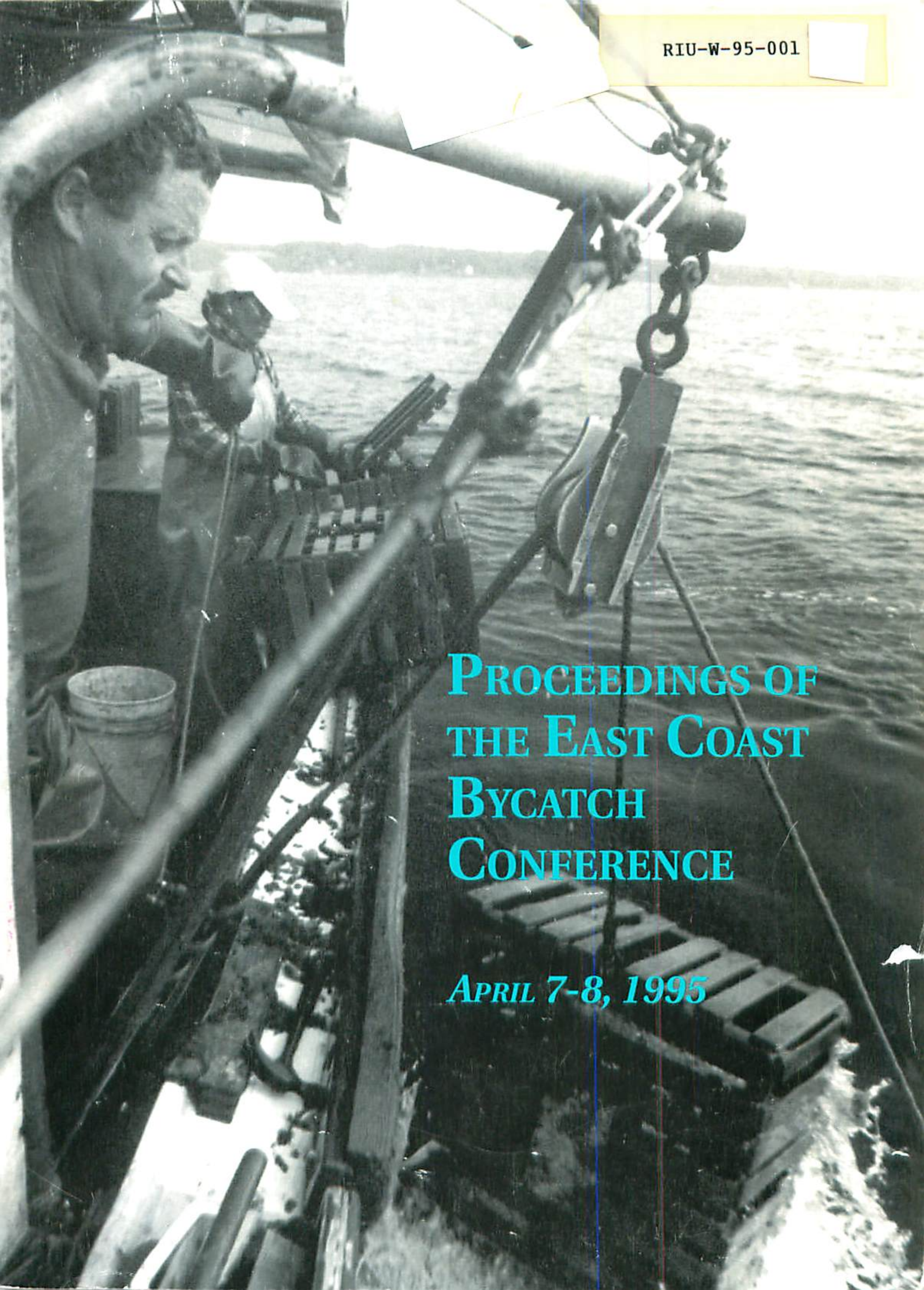

Proceedings of the East Coast Bycatch Conference

April 7-8, 1995

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Proceedings of the East Coast Bycatch Conference

