would further decrease the catch per boat.

All the invertebrates (shrimp, octopus and squid) show increasing catch rates together with sennets and curvinas and curvinatas (these last two taken together). The catch rates for nearly all the fish species are declining, though often in an irregular manner.

Fisheries in other areas

There is a small amount of trawling in the central region (Hilders, 1972) and in the Gulf of Paria (Ewald, Diaz and Cadima, 1971). The principal commercial species are shrimps. In the Gulf of Paria croaker (*Micropogon furnieri*), curvina, curvinata and mojarra (*Eugerres plumieri*) are the predominant fish species taken. The catches show strong seasonal variation with croaker, curvinas and

Table 15. Total annual landings and values in Bolivars of grunt in Venezuela (1967-1971)

Year	Catch (tons x 10^3)	Value ($B^{\$} \times 10^6$)
1967	2.94	–
1968	3.75	2.44
1969	4.10	2.85
1970	3.13	2.70
1971	3.70	3.28

Table 16. Total annual landings and values in Bolivars of croaker in Venezuela (1967-1971)

Year	Catch (tons x 10^3)	Value ($B^{\$} \times 10^6$)
1967	1.06	–
1968	1.29	0.85
1969	1.49	1.19
1970	1.18	1.10
1971	1.31	1.19

mojarras most abundant between August and November and shrimp usually most abundant in the remaining months.

Some of the species taken by the trawl fleets, such as grunt, croaker, snapper and snook, and to a certain extent dogfish and catfish (both of which are taken by bottom lines, beach seines, gillnets and other gears), have annual catches in excess of 1,000 metric tons, as do the groupers, which are not commonly taken by the trawlers.

Grunt

This species (*Orthopristis ruber*) appears to have a particularly close association with shrimp catches. The annual landings are shown in Table 15.

Croaker

Micropogon furnieri is an important component of the trawl catches. The annual landings are given in Table 16.

Snook

Centropomus ensiferus is also an important component of the trawl catches; the majority of the catches of this species are made by the eastern trawl fishery

Table 17. Total annual landings and values in Bolivars of snook in Venezuela (1967-1971)

Year	Catch (tons x 10^3)	Value ($B^{\$} \times 10^6$)
1967	1.42	–
1968	1.55	1.39
1969	1.59	1.53
1970	1.25	1.32
1971	1.40	1.37

Table 18. Total annual landings and values in Bolivars of sharks in Venezuela (1967-1971)

Year	Catch (tons x 10^3)	Value ($B^{\$} \times 10^6$)
1967	1.94	–
1968	2.11	1.85
1969	2.41	1.83
1970	2.18	1.77
1971	2.25	1.96

Table 19. Total annual landings and values in Bolivars of marine catfish in Venezuela (1967-1971)

Year	Catch (tons x 10^3)	Value (B^s x 10^6)	Year	Catch (tons x 10^3)	Value (B^s x 10^6)
1967	4.44	–	1970	6.38	2.45
1968	5.19	1.08	1971	4.33	2.10
1969	3.53	2.52			

off the coast of Anzoategui. It is also taken by beach seines, often in coastal lagoons. The annual landings are given in Table 17.

Sharks and Dogfishes

Three species are distinguished in the official statistics: shark (*Carcharhinus springeri*, *C. acronotus* and *C. limbatus*) that are usually taken by longlines; tiger shark (*Galeocerdo cuvieri*), usually taken by bottom longlines; and a dogfish (*Mustelus higmani*), which is also taken with bottom longlines but may be caught by trawlers. Other species may be included in the total catches (Table 18).

Marine catfishes

The predominant species is *Arius spixii*, which is taken usually by beach seine, mainly in northeastern Venezuela. Another species, *Bagre marinus*, is more commonly taken by bottom longline though in smaller quantities. Most of the catch from the beach-seine fishery is used for fish meal.

Table 20. Total annual landings and values in Bolivars of snappers in Venezuela (1961-1971)

Year	Catch (tons x 10^3)	Value (B^s x 10^6)
1961	3.84	7.27
1962	3.34	6.53
1963	2.86	5.62
1964	2.85	5.83
1965	2.69	5.72
1966	2.80	6.21
1967	2.39	5.58
1968	2.59	6.00
1969	3.01	7.21
1970	2.62	7.03
1971	2.61	7.80

Table 21. Total annual landings and values in Bolivars of groupers in Venezuela (1961-1971)

Year	Catch (tons x 10^3)	Value (B^s x 10^6)
1961	1.48	2.53
1962	1.46	2.56
1963	1.40	2.55
1964	1.43	2.74
1965	1.82	3.06
1966	1.34	3.02
1967	1.53	3.63
1968	1.44	3.60
1969	1.31	3.59
1970	1.11	3.28
1971	1.19	3.68

Snappers

Several species of snapper are taken by small-boat coastal fisheries using handlines and bottom longlines; trawlers also catch modest quantities. These snappers are a preferred species in the fresh fish market. The disperse nature of the fishery however has made study difficult. Table 20 shows the trend of the catches during the last decade.

The predominant species distinguished in the official statistics is the red snapper (*Lutjanus aya*), followed by mutton snapper (*L. analis*) and gray snapper (*L. griseus*). However one of the significant fish of the unclassified species is the lane snapper (*L. synagris*), an important component of the trawl fishery.

Groupers

Like the snappers, these fish are taken by the small-boat coastal fishery but are far less common in the trawl catches. They are also a preferred fresh fish variety. There are several species, but the only one classified in the official statistics is the snowy grouper (*Epinephelus niveatus*), though it only comprises 10-15% of the total catch of groupers. The catches and values for the last decade are shown in Table 21.

DEMERSAL RESOURCES - INVERTEBRATES

Shrimps

Shrimps are the most valuable living marine resource in Venezuela and the most important element in the trawl catches. Preliminary evaluations have been made by Cadima *et al* (1972), Novoa and Cadima (1972) and Racca and Griffiths (1972). The total annual catches are given in Table 22.

In western Venezuela, the white shrimp (*P. schmitti*) apparently forms one stock only, with the juveniles in Lake Maracaibo and the adults in the Gulf of

Table 22. Total annual landings and values in Bolivars of shrimps in Venezuela (1961-1971)

Year	Catch (tons x 10^3)	Value (B^s x 10^6)
1961	2.49	3.94
1962	3.80	6.08
1963	3.90	6.21
1964	4.33	7.84
1965	7.98	14.25
1966	3.40	12.77
1967	5.06	20.42
1968	4.60	17.89
1969	5.37	25.24
1970	8.67	44.72
1971	9.37	48.08

Table 23. Total annual landings and values in Bolivars of ark shell in Venezuela (1961-1971)

Year	Catch (tons x 10^3)	Value (B^s x 10^6)
1961	2.09	0.16
1962	2.12	0.17
1963	0.69	0.05
1964	2.30	0.18
1965	3.96	0.26
1966	4.29	0.32
1967	2.30	0.16
1968	3.88	0.30
1969	4.51	0.34
1970	5.37	0.38
1971	4.13	0.34

Venezuela. The amount of fishing and the total catch have both increased during the period 1965-1971. The catch per unit effort has decreased from about 420 to 160 kg per day over the same period. The relationship between total effort and total catch shows that the current level of effort (in terms of days' absence from port of the Maracaibo fleet) is probably still slightly below that required to obtain the maximum sustainable yield. Any increase in effort, however, would cause only minor increases, or perhaps even a decrease, in the total catch, and the catch per boat would decrease further. The considerable variation in catch (in the years 1965, 1970 and 1971 in this case) are thought to be due to strong annual variations in recruitment, but other possible causes need to be examined.

The beach seine fishery in Lake Maracaibo, which exploits mainly juvenile (5-16 cm total length) white shrimp, has reached the phase of decelerating growth. The catches from the Lake constitute about 15% of the total shrimp catches of western Venezuela. The relation between the Lake stock and the Gulf stock of white shrimp has not yet been elucidated. Although recruitment is continuous, both stocks receive two main recruitments per year, one from February to June and the other from August to October, though with appreciable inter-annual variation and some phase differences between the Lake recruitments and the Gulf recruitments, which is not unexpected in a migratory species such as white shrimp.

The grooved shrimp stocks (*P. aztecus, P. duorarum* and *P. brasiliensis*) are largely confined to the Gulf of Venezuela and are exploited mainly by the Punto Fijo fleet. The catch rates of the grooved shrimp have also declined, from about 170 to 130 kg per days' absence for the Punto Fijo fleet, during the period 1962-1971. The fishery seems to be approaching the maximum sustainable yield, and a further increase in the number of vessels would cause only a minor increase in, or might even decrease, the total catch. Again, there are wide variations in the years 1965, 1970 and 1971. The grooved shrimp fishery, though in a phase of decelerating growth, has only one rather prolonged, ill-defined recruitment maximum.

In eastern Venezuela, the fishery for white and grooved shrimps is in the developing phase. The increase in exploitation from 1967 to 1971 has produced higher catches per boat-month (from about 1,800 to nearly 3,000 kg per boat-month) as well as higher total catches (from about 81 tons to about 1,200 tons in 1971). The level of exploitation is certainly below that required to obtain the maximum sustainable yield, and an increase in the present level of fishing effort will most probably increase the total catches, though it is not possible to determine the magnitude of this expansion. At the moment, 60 vessels are fishing in the area.

The catch rates show two annual maxima, one from March to May, the other from September to November.

White shrimp predominate in the catches of the small-trawler fishery of the Gulf of Paria (Ewald, Diaz and Cadima, 1971), occupying more than 50% during most months of the year except August through November. The total annual landings of this small fishery were about 184 tons in 1969 and 149 tons in 1970.

The Gulf of Paria and the Orinoco delta provide special conditions that have determined an uncertain development for this fishery so far. In view of the considerable shallow inshore areas where shrimp are thought to be abundant, rather specialized fishing boats, gears and methods may be required to take full advantage of the resource.

The sea-bob (*Xiphopenaeus kroyeri*) appears in great quantities, together with white shrimp, in the trawl catches in western and eastern Venezuela, but it is discarded at sea. The main reason for this seems to be its lack of commercial value in Venezuela, though in some Central American. Brazilian and Guyanian fisheries the sea-bob is an important species that is exported to the U.S. The Pacific coast fisheries of Colombia are now landing and processing this species for export.

Scattered information indicates that the sea-bob is very abundant in the catches, and preliminary estimates give a proportion of 5 or more tons of sea-bob per ton of white shrimp. It is probable that most of the sea-bob at present discarded at sea does not survive. If so, the fishing could be affecting the stocks, but the almost complete lack of information on the catches makes it impossible to estimate this influence as well as the potential yields of this resource.

Small amounts of freshwater shrimps of the genus *Macrobrachium* are taken in the Lake Maracaibo area and elsewhere.

Lobster

A preliminary evaluation (Cobo de Barany, Ewald and Cadima, 1972) of the lobster fishery (*Panulirus argus*) of Los Roques shows that total catches have decreased by 25% from 140 tons in the 1962-1963 fishing season to about 100 tons in the 1969-1970 season. Over the same period, the catch per trap has decreased from 17 to 9 kg.

The level of fishing effort that will produce the maximum sustainable yield seems to be about 50-60% of the present total effort of 13,300 traps.

Crabs

The trap fishery for crabs (*Callinectes sapidus* and *C. bocourti*) in the Lake Maracaibo area started in 1969 and is increasing rapidly (Griffiths, Cadima and Rincon, 1972). *Callinectes sapidus* is the predominant species.

The two principal fishing areas are the southwest and the southeast coasts of the Straits of Maracaibo. Some crab fishing is also done in the southern part of Tablazo Bay.

The fishing effort, catch and catch per unit effort have increased steadily since 1969. The season of highest catches per unit of effort (kg per trap-day) is the second half of the year. The present average catch rate is about 2 kg per trap-day. The catch in 1970 was 276 metric tons and in 1971 463 metric tons. In the first quarter of 1972, the catch reached 408 tons.

The catches are composed predominately of males (90%) because the distribution of the two sexes is different; the females prefer salt water except when they enter brackish or fresh water to mate with the male crabs.

Recruitment of young crabs to the fishery apparently occurs mainly in July and November. These months correspond to periods of greater abundance of egg-bearing females, July being predominant in this respect. It may be inferred that recruits to the fishery are at least 1 year old.

The possibilities for the expansion of this fishery are considerable. Further biological studies and stock assessment work are required however.

Mussel

This mussel (*Perna perna*) is abundant in Venezuelan waters; it is similar to the common mussel, *Mytilus edulis.* The fishery is based on natural beds and on culture rafts (Salaya *et al,* ms). The mussel beds, numbering about 30, are found along the north coast of Sucre. Limited accessibility has rendered exploitation of most of these beds difficult. Nevertheless the more accessible beds west of Carupano are so heavily fished, since efforts at cultivation started in the early 1960s, that the yield of seed mussels from these beds has been reduced to critical levels within the space of a few years.

Historically, the mussel beds have been exploited by manual removal of the mussels from the rocks. The mussels are found between the intertidal zone and 10-m depth. The catch is destined for fresh consumption and canning. At present two companies are engaged in mussel cultivation; one operates six rafts in La Chica, Gulf of Cariaco and the other operates two in El Guamache Bay, Margarita. There are a few other private and experimental rafts in operation. The rafts produce 20 to 40 tons of commercial grade mussels per raft per year (Salaya *et al,* ms).

Since 1960 the yield has been variable, ranging from 141 tons (including shell) to 312 tons in 1968. Production decreased in 1971 to 138 tons from the natural beds and 93 tons from the rafts.

This mussel grows approximately 10 cm during its first year, which is considerably more than the growth rates observed in Europe for *Mytilus edulis,* a similar species.

The period of most intense spawning is December-April. January and February are the months of maximum abundance of larvae, and February, March and April the months of maximum fixation of seed mussels.

The prospects for cultivation are favorable, given the high growth rate, the high biological productivity of eastern Venezuela coastal seas, the absence of environmental extremes and the large number of protected yet productive bays. Nevertheless, several technical and economical difficulties in the design and construction of the rafts have yet to be overcome before successful myticulture can be achieved.

Pepitona

Until 1957, the catch of this bivalve (*Arca zebra*) was low, not exceeding 600 tons (unshucked). Since 1957, the fishery has grown steadily and the annual catch (Table 23) is now about 4,500 tons (Salaya, 1971). Therefore, in terms of weight, this is the second most important invertebrate resource after shrimps. Venezuela is the number one producer of ark-shell in the world (FAO Fisheries Statistical Yearbook 1971). The fishery is by dredge and the most important beds are along the northeastern, eastern and southeastern coasts of the island of Margarita and the northeastern coast of the island of Cubagua. Although there are ark-shell beds in western Venezuela, they are not at present exploited. The catch rate may reach 1,500 kg per hour of dredging (i.e. not counting lowering and raising time), although 1,000 kg is more usual. The yield of meat is about 20% of total weight. The catch is mostly canned for national consumption.

The catch-effort data are not adequate for determining the present status of the fishery, but annual catches, though variable, have been increasing. However, the catch is 1971 was only 4,150 tons, decreasing from a miximum value of 5,400 tons in 1970.

Pearl oyster and Mangrove oyster

The pearl oyster (*Pinctada imbricata*) resource reached a stage of over-exploitation years ago, possibly as early as 1946, and only three banks are now producing commercial quantities of pearls of inferior quality (Salaya and Salazar, 1972).

The catch in 1969 was only 149 tons (compared with 6,816 in 1953) producing only 495 carats of pearls. Some efforts at oyster culture have been made together with mussel culture, and there appear to be prospects for this.

Fishing by diving disappeared over a decade ago, and only drags are used now. The fishery is now completely overshadowed by that for pepitona which has occupied areas once dominated by the oyster.

Oyster meat has been canned in moderate quantities since 1941, and the economic yield of this product has exceeded that of the pearls.

The mangrove oyster (*Crassostrea rhizophorae*) is exploited locally, mainly for fresh consumption, but this is hardly more than a subsistence fishery.

Scallop

Pecten papyraceus recently became prominent in the trawl catches of eastern Venezuela, off the east coast of Isla Margarita, and the production has been mostly exported to the U.S. as frozen scallop mussel. There is a limited local consumption of fresh scallops, which are sold unshucked.

The catch in the first half of 1972 amounted to about 300 metric tons; the price paid to the fisherman was Bs 1.00/kg.

Three trawlers are fishing specifically for this species. As an incipient fishery, the prospects for expansion seem favorable. Fishery statistics are now being obtained to quantify this development.

RELATED WORK

FISHERIES OCEANOGRAPHY

Some studies of the marine environment were made to determine, as far as possible, the main features that could be related to fish distribution and abundance. These studies were made mainly in conjunction with egg and larval surveys and acoustical surveys. Some data collected several years ago were also analyzed. These data consisted of observations of sea temperature, salinity and dissolved oxygen content, zooplankton and phytoplankton standing crops, and wind conditions in the Gulf of Cariaco from 1959 to 1961 (Simpson and Griffiths, 1971; Griffiths and Simpson, ms).

Relatively well defined seasons were found to occur. Between January and April, northeasterly winds were predominant, causing upwelling and low sea-surface temperatures, subsequently resulting in high standing crops of zooplankton and phytoplankton. Generally speaking, large sardine catches also occurred in this period. Later in the year, the northeasterly winds were largely replaced by weaker northwesterlies and maximum temperatures occurred in the late summer and autumn months (August to October). The period of peak northwesterly winds (August-October) produced a secondary maximum in the phytoplankton standing crop in September.

These seasonal extremes in the first and third quarters of the year play an important role in the biological cycles of the various species and the fisheries covered in this report.

The seasonal nature of the influence of the Orinoco, and possibly the Amazon river, on the coastal waters of northeastern Venezuela has been confirmed by recent data. The same studies show the occurrence of upwelling in the Gulf of Cariaco, the waters along the north coasts of the Peninsulas of Araya and Paria and waters off the west coast of Araya and the south and east coasts of Margarita. All these areas are centers of fishery activity.

The relationship between long-term temperature records and sardine catches was described earlier. In the Maracaibo area, salinity and temperature data were collected regularly for about 2 years (1970 and 1971) and are now being analyzed.

PELAGIC EXPLORATORY FISHING

In spite of the lack of a fisheries research vessel, some pelagic exploratory fishing has been carried out with a small drum seiner. Besides sardine, the drum-seiner frequently caught small amounts of half-beak, flying fish, sennet, rough scad, porgy, pompano, bumper, tenpounder, anchoveta and camiguana. Except for rough scad, sennet, anchoveta and camiguana, these species are not normally caught by the coastal fishermen. As mentioned earlier, the first experimental purse-seining for tuna in Venezuelan coastal waters was carried out by a Spanish purse-seiner, accompanied by two chummer boats, under a special license issued by the National Fisheries Office from May 10 to July 9, 1972, off La Blanquilla and La Tortuga islands (Mihara, Medina and Griffiths, 1972).

DEMERSAL EXPLORATORY FISHING

The trawler *Carmelina* was chartered for fishing the inner Gulf of Venezuela and the Lake of Maracaibo. Six exploratory trips were made (Ewald *et al*, 1971). One hundred and twelve species of fish and eight species of shrimp were caught.

In Lake Maracaibo, the most commonly caught commercial fish were mojarra (*Eugerres plumieri*), Lake curvina (*Cynoscion maracaiboensis*) and catfish (*Arius* sp.).

Shrimp catches as high as 21 kg per hour were obtained in the deeper areas. These are not exploited by the local beach-seine fishery. The catches consisted of a large percentage of juvenile brown shrimp (*P. aztecus*), whereas the beach seine fishery in the Lake exploits juvenile white shrimp (*P. schmitti*) stocks; the brown shrimp were not thought to be present in the Lake prior to this exploratory fishing. Large commercial quantities of the blue crab (*C. sapidus*) and the clam (*Polimesada*) were taken.