Newport, Rhode Island
April 7-8, 1995

Compiled and edited by
Kathleen Castro
Tony Corey
Joseph DeAlteris
and
Chris Gagnon

Photos by David B. Esau

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Introduction and Opening Remarks

Joseph DeAlteris
Rhode Island Sea Grant

Jake Dykstra
Point Judith Fishermen's Cooperative

Compiled by K. Castro, Rhode Island Sea Grant

Welcome to the first Northeast Regional Bycatch Conference. It is good to see so many familiar faces in the audience—fishermen, scientists, managers, conservationists, and others who have been involved in trying to solve the problems facing the fishing industry today.

In February 1992, a National Bycatch Conference was held in Newport, Oregon. Fishermen, scientists, and government research managers from the entire country participated in the fishing industry-sponsored conference. The purpose of that meeting was to develop an industry initiative to deal with the bycatch issue, including the establishment of national goals and criteria for bycatch and the consideration of economic issues associated with fishery management options to limit bycatch, as well as other important points. The consensus of that meeting was that bycatch is a problem in many fisheries in all regions of the country, and more importantly, that the bycatch issue, whether real or perceived, has threatened and may threaten the future of many commercial fisheries in the United States today.

Fishermen attending that meeting were given a mandate to address the bycatch issue within their own regions. The objective is to be proactive on this sensitive issue now, rather than reactive and defensive in the future. In April of 1992, several leaders of the Rhode Island fishing industry met with leaders representing the fishing industry from Maine to Virginia and decided that a bycatch conference should be organized for the East Coast. Over the past three years, these leaders met with their respective Sea Grant representatives, and a joint conference was planned, with additional support provided by the National Marine Fisheries Service and the regional fisheries councils. Speakers were invited, funds were procured, and the result is this two-day conference.

Representatives from all major players are sitting here in this room today, ready to work together to find solutions. The format of this meeting is somewhat unique. We will start with some general information about bycatch: What is it? How much is there? What does it cost, both economically and socially? We will follow this with a consensus-building session, with participants expressing different viewpoints—fishermen, conservationists, and managers. We will then break into regional groups to discuss specific problems of the Northeast, the Mid-Atlantic, and the South Atlantic fisheries. Day two will begin with presentations about ongoing work with bycatch reduction—fishermen and scientists discussing their data and thoughts about each fishery. We will continue regional discussions and then convene to discuss issues brought up by the regional groups.

During this two-day meeting we hope to:

- Recognize that bycatch is a regional problem that has contributed to depressed fish stocks, but that it is a manageable problem that can be solved when the industry is involved with all the major players
- Generate new joint research projects into specific fisheries to address the real bycatch problems and education programs to address the perceived problems.

Please enjoy the conference. We, the fishing industry and the Northeast Sea Grant programs, thank you all for coming. We especially thank the National Marine Fisheries Service, its Policy and Coordination Office and its Northeast Regional Office; the National Sea Grant Office and the Sea Grant programs of MIT, Rhode Island, Maine-New Hampshire, Georgia, and Connecticut; the Mid-Atlantic Fishery Management Council; and the Massachusetts Division of Marine Fisheries for the donations that have made it all come together.

Welcome

Rolland Schmitten
National Marine Fisheries Service

Good morning. I'm really honored to be here and to be given a role at this East Coast Bycatch conference sponsored by the East Coast Sea Grant programs. In particular, Joe and Erik deserve our thanks.

In my tenure as assistant administrator of fisheries and director of the National Marine Fisheries Service, my vision for the agency has included a focus on rebuilding overfished stocks, on reorganizing the agency and putting service back in the National Marine Fisheries Service. But the two issues that are contemporary and that demand immediate resolution are the issues of habitat and bycatch. I'll reserve my habitat enthusiasm for another time and turn my energies to the problem before us, and that is bycatch.