Large catches of pepitona (*Arca zebra*) were obtained with a small try net in 20-fathom depths just west of Punto Fijo in the Gulf of Venezuela.

Non-commercial species usually predominated in the catches in both zones, however.

It was not possible to carry out deep water trawling as no appropriate vessel was available. However, two Spanish trawlers were given a special license to conduct exploratory trawling along the Venezuelan coast between Puerto Cabello and Isla Margarita. They fished at a depth of 200-400 fathoms, as well as at shallower depths, between December 1971 and April 1972. In the central region (Puerto Cabello to Isla Tortuga), the predominant species in the catch were hake (*Merluccius albidus*) and red shrimp (probably *Plesiopenaeus edwardsianus*) at the depths trawled. These were followed by a type of Norwegian lobster (*Nephrops*) and spiny crab (*Maia*).

The catches from north of Isla Margarita were those usual for that area as mentioned earlier: white shrimp, snapper, grouper, panchito (*Pristipomoides macrophthalmus*), cunaro (*Rhomboplites aurorubens*), a dogfish (*Mustelus higmani*) and chub mackerel (*Scomber japonicus*).

Some exploratory fishing was done in the inshore area of the Gulf of Paria. Three main areas of relatively good fishing have been discovered: one between Guiria and Irapa, another north of Cotorra Island in the southern part of the Gulf and a third in the southern entrance to the Gulf (Serpent's Mouth).

HYDROACOUSTIC SURVEYS

Nineteen surveys were made in 1971 (Ødegaard, Abad Carpio and Malave, 1971a; 1971b). The main vessel used for this work was a converted Florida shrimp trawler. It is equipped with a Simrad EH2E sounder and a Simrad Skipper sounder. The drum-seiner mentioned earlier was also used occasionally. It carried an Ekolite RS2 sounder and a Wesmar SS300.

The area surveyed comprises the Gulf of Cariaco, the Santa Fe coast, the north and west coasts of the peninsula of Araya, the coastal waters of the Islands of Margarita, Cubagua and Coche and the north coast of the Peninsula of Paria over a period of 8 months, which is too short a time to draw any firm conclusions on fish stock abundance and distribution. The areas of highest apparent abundance were found to be the central part of the Gulf of Cariaco, the southeast coast of the Island of Margarita and the area between the island and the Peninsula of Araya.

EXPERIMENTAL FISHING

Several new and modified gears have been built and tested. Many of these are described by Mihara *et al* (1971a). The gears are: multiple-hook handline, one piece longline, monofilament gillnets, three-beam lift net, trammel nets, beam trawl, special beach seines (Mihara *et al*, 1971b), fish and octopus traps and various other types of small gear.

DISCUSSION AND CONCLUSIONS

Considerable progress was made during the last 5 years in investigations on the marine fishery resources of Venezuela. Although stock assessments based on the analysis of the catch and effort data are preliminary, they provide the best knowledge available on the status of the resources and show which fisheries can be safely expanded (mostly the inshore, small-boat fisheries), those that can be cautiously expanded (e.g. shrimp, especially in eastern Venezuela) and those that offer no prospects of a higher yield with increasing fishing effort (e.g. yellowfin tuna, certain demersal species and lobster). With improved data over a longer term, more precise evaluations would be possible, but these are unlikely to alter substantially the preliminary estimates.

Certain resources are thought to exist but firm evidence is not yet available. These are the shrimp and related demersal resources of the Gulf of Paria and the demersal resources of the Gulf of Paria and the Orinoco delta area.

Several artesanal fishing gears have been developed. These could appreciably increase the productivity of the inshore fisheries, but a rapid increase in production is subject to market development.

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Observations on the Fishery and Biology of Pink Spotted Shrimp, *Penaeus brasiliensis* Latreille, of Margarita Island, Venezuela

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INTRODUCTION

The pink spotted shrimp, *Penaeus brasiliensis* Latreille, is widely distributed from Cape Hatteras in the West Atlantic Ocean through the Gulf of Mexico and Caribbean Sea to Rio Grande-Lagoa dos Patos, Brazil, but is of commercial importance only in several Latin American countries (Perez-Farfante, 1969). In Venezuela, this species is caught along the whole coast (Ewald, 1967; Khandker, 1965). In the Gulf of Venezuela, where the shrimp fishery is most extensive, it sometimes comprises as much as 20% of the catch (Ewald, 1967). It is of greater commercial importance in the shrimp landings from the Island of Margarita. At present, some 30 trawlers based in the ports of Cumana, Puerto La Cruz and Juan Griego operate in that area. Due to its scarcity in the commercial catch in western Venezuela, no detail work had been done on the fishery and biology of this pink spotted shrimp. This paper reports a phase of the work undertaken by our Institute on this species.

MATERIALS AND METHODS

All data were collected from commercial trawlers based in Cumana fishing in the area of the Island of Margarita, as shown in Figure 1. The trawlers are of Italian type averaging 20 m in length. In Venezuela, they have been modified to operate two trawls simultaneously. Trawls measure 21 m across the mouth and 26 m in length. Although trips were made in different boats at different times, all boats used the same kind of net. Monthly trips of about 8 days each were made between February 1971 and January 1972. One assistant from our laboratory went on all the trips, noted fishing information in a log book and collected and iced samples of shrimp for later laboratory analysis. All measurements and weights were taken from fresh shrimp.

Catches shown in this paper are from a pair of trawls operated simultaneously. Weights reported here are for whole shrimp.

COMPOSITION OF SPECIES

Pink spotted shrimp, *P. brasiliensis,* constituted 95% of the catch of shrimp; in deeper waters (31-40 fm) almost 100%. Other Penaeid species were *P. duorarum notalis* and *P. aztecus subtilis.* Even in the field it was not difficult to identify *P. brasiliensis* since invariably a reddish brown spot was present on both sides of the tail between the third and fourth abdominal segments (Fig. 2).

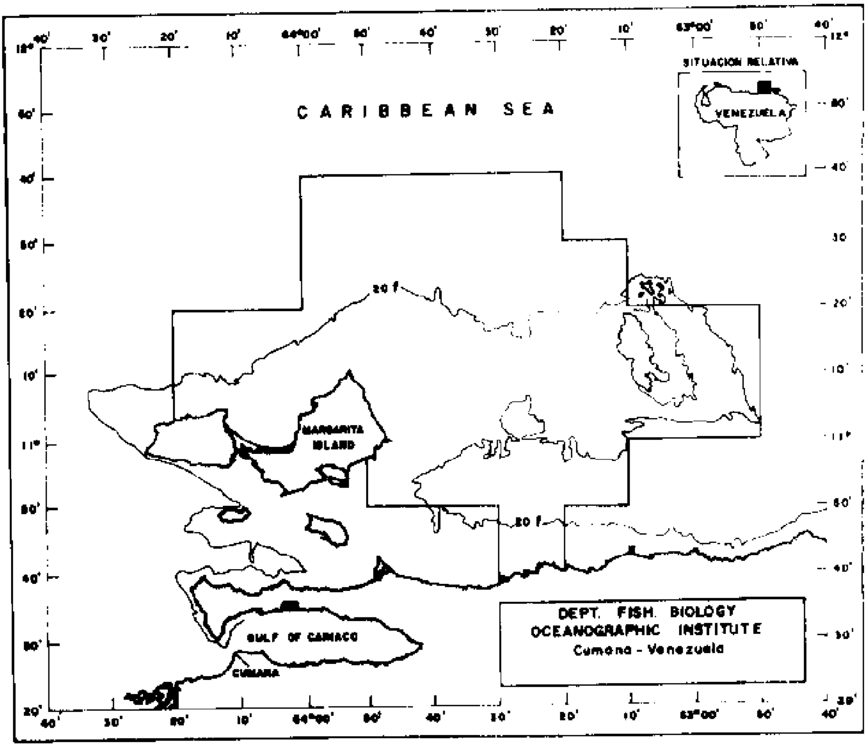

Fig. 1. Fishing area around the Island of Margarita.

Holthuis (1959) also reported such a spot on specimens from Surinam and French Guiana.

CATCH

In total, 494 hauls were examined during the 12-month period. Of these, 62.8% contained shrimp. Percentages of shrimp in the total catch varied widely between 5 and 60%. The maximum catch per hour of trawling was 73.3 kg, and averaged 14.4 kg.

Analysis of the catch of shrimp at different depths (Table 1) shows the maximum catch rate was obtained from depths between 31-40 fathoms, averaging 16.9 kg per hour. This generally agrees with Holthuis (1959) who reported *P. brasiliensis* to be abundant in waters off Surinam at depths between 20-30 fathoms, and off French Guiana between 22-38 fathoms. The pink spotted shrimp is also abundant in our area in depths shallower than 20 fathoms, but the size is small. Sometimes large quantities of juvenile shrimp between 90-120 mm total length (t.l.) were caught and discarded.

The substream preferred by adult *P. brasiliensis* seemed to be hard sandy bottom often mixed with dead molluscan shells. Juveniles seemed to prefer sandy silt bottom.

Fig. 2. Pink spotted shrimp, *Penaeus brasiliensis*, showing reddish brown spot.

Both daytime and nightime trawling was conducted, but virtually all shrimp were taken at night. Catches were less during twilight hours. Catches in daytime were very insignificant in the area where shrimp were caught at night. *P. brasiliensis* is definitely nocturnal, which is in agreement with the findings of Bullis and Thompson (1959).

On each trip of 8 days, 41-44 hauls usually were made, each of 3 hours duration. During the trips, the captain of the boat conducted fishing operations without any instruction or interference from the scientists. So the operations were typical commercial fishing trips. The average catch per day has been calculated for each month (Table 2). The catch does not show any significant seasonal trend. The maximum catch was in the month of May, when the least number of hauls was made. The annual average catch rate was 141.0 kg per day. This compares favorably with 150 kg taken by the same type of trawlers in the Gulf of Venezuela (Lundberg *et al*, 1970). After adjusting our catches to a 24-hour trawling day, they were about average compared to catches in most areas off the

Table 1. Catch of shrimp according to depth (catch/haul/hour)

Depth (fm)	Average catch (kg)
> – 20	15.5
21 – 30	12.2
31 – 40	16.9

United States where 133-237 kg per day (heads on) have been reported (U.S. Fish & Wildlife Service, 1958).

SEX-RATIO

The sex-ratio was calculated for each monthly sample and the combined 12 monthly samples (Table 3). Females dominated in samples from 4 months (February, March, May and December), the ratio being significantly different from 1:1 as shown by the chi-square value (.05 level). In one month (July), males were significantly greater in number. For the combined 12-month sample, the sex ratio was significantly different from 1:1, and females predominated.

SIZE FREQUENCY

Record sizes for both sexes were recorded for this species. The largest female was 63.9 mm c.l., 250 mm t.l. and weighed 142.0 gm. The largest male was 45.1 mm c.l., 200 mm t.l. and weighed 69.9 gm.

Table 2. Shrimp catch per day by months (weight in kg – heads on)

Months	Length Trip (days)	Number of Hauls	Total Catch	Average Catch (day)
February '71	8	44	820	102.5
March	8	41	1020	127.5
April	8	43	1330	166.3
May	8	32	1980	247.5
June	8	42	810	101.3
July	8	41	1165	145.6
August	8	44	985	123.1
September	8	44	849	106.1
October	8	41	1715	214.4
November	7	38	470	67.1
December	8	43	1244	155.5
January '72	8	44	1008	126.0
Totals	95		13396	141.0

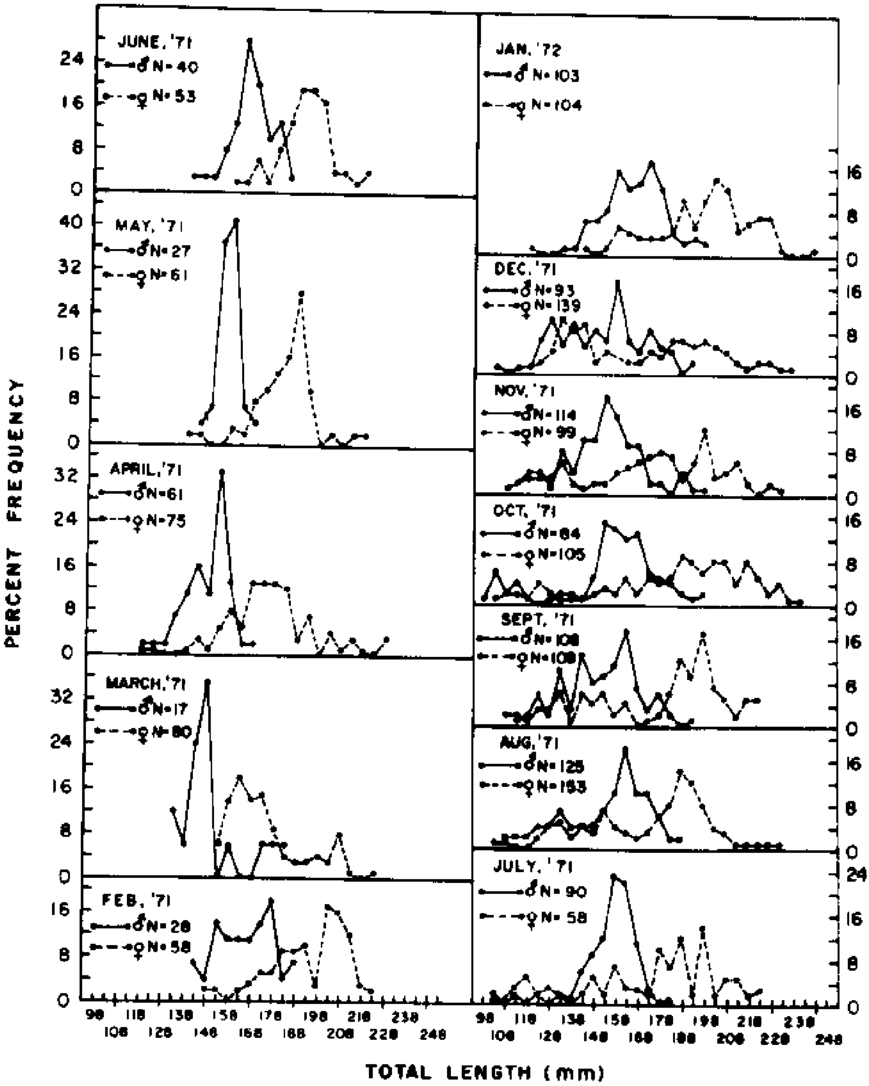

Fig. 3. Size frequency distribution of *P. brasiliensis*

The smallest male was 19.8 mm c.l. and 99 mm t.l. The smallest male with a joined petasma was 24.3 mm c.l. and 114 mm t.l. This size is larger than the 15 mm c.l. and 69 mm t.l. noted by Perez-Farfante (1969) for this condition. It seems that in our area large numbers of juveniles in subadult condition migrate to the sea from inshore nursery grounds.

The size frequency diagram (Fig. 3) showed strong modal values, especially for males. The modal value for males varied between 148-178 mm t.l. and for

Table 3. Sex ratio of pink spotted shrimp, *Penaeus brasiliensis*

Month	Male No.	Male %	Female No.	Female %	Chi-square value
February '71	28	32.6	58	67.4	10.460**
March	17	17.5	80	82.5	40.910**
April	61	44.9	75	55.1	1.440
May	27	30.7	61	69.3	13.130**
June	40	43.0	53	57.0	1.810
July	90	60.8	58	39.2	6.910**
August	125	45.0	153	55.0	2.820
September	108	49.8	109	50.2	.004
October	84	29.1	105	70.9	2.330
November	114	53.5	99	46.5	1.050
December	93	40.1	139	59.9	9.120 **
January '72	103	49.8	104	50.2	.004
Totals	890	44.9	1094	55.1	20.970 **

**Significant at .05 level

females between 163-203 mm t.l. There is an average difference of about 30 mm in modal value between males and females, showing clearly the size discrepancy between the two sexes. From July to December, there was a greater size range of shrimp, especially the smaller sizes. This may indicate the months of recruitment to the fishery.

From the size frequency, it appears that male *P. brasiliensis* live at least 2 years and female as long as 3 years. Probably the males above 140 mm t.l. are 1-year old, and above 180 mm 2 years old. Females above 170 mm t.l. are 1-year old, above 210 mm 2 years old and above 240 mm 3 years old.

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The Potential of Pollutants To Adversely Affect Aquaculture

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INTRODUCTION

The purpose of this report is to examine the potential of pollutants to act as limiting factors on aquaculture. Judging from the lack of documented cases, this has not been a serious problem in the past. Apparently, this stems from a negative correlation between industrial development and aquaculture development: Those sections of the world that have seen the greatest industrial advancement have not developed extensively in terms of aquaculture. One of the exceptions to this general pattern is Japan which, significantly, has experienced serious interactions between industrial polluters and culture and inshore fishery operations (e.g., reduced production from pearl oyster rafts anchored in polluted waters and the Minamata Bay disaster.)

Before discussing specific types of pollutants, it is useful to make two points:

(1) INTENSIVE VERSUS EXTENSIVE AQUACULTURE

As the world becomes more highly developed industrially, the amount of damage to aquaculture from pollution will be related to the degree of control exercised by the aquaculturist over his operation. Considered as a compartment, the aquaculture facility has three major inputs – one from the atmosphere, one from land drainage and one from the water source. In an extensive (open) operation, such as the raising of fish in a large lagoon blocked off with netting, little or no control is possible over any of these inputs. In an intensive (closed) operation, such as a pond, control is possible over everything except the atmospheric input. In some theoretical plans, such as bottle culture of trout and rearing of shrimp in individual plastic cells, complete control is possible. This assumes, of course, that continual monitoring of incoming water can be performed routinely. In the future, one way that aquaculture may continue to flourish in certain highly developed countries may be through the use of sophisticated, intensive methods.

(2) DECREASED ECOLOGICAL STABILITY

Because aquaculture is maintained at elevated net production levels through the use of external energy subsidies, aquaculture facilities ecologically are highly unstable and much more easily perturbed than a natural ecosystem (see Fig. 1). The concept of ecological stability is used here as defined by Hurd *et al* (1971) as the ability of a system to maintain or return to its ground state after an external perturbation.

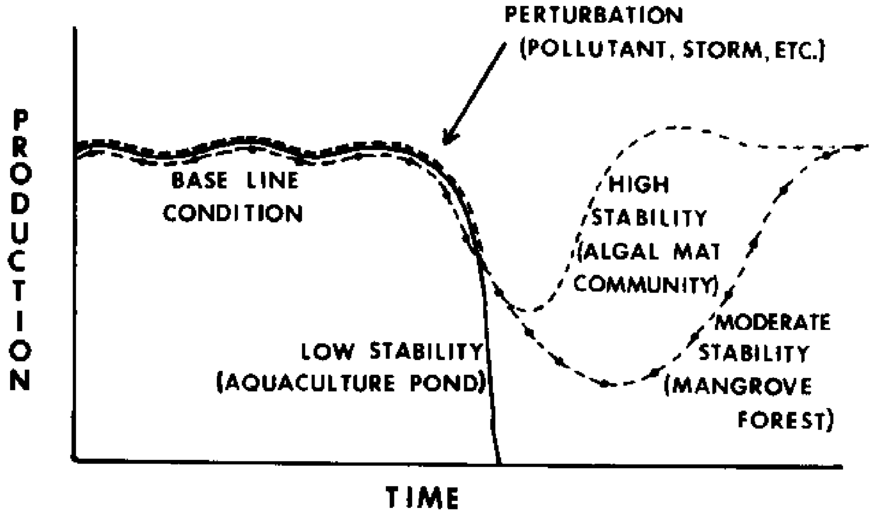

Fig. 1. Hypothetical representation of three responses to an external pertubation. Note the considerable damage but rapid recovery of the high stability system, the greater damage and slower recovery of the moderate stability system and the complete collapse of the artificial culture system. In the latter case, production may eventually recover, but in an entirely different form from the original condition. For instance, once a shrimp or pompano population has been destroyed, natural mechanisms will not recreate the original condition.