One of the points raised about bycatch is, why now? The idea of becoming proactive on the issue of bycatch has haunted me since the 1992 National Industry Bycatch Workshop that was held in Newport, Oregon. Although it was mechanically flawed from the start with criticisms—why this industry, too much West Coast, too weighted toward one gear type—in reality it was a bold, imaginative attempt to bring the industry together to focus proactively on the single problem and the solution to the problem.

That was the genesis, I think, of this and all other bycatch workshops. One of the really substantive outcomes of that workshop, in my opinion, was the call for the worldwide report, for which Dr. Alverson was one of the key members.

What's fueling the need for resolution to the bycatch issue, I think, is the proliferation of bycatch articles with sensational headlines that we've seen in the past year. Last summer, a Cambridge daily had a front page story with two-inch headlines usually reserved for declarations of war or significant disasters that demanded, "Stop the Waste; Stop Bycatch." A Seattle Times editorial bluntly stated, "Quit Wasting Seafood." But the headline that really grabbed my attention was one that I saw by the boarding gate of a commuter airline in Portland, Maine. It was the Maine Times, which ran a four-page exposé titled, "Scandal of Wasted Fish: The Truth about Bycatch." The front page shows a fisherman sorting bycatch; the second half page has a picture with a caption stating that fishermen in the Gulf of Maine cut off the heads of codfish and slam them against the decks just to make sure they're dead before dumping them overboard. The problem with this kind of sensationalism is that it misleads the public and polarizes the constituencies. These articles do not serve a constructive purpose; they simply serve once again to lead us down that often-trod path—fishermen versus the environmental community and the conservation community, generally with the government or the courts in between as arbiters.

There's got to be a new approach to bycatch—which is what truly excites me about this conference. In reality, both groups, the fishing community and the conservation community, have come together to find solutions to bycatch. Listen today to what people in the conservation community are saying. Listen to people like Suzanne Iudicello of the Center for Marine Conservation. Listen to people from the Conservation Law Foundation. I think you'll be impressed with their willingness to be here and to have these issues addressed. I particularly like one sentence in the call for this conference today: "Our purpose is to bring together fishermen, scientists, environmentalists, and resource managers in a discussion of bycatch issues in East Coast fisheries." We are here in a spirit of cooperation to try to solve a common problem.

You know, bycatch is not a new issue. It has been around for a long time. Some of you probably don't realize just how long. Let me just read something to you: "The kingdom of heaven is like a net that was cast into the sea and gathered fish of all kinds. And when it was full, you drew it ashore and sat down and sorted the good into vessels and threw away the bad." Matthew 15:47-48. Yes, bycatch has been around a long time. And while we certainly can, and we must, do something about bycatch, it's naive to think we will not always have some degree of bycatch.

Bycatch is a result, largely, of our efficiencies—using nonselective fishing gears, often exacerbated by federal government regulations that prohibit unauthorized species. Bycatch is a "now" issue to resolve. A friend of mine offers a contemporary description framing the urgency of the need to address bycatch. He's Jim Martin, past fisheries chief of

Oregon's Department of Fish and Wildlife. He put it this way: Remember Indiana Jones in *The Raiders of the Lost Ark.?* Indie's creeping along in an ancient cobwebbed temple, and there are all sorts of booby traps around. He's creeping along; he's checking things out; he's gotten by almost all the traps, when suddenly he steps down and he hears this little click. All of a sudden a huge rock comes rolling down the passageway. Indie's got to figure out how to beat the rock or get out of the way. But there's no place to get out of the way.

Well, we just heard that little click. The bycatch issue is one part of that big rock.

This conference proves that we've heard the click. Now, what are we going to do about it? First I think that we—and "we" encompasses a lot of people: industry, government, conservation people, states—have got to beat our bycatch swords into handcuffs and shackle ourselves together to forge the solution. While I dogmatically believe that industry needs to play the lead position, there is also a role for government. We can help by funding workshops such as this —this is the second of five that I am aware of. The reason there are so many is that each geographic area's interest is different. There is not going to be a "one size fits all" solution that's going to work for bycatch.