This lowered ecological stability is reflected both by the entire system and the populations of culture organisms within. This means that diseases, parasites and levels of lowered oxygen or increased pollutants that would have little effect on a population in its natural environment may limit growth or even prove fatal in the extreme conditions of an aquaculture pond. It also means that synergistic effects of crowding, such as those created by high nutrient levels, elevated temperatures and pollutants working together, may create results that could not be foreseen from experience or experiments in the natural environment. As an example, Pringle *et al* (1968) have shown that in a "simulated natural environment," multiple factors such as temperature, time of exposure and the physiological activity can combine to increase the rate of heavy metal uptake by shellfish. This may explain why Galtsoff *et al* (1947) found oysters near a paper mill effluent reacting to the stressful environment by concentrating copper at abnormally high levels even though the effluent contained no increased copper concentration.

ORGANIC WASTES AS POLLUTANTS

Included in this category are animal waste products and other naturally occurring organic materials. These are biodegradable substances for which there exist naturally evolved mechanisms which, if not overloaded, take care of treatment by decomposition. Generally, these compounds are non-toxic (note the exception of certain petroleum by-products) and at low to moderate concentrations may stimulate production.

The beneficial effects of limited biodegradable pollution have been recognized for centuries and incorporated into traditional aquaculture practice (discussed by Hickling, 1970). These included the judicial addition to ponds of human and animal wastes along with many types of organic matter – leaves, wood and portions of agricultural plants.

At higher concentrations, adverse effects begin to appear, but these are often difficult to recognize because they are usually manifested in an indirect manner. Potential problems for aquaculture include: (1) LOWERED DISSOLVED OXYGEN CONCENTRATIONS – at high concentrations of organic matter, the demand for oxygen from chemical and microbial decomposition becomes so great that the oxygen concentration in the water may be lowered disastrously. This is a common problem for pond culturists who have intentionally or unintentionally allowed too much organic matter to enter their ponds. Usually, large die-offs of culture species due to reduced oxygen concentrations occur at night when plant respiration is added to microbial demands. Mechanisms commonly employed to prevent depletion involve aeration of the water with devices such as fountains and water wheels. (2) UNWANTED INCREASES IN PRIMARY PRODUCTION – elevated nutrient levels accompanying high concentrations of organic input can encourage plant forms that are useless to the herbivores under culture and may further lower oxygen concentrations during the night. (3) INCREASED TURBIDITY – when large concentrations of fine, particulate organic detritus are added to a pond or stirred up from the bottom sediments they may interfere with light transmission. The nutrients accompanying organic additions to a pond may cause phytoplankton blooms, which also increase turbidity. In either case primary production is limited by the lower light levels and the result may be a large scale death of algae and lowered oxygen levels. (4) LOWERED PH – humic acids derived from excess amounts of organic matter decaying within a pond or its watershed are capable of lowering the pH to a point where production is adversely affected. This is a particularly serious problem in stagnant ponds with low flushing rates. Problems have been encountered in the Philippines in situations in which mangrove swamps drain into large ponds with restricted flushing and high evaporation rates (Heald, personal communication). A pH of 5 or below seems to seriously inhibit both plant and fish growth. If the pond has a carbonate sediment bottom, the pH remains at a higher level.

CASE HISTORY

One of the best documented and most quoted cases of alteration of a culture operation is that associated with the expansion of duck farms adjoining the oyster fisheries of Moriches Bay and Great South Bay, Long Island, New York (Ryther, 1954; Barlow *et al.* 1963; Galtsoff, 1956). Organic matter and nutrients originating from untreated wastes from these duck farms completely altered the ecological characteristics of the two embayments into which the effluents emptied. The most striking effect was a change in the types of dominant phytoplankton present. Unfortunately, the forms of phytoplankton encouraged by the eutrophicated conditions were not suitable for oyster growth, and oyster production declined.

HEALTH HAZARDS FROM THE USE OF SEWAGE

Examples of damage to aquaculture from untreated sewage are numerous. These have been especially serious in the culture of filter-feeders such as oysters and clams, which may not be noticeably affected but are capable of concentrating bacteria and viruses harmful to man (discussed by Paoletti, 1965). Attempts to use treated sewage as a nutrient source for aquaculture should be accompanied by precautions to insure that the treated sewage is free of harmful microorganisms.

CHLORINATED SEWAGE EFFLUENTS

If the sewage is treated with chlorine, further precautions should be taken to insure that the effluent is free of chlorine before being dumped into cultural ponds. Tsai (1968) has shown detrimental effects of chlorinated sewage effluents immediately below sewage outfalls. These include lowered species diversity and abundance of fishes even though oxygen and pH were normal. On the other hand, Rickards (personal communication) encountered no difficulties in using sewage effluents treated with low levels of chlorine in aquaculture ponds at Morehead City, North Carolina.

One way to avoid this problem, if it exists, would be to replace chlorine treatment with ozone treatment. Although slightly more expensive, this method produces no harmful contaminant in the effluent.

INDUSTRIAL WASTES

Substances such as long-chain phenolic chemicals, ammonium salts, cyanides, sulfates, nitrates and heavy metals are common to industrial wastes and pose a threat to aquaculture facilities in the vicinity of industrial outfalls. In contrast to organic wastes, these are nondegradable pollutants that either degrade very slowly or do not degrade at all. The toxicity of these substances to fish and aquatic invertebrates has been firmly established (see Jones, 1966; Anon., 1968). Any significant addition of these compounds to the environment or to an aquaculture operation will result in lowered secondary production. Potentially more serious is the tendency of many organisms and especially filter feeders to concentrate and store copper, mercury, lead and arsenic at levels that may be dangerous for the consumer.

MINAMATA BAY

The disaster associated with Japan's Minamata Bay (Irukayama, 1966) demonstrates the potential of industrial effluents to severely disrupt inshore fisheries and aquaculture. This problem originated from a plastics factory that produced vinyl chloride with the use of a mercury catalyst. From 1948 to 1960 this factory dumped in excess of 300 grams of methyl mercury daily into the bay. The mercury was quickly taken up by the sediments and then by fish and shellfish. Between 1953-1960 large numbers of people who ate these organisms became seriously ill and 46 died. A similar disaster occurred at Nigata in 1965, resulting in 120 stricken and five deaths.

Although conventional fisheries were most seriously affected, both cases demonstrate the potential for an industrial pollutant to seriously upset the operation of an aquaculture facility at some distance from the source.

PETROLEUM PRODUCTS

Extensive aquaculture (open systems) in the vicinity of heavy shipping or oil refineries may suffer damage from oil pollution. Iversen (1968) mentions several instances of oyster farms in Puget Sound, Washington, which experienced extensive damage from nearby oil spills.

Evidently, molluscs are more susceptible to direct mortality from petroleum products than are fishes (Nelson-Smith, 1970). This is because the outer surface of fish, their mouths and gill-chambers are coated with a slimy oil-repellent mucous. Steed and Copeland (1967) have shown, however, that low concentrations may stress fish and other organisms to the point that growth is curtailed, and the organism becomes more susceptible to other stresses such as lowered oxygen. Lower concentrations that do not noticeably affect the metabolism may cause the flesh to have an undesirable flavor. Mann (1965) has implicated low concentrations of phenolic compounds, tar derivatives and mineral oils as responsible for unappetizing flavors in fish. As little as 0.01 parts per million (ppm) oil can give rise to a marked taste in the oyster, *Crassostrea virginica*, and after heavier doses the offensive flavor may persist for 6 months (Menzel, 1948).

PESTICIDES

The problems associated with the intentional or accidental introduction of pesticides into estuaries have been reviewed by Butler (1966) and Johnson (1968). The types of adverse effects encountered by the aquaculturist include loss of production, ill-defined but significant mortality and sub-lethal effects such as lowered resistance to disease, behavioral and feeding difficulties and poor reproduction.

McLarney (1970) has cited specific cases of pesticide damage to aquaculture. In one instance, a bait minnow farmer in Arkansas attempted to convert 115 acres of cotton fields into fish ponds, but failed completely because of concentrations of endrin and dieldrin that had accumulated in the soil. He also points out the dangers to the catfish industry of high non-lethal levels in their final product. Wild catfish have been caught with DDT levels as high as 58 ppm, 10 times the amount allowed by the U.S. Food and Drug Administration.

In southeast Asia, fish kills are more frequent in rice paddy aquaculture because of increased pesticide usage to protect the "Green revolution" (Hinckley, personal communication). As a result, the protein intake of the peasant population has been lowered.

INPUT VIA FOOD SUPPLEMENTS

In most cases, pesticides enter culture ponds from the atmosphere or water supply. Stober and Payne (1966) have shown an additional source – commercial fish food pellets. Analysis of several commercially available pelleted fish foods revealed chlorinated hydrocarbons at low parts per billion levels. Routine consumption of this food could lead to unacceptable concentrations in the culture species. An even more serious problem has been mentioned by Bookout (in press). Brine shrimp originating from Salt Lake, Utah, and used to rear larval culture organisms had such high pesticide levels that they caused extensive larval mortality.

EFFLUENTS FROM POWER STATIONS

EFFECTS OF HEATED EFFLUENTS

Detrimental effects to properly located aquaculture facilities from heated water should be minimal and heavily outweighed by beneficial effects, including increased growth rates. It should be remembered, however, that a rise in water temperature often increases the susceptibility of organisms in a synergistic manner to toxic materials, disease or parasites.