There are other things we can do. For instance, this agency needs to turn its attention to increasing resources for the issue of bycatch. In 1995, various organizations are sponsoring bycatch research; for example, SK is dedicating $1.4 million toward the issue of bycatch. In-house, I've allocated $2.5 million to our scientists for bycatch projects. And $6.7 million is going over to bycatch-related projects on protected resources. Once again, I've reserved funds for you to help yourselves by sponsoring these workshops and developing proceedings. We need to work together, which is something you probably haven't seen in government—a partnership.

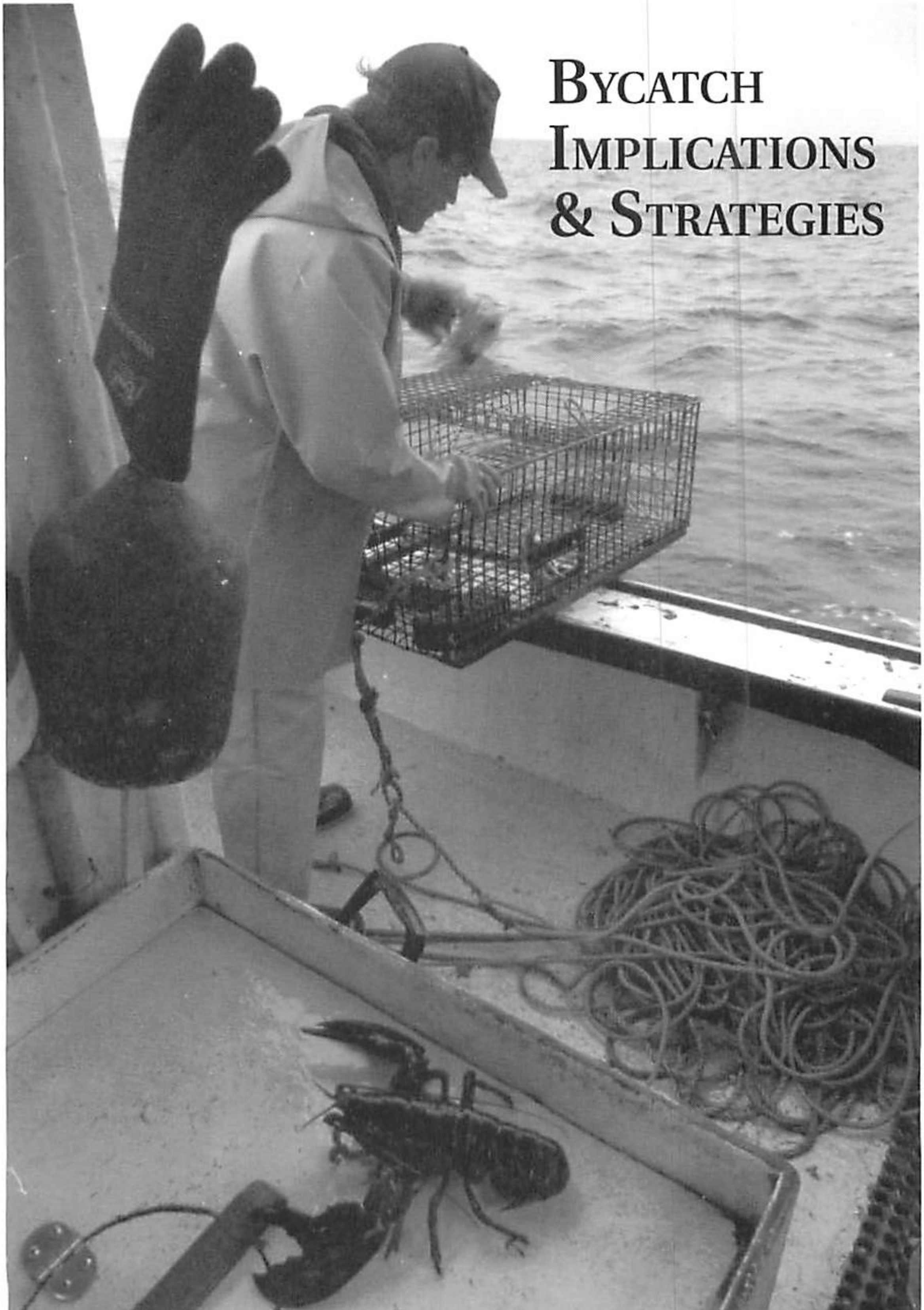
There are some other things we might consider. Bycatch parties should carefully consider the use of professional mediators to force the breaking of the polarization. Too often at constituent meetings, it's like an orchestra playing without a conductor. All you do is create noise. We need some guidance. We have some common needs related to bycatch. Personally, I advise the parties, "Don't send your fighters; send your problem-solvers. Work in recognition of each other's needs, not a winner-take-all approach." Something else I've learned, being around Congress over the last months, is to involve representatives and their staffs early on because a) they are sincerely interested and b) it keeps everybody honest and prevents problems in the last moments of a decision.

Let me close with an "up" note. I think a good starting point is the definition of bycatch, because it means different things to different people. Generally, to fishermen it means fish. But to the eyes of others it may mean marine mammals, it may mean birds. Discards, bycatch, and incidental catch—the terms are often used interchangeably, but they are not necessarily synonymous. One of the things we can do is define them better. I also think it would be very helpful if we do not see the kind of sensational articles that I was showing you but instead educate the public with a series of articles and editorials on the facts. Just the facts.

We generally know what the tools are in the bycatch war chest. What we don't know is the proper application. We know there's gear technology—that's an area that my agency used to lead in and somehow we've lost sight of our priority. We know that we need to look at additional time-area management schemes, and that requires better science data. We need to emphasize better utilization. I remember promotions to encourage the Department of Defense to use pollock nuggets for fish sticks. We probably gained 10 pounds putting on fish dishes to promote this, but, you know what, we won. Millions of dollars of fish were being sold to the military and school lunch programs because of our efforts to get fish into the market. Finally we need some incentives that attract the industry to utilization. We've got to be risk-takers. The university, the conservation community, the industry—we've got some very smart people, and every constituency has some very good points. We've just got to bring them together.

Yes, the bycatch boulder is in our way. Our fate is in our own hands. Government can help, especially by funding this kind of workshop. But beyond that, industry-led efforts to form new partnerships for support, and most of all, communication with the parties concerned, will determine the success of the bycatch story.

Bycatch Implications & Strategies



Discarding: A Part of the Management Equation

DAYTON L. ALVERSON
Natrual Resources Consultants, Inc.

Abstract: *Bycatch and discards are seen by many as a significant waste of the biological potential of the world's oceans, causing potentially undesirable ecological shifts in the species complex and in the ecosystem structure of heavily fished regions. These perceptions have in themselves promoted and encouraged the evolution of national and international policies designed to lessen the impacts of bycatch and discards.*

Although our knowledge of discards in world fisheries has increased rapidly in the past two decades, the quality and detail of information are still lacking for many regions of the world. The provisional global estimate of 27 million metric tons of discards provided in the publication A Global Assessment of Fisheries Bycatch and Discards *constitutes roughly one-third of the global marine catch and generates an image of the potential scope of the problem. It will be important to improve the quality of the estimate, but it is perhaps more important to begin the process of documenting the consequences of discards to the target and nontarget populations as a modification to traditional population assessments.*

In many instances, levels of perceived waste that seem huge when translated into kilos or pounds may often be trivial in terms of the impacted populations. Conversely, relatively low discard rates may, as the result of the magnitude and the geographic distribution of the fisheries involved, have significant impacts on nontarget species at the population level. This is particularly true for marine mammals and turtles. The role of the scientist and the technician as we move toward the next century should be to better clarify the impacts of discards at the population level and provide a scope and quality of information that can be used for improving management.