ISOTOPES

The effluent from nuclear power plants is not regarded as a likely source of serious environmental contaminants. This is because levels of stable elements (Cl, Cu, etc.) and radioisotopes in the discharge waters are generally low and are further diluted when dumped into natural bodies of water. Preston (1968) has confirmed this assumption for nuclides after monitoring shellfish in the region of existing nuclear stations in Britain.

One possible exception to this assumption concerns the proposed culturing of organisms such as shrimp, oysters and catfish (Yee, 1972) directly in the warm, undiluted effluent adjacent to the power station. Such practices could lead to problems, particularly for organisms such as oysters, which are capable of concentrating nuclides at levels thousands of times greater than in the water in which they are found. The phenomenon of uptake and bioaccumulation of radioisotopes through aquatic foodchains has been discussed by a number of authors (see Davis and Foster, 1958; Aberg and Hungate [eds.], 1966; Wolfe, 1969). In addition, many organisms, including oysters, have the ability to absorb zinc and other elements directly from the water across active membranes such as gill tissue.

CASE HISTORY: HUMBOLDT BAY POWER PLANT

To test the possibility of bioaccumulation in reactor effluents, Salo and Leet (1967) suspended trays of Pacific oysters, *Crassostrea gigas,* in the discharge canal of the Humboldt Bay Power Plant near Eureka, California. The oysters were maintained for over 400 days and sampled periodically.

This plant is typical in that low-level wastes are collected routinely and discharged periodically into the effluent. These wastes accumulate during normal operation from reactor water, steam system drainage, floor drainage of the radiation zone, liquids associated with fuel handling, fuel storage basins, the radiochemical laboratory, the laundry room, from equipment decontamination activities and from routine maintenance operation. Prior to discharge, the wastes are stored in holding tanks where they undergo radioactive decay until necessary standards can be met.

Samples of discharge water from the plant during the period of January 1965 up to June 1966 revealed significant amounts of induced nuclides: ^{65}Zn, ^{54}Mn, ^{59}Fe, ^{51}Cr and ^{60}Co. Eighty-seven percent of total activity was due to ^{65}Zn. After February 1966 ^{137}Cs and ^{134}Cs resulting from defective fuel cladding were present in the discharge water as well as induced nuclides.

During the 13-month period of the experiment, ^{65}Zn concentration in the water ranged from 0.104×10^{-2} pCi/ml to 1.963×10^{-2} pCi/ml; the variation reflected the amounts of stored wastes added to the discharge. The concentration in oyster meats reflected these changes in the discharge water and ranged from 0.99 pCi/g to 174 pCi/g.

Even though the levels in the oyster meat represented a concentration factor of 5000 to 10,000, the maximum concentration of 174 pCi/g was not judged to be dangerous. The authors concluded that the maximum body burden that a human would derive from a protein diet consisting of these oysters would be well within maximum permissible concentrations.

A similar oyster cultivation study was conducted in the discharge water of the Bradwell Nuclear Station in Great Britain (Preston, 1967). Interestingly, the concentrations of radionuclides accumulated by oysters in this discharge canal were in the same range as the Humboldt Bay oysters.

THE DELANEY CLAUSE

At the present time, any consideration of aquaculture in nuclear power plant effluents is rendered virtually impossible by the Delaney Clause of the Federal Food, Drug and Cosmetic Act [sec. 409 (C) (3)(A)]. This amendment stipulates the removal from interstate commerce of any food that contains analytically detectable amounts of a food additive shown to be capable of inducing cancer in experimental animals when given in very high doses. Clearly, this 20 year-old clause should be modified for certain situations. Refined research equipment has redefined "analytically detectable" by several orders of magnitude, and extensive research has shown that many contaminants are harmless when present at low concentrations.

COPPER

A number of papers have demonstrated the ability of organisms, particularly oysters, to concentrate stable copper at high levels from water low in copper (summarized by Roosenburg, 1969). The toxicity of copper in oysters to humans has been reported by O'Shaughnessy (1966) and Chang (1962). Since increased concentrations of copper are often present in power plant effluents, presumably originating from condenser tubes, it might be good to take a closer look at this potential problem.

CASE HISTORY: CHALK POINT POWER PLANT, MARYLAND

Roosenburg (1969) has studied the concentration of copper in oysters (*Crassostrea virginica*) in the Patuxent River estuary downstream from the Chalk Point, Maryland, steam electric generating station. The condenser tubes in this plant were originally stainless steel, but rapid erosion caused their replacement with aluminum-bronze tubes and finally copper-nickel tubes.

Shortly after initiation of plant operations, oyster meats near the outfall of the plant displayed a green color and high copper concentrations. With time, high copper concentrations spread to oysters further downstream. Copper content of oysters decreased with distance from the outfall.

It was concluded that erosion of copper from condenser tubes alone may not have been responsible for increased concentrations in oysters. Other factors such as increased temperature stress along with low levels of chlorine may have interacted to produce the phenomenon. Whatever the cause, the implications are serious to anyone wishing to grow oysters in power plant effluents. Green coloration, a bitter taste and possible toxicity from copper would render the oysters unfit for consumption.

CHEMICALS FOR THE PREVENTION OF FOULING

Chemicals for the prevention of fouling pose a serious problem to the aquaculturist attempting to utilize undiluted heated discharges. For example, continual low levels of chlorine are used by many generating stations as a treatment for prevention of condenser slimes and fouling organisms. Ansell (1969) has mentioned that low levels of chlorine residues remaining in the discharge water are effective in reducing growth in the mussel, *Mytilus edulis,* and the clam, *Mercenaria.*

That chlorine can be present at relatively high concentrations at some distance from reactor outfalls is emphasized by Carter's (1968) inability to use dye tracers to follow discharges from the Chalk Point Plant due to interference of chlorine residues with the dye.

A FINAL POINT

Not only pollutants but also large scale modifications of the environment such as water diversion, dredging and filling all have the potential to disrupt aquaculture facilities. For instance, Cronin (1967) discusses the effects of the Bonnet Carre Spillway, which diverts flood waters from the Mississippi River through Lake Pontchartrain and eventually the Gulf of Mexico. Effects on oyster culture in the Lake were mixed. Beneficial results include nutrient addition of 40,000 tons/year and reduction of oyster predators due to lowered salinity. Detriment to the oysters stemmed from increased siltation on oyster beds. Although Gunter (1953) concluded that the total beneficial economic effect outweighed the partial oyster mortality, in other situations the outcome might not be so favorable.

LOSS OF ESTUARINE LAND

Hickling (1970) makes the point that the future of estuarine aquaculture is linked with the fate of the estuaries themselves. In rapidly developing countries such as the United States, this is a serious problem. For example, Schmidt (1966) calculated that 47,000 acres of marsh between Maine and Delaware have been lost since 1954. The cause of these losses include: dumping of soil, 34%;

bridges, roads, airports and parking facilities, 27%; housing developments, 15%; industrial sites and trash dumps, 10%; recreation facilities, 13%; schools, agricultural croplands, drainage and beach erosion controls, 1%. All of these uses compete directly with aquaculture for the limited space available.

SUMMARY

(1) Documented cases of damage to aquaculture from pollution are rare.

(2) Intensive (closed) operations should have greater control over the introduction of pollutants than extensive (open) facilities.

(3) Aquaculture ponds are ecologically unstable and more easily perturbed than natural ecosystems.

(4) Deleterious effects of organic wastes are usually manifested in an indirect manner -- lowered oxygen concentrations, lowered pH and/or increased turbidity.

(5) Minamata Bay is presented as the type of problem that may arise from pollution of aquaculture from industrial wastes.

(6) Petroleum products may affect survival, growth and taste of culture organisms depending upon the concentration of the pollutant.

(7) Pesticides may be introduced by way of pelleted foods.

(8) The danger of bioaccumulation of isotopes in nuclear power plant effluents is discussed and discounted.

(9) Copper and chlorine may be serious contaminants in power plant aquaculture.

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Innovations in Coastal Management[1]

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INTRODUCTION

In recent years, our enhanced understanding of the important role played by coastal bays and estuarine regions in the maintenance of sport and commercial fisheries, as well as their aesthetic and recreational values, has led to greatly increased public and official desire to preserve these areas wherever possible. On the other hand, we are faced with a continual and ever-increasing public need for water-oriented activities, such as waterfront living, boating, swimming, fishing and generation of electric power. Pursuits of many of these activities impose stress on fragile estuarine environments.

It is probably safe to say that one single factor stands out above all others as a stress-producer -- the requirement for housing, particularly waterfront communities. If we accept the premise that people will always wish to live near the water, and that more and more people will wish to work, retire or vacation near the seashore, then our coastal environments will continue to deteriorate. This cannot be allowed to happen.

What, then, are the alternatives facing us?

Perhaps the most appealing and obvious alternative is to acquire coastal lands with state or federal funds and thus prevent their development. This seems hardly practical. Funds are insufficient to buy all coastal areas, and even if this *could* be achieved there will still be an upland boundary to the acquired lands. Development would proceed unabated behind this boundary, and its effects would *still* be felt in the coastal zones. If a preserve the size of the 1.3-million-acre Everglades National Park is too small to prevent alteration of an ecosystem, we cannot expect smaller preserves to survive unchanged. Strict preservation is obviously not the complete answer. We must attempt to manage our coastal resources for multiple usage.

Of all multiple use components, human habitation is probably the least compatible with the others; but as it is also the most powerful single component, we must try to increase its compatibility (i.e. lessen its impact on other components). With current public opinion now tending to limit the loss of marshlands and submerged lands by dredge and fill operations, the emphasis shifts to the effects of development adjacent to the newly spared marshes and bays. When we look at these effects, two stand out particularly; *firstly*, damage resulting from nutrient-rich waters entering bay systems (via storm drains, sewage facilities or dead-end canals) and, *secondly*, the loss of valuable beaches

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(actual loss and aesthetic loss) as a result of building on or seaward of the dune line. The concepts we are about to briefly discuss seem to us to offer the possibility of alleviating certain aspects of these two problems.