Bycatch has become the management issue of the decade. The issue has rapidly transformed from one involving catches of secondary target species to one that includes a host of new meanings frequently associated with waste, threatened species, overfishing, and economic loss and/or ecosystem degradation. Bycatch, which played a historical role in net selectivity, has more recently surfaced as the culprit of bad management.

This Rhode Island workshop constitutes one in a series of formal discussions emerging broadly at the national and international levels. The sudden impetus for bycatch stardom has been kindled by:

1) documentation or expressions of concern by environmental and conservation groups regarding the potential impacts of fisheries on nontarget marine mammals, birds, turtles, etc.

2) increased documentation of the potential extent of bycatch

3) recognition that bycatch in many instances constitutes economic loss to sectors of the industry that feel they possess historical rights to selected resources

4) the emotional response of the public to published numbers and weights of fish discarded, amounts that appear astronomical

Those attempting to make sense out of the bycatch tsunami have struggled with the definitional issues, the tangling of biological and economic issues with emotional rhetoric, the selection of priorities among many choices, and the potential solutions available to reduce bycatch or make more effective use of what is caught.

At almost every conference, discussion forum, seminar, and workshop dealing with the issue of bycatch there has been a great deal of confusion over an acceptable definition of bycatch. Historically, the literature has used the term to cover a variety of meanings, including (a) the catch of species not specifically targeted but retained because of their value, (b) discards only, (c) discards plus catch, and (d) retained nontargeted species. Some authors have excluded discards of undersized target species from their definition of bycatch, while many others have identified all discards, whether target or nontarget species, as bycatch. Scientists examining this question at the Newport Fishing Industry Workshop recommended a definition encompassing all catch, discarded or retained, other than the targeted species.

It would obviously be in the best interests of the scientific, fisheries, and conservation communities if a common definition could be agreed upon. But at a minimum, those who write on the subject should incorporate their operational definitions of bycatch in an introduction to their papers. This discussion today will focus on discards, which as undocumented catch, are a significant factor in fishing impacts.

The issue of bycatch has frequently been engulfed in emotional rhetoric, partly because there is legitimate concern regarding the impacts of bycatch, but also because published discard numbers or weights are generally translated as "tragedy," "walls of death," "ecological disaster," without any understanding of the actual biological and economic impacts.

Numbers vs. impact

The book *A Global Assessment of Fisheries Bycatch and Discards* recognizes that very large discard levels may amount to billions of individuals and that hundreds of thousands of metric tons of fish may have little measurable biological impacts on the populations impacted. Thus the imposed mortality at the population level remains low because of the broad geographic distribution and tremendous size of the populations involved.

Conversely, the book warns that relatively low discard rates involving large-scale fisheries that broadly distribute their effort over large geographic areas may impose levels of mortalities on nontargeted species that exceed levels that would allow the species/population involved to persist. Biological impact analysis of discards must be evaluated in terms of the mortality imposed on a population or population sectors and the consequence to the species/population's status over time.

Economic issues of discards are perhaps more difficult to sort out, beyond downstream loss of catch, although mortalities imposed on juveniles of the target species are relatively well documented. Deaths generated among nontarget species of one fishery that are the target of another fishery can also be quantified, but the gains and losses to each group are seldom subject to professional economic analysis. Thus the reasons for remedial actions are often unclear and buried in political rhetoric. Management, at a minimum, should attempt to clearly define the nature of economic gains and losses that flow from proposed regulations.

Selecting priorities

Selecting bycatch projects from a host of potential fisheries projects needing attention rests on the assumption that the decision-maker has some qualitative and quantitative understanding of the character and magnitude of discard in the fisheries of a particular region; it also rests upon the impacts or perceived impacts resulting from the discards. Unfortunately, such impacts are often unknown and frequently largely anecdotal in nature. This suggests that documentation of discard mortalities and knowledge of impacted populations/species is a starting place for the selection of priorities.

Ideally, priorities should be set to eliminate or minimize losses impacting threatened or endangered species and overexploited stock. Unfortunately, the actual selection may respond in part or totally to political perceptions of bycatch problems precipitated by public notoriety and uninformed commercial media.