THE INTERCEPTOR WATERWAY

Consider first the problem of runoff from urban developments adjacent to coastal marshes, bays and estuaries. In many cases this runoff, with its accumulated nutrient materials (including poorly treated sewage), enters narrow, box-cut canals so typical of Florida waterfront communities. Many of these canals, by virtue of their design characteristics, are unable to handle such nutrient loads and their water quality degenerates as a result of overenrichment. This low-quality water eventually enters the nearby bays and imposes undue stress on the environment.

We have chosen to call the water management concept, which we hope will protect natural systems from such stresses, the Interceptor or Perimeter Waterway. This concept was mentioned briefly by Bernard Yokel at the last Gulf and Caribbean Fisheries Institute meeting (Yokel and Tabb, 1971). Since then we have given the concept a great deal of attention and detailed thinking. As visualized, this management tool should perform best on an *extensive,* not *small,* scale.

The Perimeter Waterway can perform a number of functions, the primary one being the interception of, and nutrient removal from, runoff water before it reaches the bay. Water thus intercepted, spread laterally and "scrubbed" is then released seaward over the whole length of the canal rather than from the seaward end of single large canals dug directly to tide water as has been done in the recent past (Fig. 1).

For the waterway to function properly, sewage must be handled separately and treated to a very high level before disposal, preferably on an upland site where it helps in replenishment of ground water, or disposed of by deep well injection. If this is done, the waterway is capable of handling the "other" pollutants that originate from city areas. *Basic design criteria* to achieve this goal are: (1) the waterway must be wide (minimum 400 feet) to permit maximum wind effect for mixing and prevention of stratification, and it must be shallow (maximum 7 feet; mean < 5 feet) to allow adequate sunlight penetration; (2) it must parallel natural contours on its seaward edge to conform with good land planning practices; (3) it should maintain itself under a given realistic nutrient-loading stress without significant aid from tidal exchange; and (4) it should be designed to develop a positive head within its confines - forcing excess water out over its seaward edge. This means control structures at either end and a uniform sill height where the waterway intercepts natural creeks. Locks for boat passage may be incorporated where the waterway approaches navigable tidal streams. (We specify this because in all probability developers will desire boat access to the Perimeter Waterway.)

The location of this waterway should be upland of tidal marshes and mangroves, and it should not broach the heads of tidal creeks unless unavoidable. Where creeks must be crossed, the waterway sill must be built up to *control*

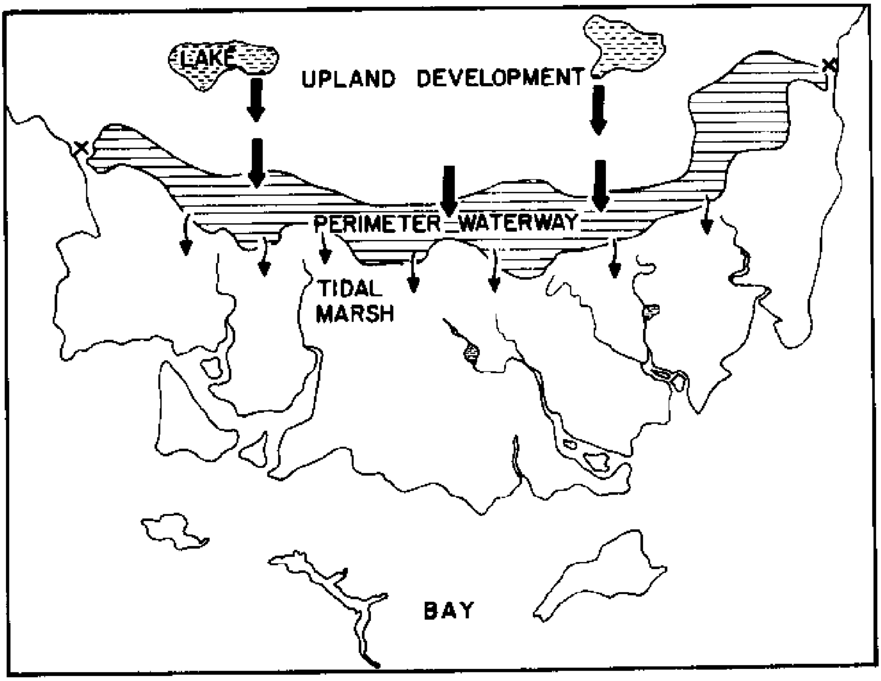

Fig. 1. The lateral distribution of runoff water by a perimeter waterway. Points of controlled boat access to the waterway are marked X.

elevation. Exact placement of the seaward edge of the waterway (i.e. on what contour) must be determined on the basis of careful land survey and observed tidal conditions in closely adjacent natural waterways.

The *operational principle* underlying the ability of this waterway to remove nutrients is that the biota associated with a given volume of impounded water can consume and convert given amounts of dissolved nutrients into food chain components, providing that the configuration of the waterway permits good sunlight penetration and wind-induced circulation. Drawing on mariculture experience, primarily our shrimp culture experiments, we have made tentative estimates of the "loading" capacity of a wide, shallow, non-tidal body of brackish to saline water. It must be stressed that the surface to depth ratio is critical: wind induced turnover is the single most important factor in maintenance of adequate oxygen levels and hence high nutrient assimilation levels in an enclosed water body. We know that a seawater body of 1 acre extent, with a maximum depth of 5 feet and a mean depth of 4 feet, is capable of assimilating considerable nutrients. At temperatures between 23 and 32C it can withstand the addition of 7 pounds of inorganic nitrogen and 10 pounds of inorganic phosphorus in a single "application," as might happen during a heavy runoff from an urban area. In addition, it can withstand the steady daily input of about 0.75 pound of protein nitrogen (for instance, in the form of leaf litter and street

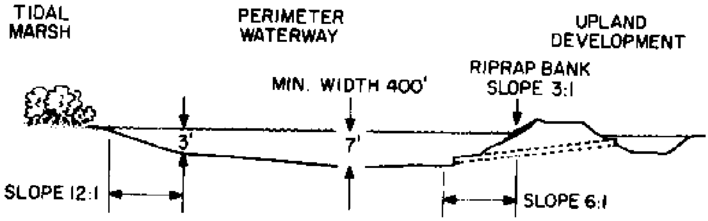

Fig. 2. Cross-section of the perimeter waterway.

washings) without becoming deoxygenated, provided that winds of 5-10 mph are fairly persistent.

Under these loading conditions, some degree of enrichment is to be expected, but the system will not become anaerobic. Ideally, such a system should have periodic net removal of accumulated organics. This can be effected by harvesting fish, shrimp, oysters and other organisms, and by allowing migratory access of native organisms across the seaward sill from the adjacent natural bays on the flood and ebb of certain tides. As visualized, the controlled elevation of the seaward edge of the waterway should be placed on a land contour that permits limited tidal flow across the entire marsh front *into* and *out* of the waterway on monthly spring tides for about 6 days each month. Such tidal conditions would permit entry and exit of organisms and consequent removal of organic production in the form of plankton, organic detritus, fish and crustaceans to adjacent natural bays. Since some waterways being planned are of very large size (about 1,000 surface acres), they can contribute significantly to the total productivity of the estuarine system.

A typical waterway cross section is depicted in Figure 2.

The Waterway obviously has a finite scrubbing capability and therefore should be used in conjunction with upland lakes where some preliminary scrubbing of runoff water occurs before discharging to the waterway. Then the waterway can perform its designed functions of second stage clean-up and distribution of runoff in a sheet-flow configuration over a broad front into the seaward marsh. The marsh itself then acts as a trickle filter; delivering water of acceptable quality to inshore bays.

THE "9 AND 3 RULE"

To ameliorate the problem of beach abuse, typified by high-rise buildings on the dune crest, or even seaward of it, we put forth the "9 and 3 rule" for management consideration. This concept apparently originated in Australia in an attempt to keep tall buildings from being built in areas where they would cast shadows on the public beach. Simply stated, the concept stipulates that no building shall be built near enough to the beach so that its shadow falls on that beach between the hours of 9:00 a.m. and 3:00 p.m. The concept recognizes that where beaches are public property and where sunlight is a prime tourist

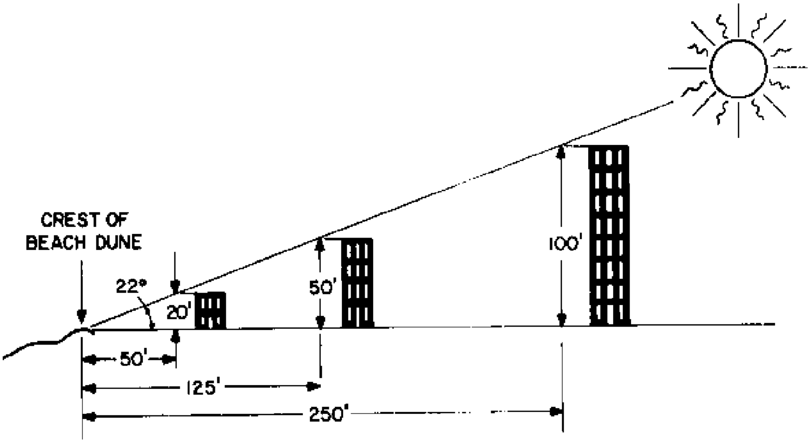

Fig. 3. Operational concept of the "9 and 3 rule".

attraction, adjacent property owners have a responsibility not to interfere with the resource. These aspects of the problem apply in Florida, and other U.S. coastal states as well, where tourism is important.

We find the concept attractive, and perhaps useful, to planners coping with decisions related to coastal set-back regulations. Part of the attractive character of the concept lies in the fact that there is a valid ecological basis for it as well as its legal-social aspects.