> ***Bycatch and discards are seen by many as a significant waste of the biological potential of the world's oceans.***

The global fisheries bycatch study (Alverson et. al.) estimated a provisional world discard of about 27 million metric tons, with a range of 17.9 to 39.5 million metric tons (see examples 1 and 2). This estimate is acknowledged to be soft, and the quality of the supporting data in many regards is poor. Data is sketchy in time and space, and frequently involves very low levels of sampling. The database is obviously improving rapidly, but even in the best-documented region, a number of gaps in the data are obvious. In many regions, knowledge of discard is highly qualitative.

Most managers or investigators will gradually realize that there are few if any fishing gears that do not have high bycatch rates, depending on species target and time and areas fished. Conversely, the same gears may at times, and depending upon the same variables, have extremely low discard rates.

Example 3 provides information about the discard rate of 348 fisheries examined worldwide. Although a substantial number of fisheries have rates that are less than 30 percent of retained catch, nevertheless, fisheries with high rates constitute a significant share of the total. Some fisheries report discard rates that are 10 times the retained catch level. Similar weight-based data are provided in Examples 4 through 6 for trawl, shrimp trawl, and longline fisheries; number-based rates for gill-net fisheries are shown in Figure 7. These groups demonstrated the broad range of rates for different gear types. Example 5 also shows the high discard rates that prevail in shrimp fisheries (mostly tropical species).

Technology, behavior, incentives

Collection of rate data, however, provides only an indicator of a potential problem. The discard must subsequently be enumerated by species, size, age, and condition, and estimates of survival must be developed. Finally these data need to be evaluated in relation to respective populations before biological, economic, and ecological impact can be reasonably quantified and used as input for setting priorities.

Assuming the manager/investigator has developed an information base that provides a reasonable understanding of impacts, there remains a broad range of possible actions that might lead to desirable reductions in the discard level. In some fisheries—for example, the eastern tropical Pacific tuna seine fishery—a significant reduction in discard mortality has been achieved by technological advances coupled with fishermen (skipper and crew) education programs. In others—selective trawls for shrimp and bottom fish—technical changes linking knowledge of different behaviors of the targeted and nontargeted species have led to significant reduction in discard levels. Other solutions that have reduced discard include application of net sizes, hook and gear configurations, time-area fishing patterns, closed areas, and incentive programs.

Incentive programs appear to have a great deal of appeal. They may stimulate solutions by offering increased fishing time to fishermen having low discard rates, or merely offer a user an agreed time period to resolve an identified problem. For example, in the Bering Sea, U.S. managers gave Japanese fishermen five years to reduce the discard level in half, without specifying what methodology should be employed. The Japanese government gave each vessel a discard quota and left the solution to the operating fishermen. The reduction level was reached in two years.

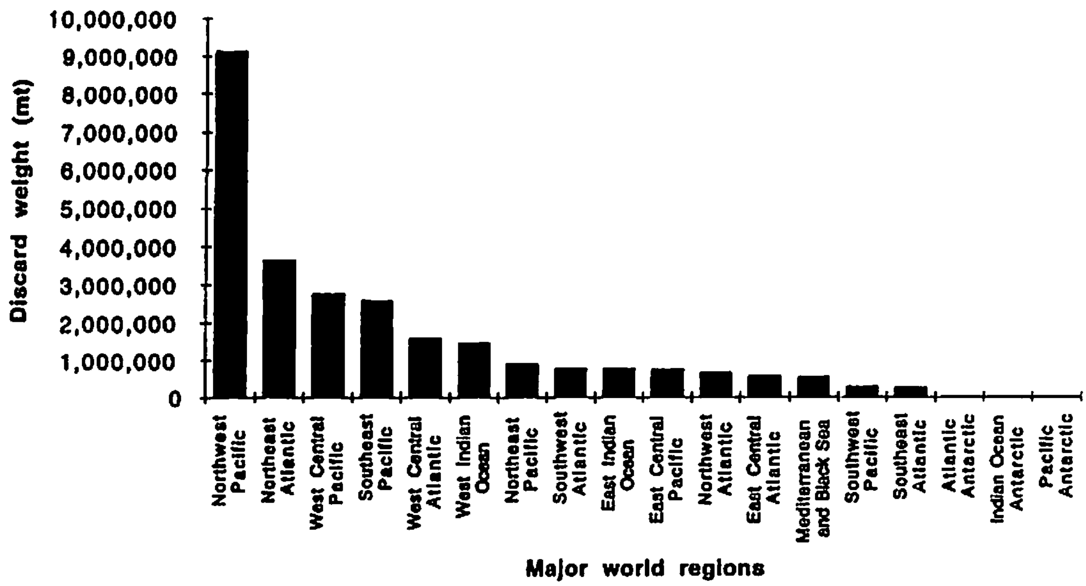
Application of incentives may require observer performance measures, but not necessarily. Fishermen who develop improved and more selective gear could be given incentives in terms of tax benefits, fishing quotas, extra time, and so on.