In examining the effect of the sun angle on light penetration of water surfaces we find that the angle must exceed 22° before 90% of available light penetrates the water surface. Below this angle light penetration drops off very rapidly (Schenck & Kendall, 1954). The ecological significance lies in the relationship between sunlight penetration and the photosynthesis of aquatic plants.

Understanding the physical and ecological basis for the concept makes it possible to compute, on any given date, the time of day when the sun angle reaches 22° above the horizon for any north-south trending coastal area. According to calculations made by Raoul Reher from solar altitude tables, this angle is reached in the Miami area at about 7:00 a.m. and again, as the sun descends at 5:00 p.m. on June 21st. On December 21st the times are 8:45 a.m. and 3:15 p.m. If it is decided that maximum sun exposure is most desirable during winter, and the winter hours for the 22° angle are chosen, it would be logical to name the concept the "9 and 3 rule" in south Florida as in Australia.

We know of no previously published rule for locating the apex of the angle from which to "shoot" the all important horizontal baseline, so propose the following: (1) that survey towers be set up a suitable distance off shore from undeveloped beaches so that the average elevation of the dune crest along its entire length can be surveyed relative to mean sea level datum; and (2) having the average elevation of the dune crest, we then propose that aerial photography be employed to give the precise chart location of the dune crest as indicated by dune vegetation and that this line with its elevation relative to mean sea level become the basic reference point from which to shoot the 22° angle. Figure 3 shows how the angle then becomes a height and set-back regulating device. For example, no building taller than 20 feet or about two stories should be built closer than 50 feet inland from the reference line on the dune crest.

The answer to questions as to how the rule applies to east-west trending beaches would be that the elevation of 22° be applied around the compass always using the dune crest as elevation control. It then could become a "universal" tool for regulating set-back lines. When applied to islands, lake shores or other waterfronts having no dune crest, it might be appropriate to select the mean high water mark as the angle apex.

The effect of the "9 and 3 rule" would be to reverse the profile of coastal development and put the highest buildings inland where their superior height could take maximum advantage of the overview of green and blue of water and vegetation. This is in accord with good land planning where visual pollution is also being considered.

In summary, we have described two new management techniques for coastal areas that we believe have merit. Neither have been fully tried or perfected, but both are being considered seriously by many people, including county commissioners, land planners and developers, in Florida.

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Developing a Marine Sport Fish Statistics Program

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INTRODUCTION

In 1970, the National Marine Fisheries Service (NMFS) assumed the responsibility for federal activities relating to marine game fish. Part of this responsibility, as spelled out in the Fish and Wildlife Act of 1956, is the collection of statistics on the marine sport fisheries of the United States. In the past, this activity consisted primarily of collecting catch, effort and expenditures data for broad geographic areas every 5 years through household surveys. NMFS recognizes that this collection effort is no longer adequate, particularly in view of increasing numbers of fishermen and in view of increasing concern for our fishery resources. Better data are needed if we are to manage our fishery resources effectively. Because NMFS recognizes the importance of meaningful statistics to public and private researchers, decision makers and policy makers concerned with fishery resources, we are attempting to determine the kinds of data needed by various interest groups and to develop a viable national marine sport fish data collection program based on determined needs.

I would like to tell you today about the progress we have made thus far toward developing a national sport fish statistics program and what we have planned for the future. First, however, I would like to describe in more detail the statistics collection activities of the past.

PAST DATA COLLECTION ACTIVITIES

Data on the number of fishermen, the number of days spent fishing and the expenditures by fishermen, have been collected every 5 years since 1955 by the Bureau of the Census in its National Surveys of Fishing and Hunting. These surveys have been funded by the Bureau of Sport Fisheries and Wildlife. Data on the number and weight of fish caught by species, geographical area and method of fishing, have been collected in Salt-Water Angling Surveys every 5 years since 1960 by the Bureau of the Census as a supplement to the National Surveys of Fishing and Hunting. The first two Salt-Water Angling Surveys were funded by the Bureau of Sport Fisheries and Wildlife and the survey for 1970 was funded by the National Marine Fisheries Service. Both of these surveys, i.e., the National Survey of Fishing and Hunting and the Salt-Water Angling Survey, are based on personal interviews with members of sample households scattered throughout the United States.

As some of you know, the results from past Salt-Water Angling Surveys for certain species in certain geographical areas have been subject to question. Errors are possible in such a survey due to two main factors: (1) small sample size and

(2) response bias; that is, the inability of persons being interviewed to give the correct answer for any number of reasons; such as, the recall period may be too far in the past to be able to remember correctly, or the individual may be reluctant to admit small or insignificant catches.

RESPONSE BIAS STUDY AND PILOT HOUSEHOLD SURVEY

Because the accuracy of the only sport fish catch data collected on a national scale was subject to question, we felt we should do what we could to improve these data. Therefore, in June 1971, we contracted with a professional survey firm, Audits & Surveys, Inc., to (1) determine the causes of error (response bias); (2) recommend methods for obtaining responses from household interviews that contain a minimum amount of error (bias); (3) recommend methods to correct for remaining error and (4) test these recommendations in a pilot household survey. The response bias study, which consisted of progressive stages of interviewing saltwater fishermen, was conducted in Massachusetts and California. The study showed that a respondent should not be required to recall more than 2 months in the past. Response bias also can be reduced by using calendars and appropriate questionnaire phrasiology designed to obtain specific information. The study suggested methods to minimize species identification problems such as presenting names and pictures of fish in the questionnaire. Estimates of catch also can be improved through a means of adjusting reported catches based on the reliability of respondents' reports.

The pilot household survey testing the above methodology was conducted in California in October and November 1971, using a stratified area probability sampling plan to obtain number, length and weight of fish caught by species, and fishing effort (angler days) by different fishing methods and locations. Anglers were queried on a trip-by-trip basis about the most recent trip and for trips during the prior 2 months or less.

California party boat logbook data, collected by the California Department of Fish and Game, were used for comparing the Audits and Surveys catch estimates. These party boat data comprise one of the best continuous sets of marine sport fish catch statistics in the country. Some comparisons based on data for southern California follow. The pilot household survey estimated 490,800 fish caught during the 2-month period, an over-estimate of 15% compared with the logbook catch of 427,700 fish. For October, the pilot survey overestimated the catch by 24% and for November by 1%. Estimated angler days from the pilot survey were 50,400 compared with 51,800 from the logbooks, an underestimate of 3%.

The pilot household survey resulted in substantial improvement over the 1-year recall Salt-Water Angling Survey, as indicated by comparison with the California party boat logs. The 1965 and 1970 Angling Surveys produced total party boat estimates for southern California of 305% and 193%, respectively, above the logbook estimates, while the pilot household survey estimate was only 15% over the California logs.

Our Tiburon, California, Laboratory conducted a field survey for all fishing methods except party boats, to obtain length and weight data for comparison with the household survey. Anglers were better able to estimate lengths than weights. Comparing averages taken over all species and fishing methods, lengths were overestimated by 13% and weights by 231% in southern California. In northern California, anglers underestimated lengths by 4% and overestimated weights by 158%. Statewide, lengths were overestimated by 8% and weights by 204%. Conversion of average length data to weights would result in better weight data than direct estimation of weight by anglers.

The above studies were conducted in an attempt to improve on estimates produced by the Bureau of the Census. Now, I would like to discuss our efforts to date in developing an optimum statistics collection program.

DETERMINING DATA NEEDS AND DEVELOPING A PLAN OF ACTION

A first step to developing a viable national sport fish statistics program is to determine the kinds of data needed by various interest groups. After preliminary discussions with persons knowledgeable in the area of marine sport fisheries, we soon learned that there are as many different kinds of data needed as there are people interested in marine sport fisheries. To be as responsive as possible to the needs for various data on the marine sport fisheries, we contracted with a private research firm, Moshman Associates, Inc., to develop a priority listing of data needs and to prepare alternative 5-year development plans for collecting these statistics, based on various levels of funding. In developing the priority listing of data needs, Moshman has questioned over 100 individuals representing the coastal state fishery agencies, universities, sport-fish-related industries, the National Marine Fisheries Service and others. In addition to the kinds of data needed, Moshman also is asking why each kind of data is needed and what degree of accuracy is acceptable for each kind of data.

Based on the priority listing of data needs, the results of the study by Audits and Surveys and other available information, Moshman is preparing alternative 5-year program development plans laying out when and how the data specified in the priority listing are to be collected. One plan would involve a national survey to be carried out (probably by contract) by the National Marine Fisheries Service. The second plan would encourage each coastal state to participate by collecting data on the marine sport fisheries off the coast of the respective state, probably with funding assistance from the federal government. Each plan will be developed in such a way that it can be implemented in priority stages depending on available funding. It may be that because of the kinds of data to be collected, we would want to have a "mixed" collection plan, i.e., some data would be collected by a national collection agency and other data collected in a cooperative program with the states.

A report presenting both the priority listing of data needs and the alternative program development plans are expected to be completed by December 4, 1972. The report will be reviewed by a special board consisting of the Executive Directors of each of the Inter-State Commissions, the Executive Director of Sport Fishing Institute, a university professor and representatives from NMFS.

THE FUTURE

With the help of the states, Sport Fishing Institute and others interested in marine sport fishing statistics, we expect to begin finalizing a data collection program after the Moshman report is approved. Perhaps "finalizing" is the wrong word since I don't want to convey the idea that the program will be set in concrete. To the contrary, because we are aware that data needs will change over time due to a variety of factors, we intend to develop a program that will be flexible enough to be able to respond to such changes.

Developing a viable sport fish data collection program has high priority in NMFS, and as soon as the budget permits we expect to increase funds in this area. Collecting statistics is a costly business, and to collect the data that will probably be called for will require a substantial amount. Of course, we'll do the best we can with whatever amount we have available. In any case, we intend to work closely with each coastal state in developing a cooperative program that will produce accurate data. We feel State-Federal cooperation is extremely important in this kind of endeavor and so we will be asking for assistance from, and providing assistance to the states as we work toward developing a viable program.