In the end it is unlikely that any specific gear development can have wide application to different fishery areas and gear types. Each region is likely to have its own peculiar and unique situations, which prevent a single template from being a national or international solution.

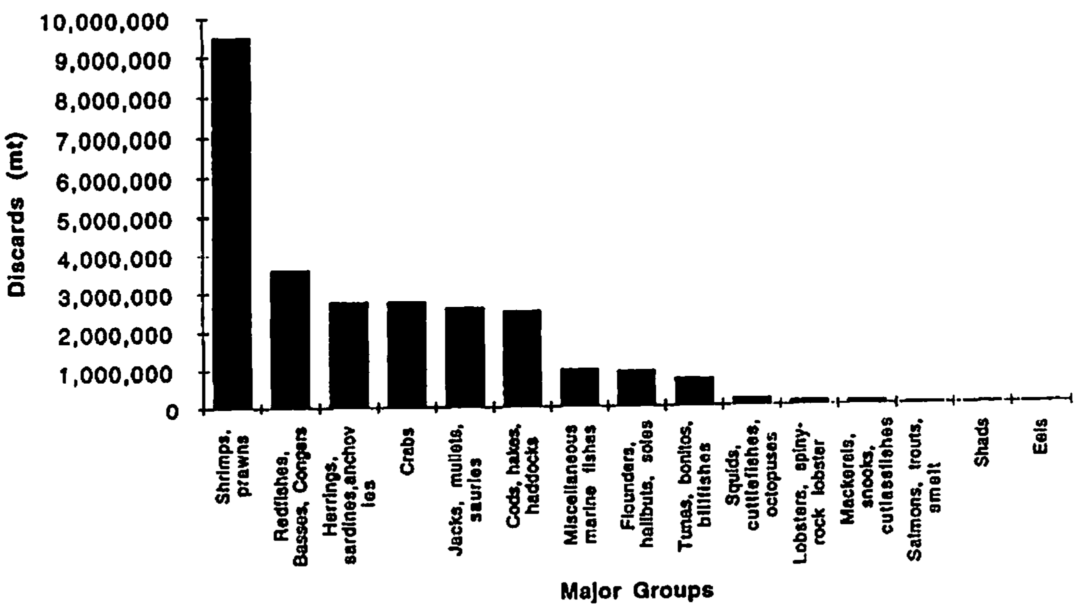
Historical discard solutions have never come easy and frequently have constituted years of dedicated effort. Most solutions have been the result of innovation by fishermen within the impacted fisheries. It would seem that motivation of the users themselves may be the most likely source of progress towards discard reduction. Government, however, needs to create the environment in which users recognize the need for and the benefit of developing more responsible fishery gears and tactics. And government needs to give industry and academia the latitude to evolve the technology and fishing patterns that effectively address discard problems.

In the end, discussion of discard levels is an essential element in understanding the overall consequences of fishing on marine populations, target or nontarget. Requiring reductions in discard should clearly address well-defined societal objectives for responsible fishing.

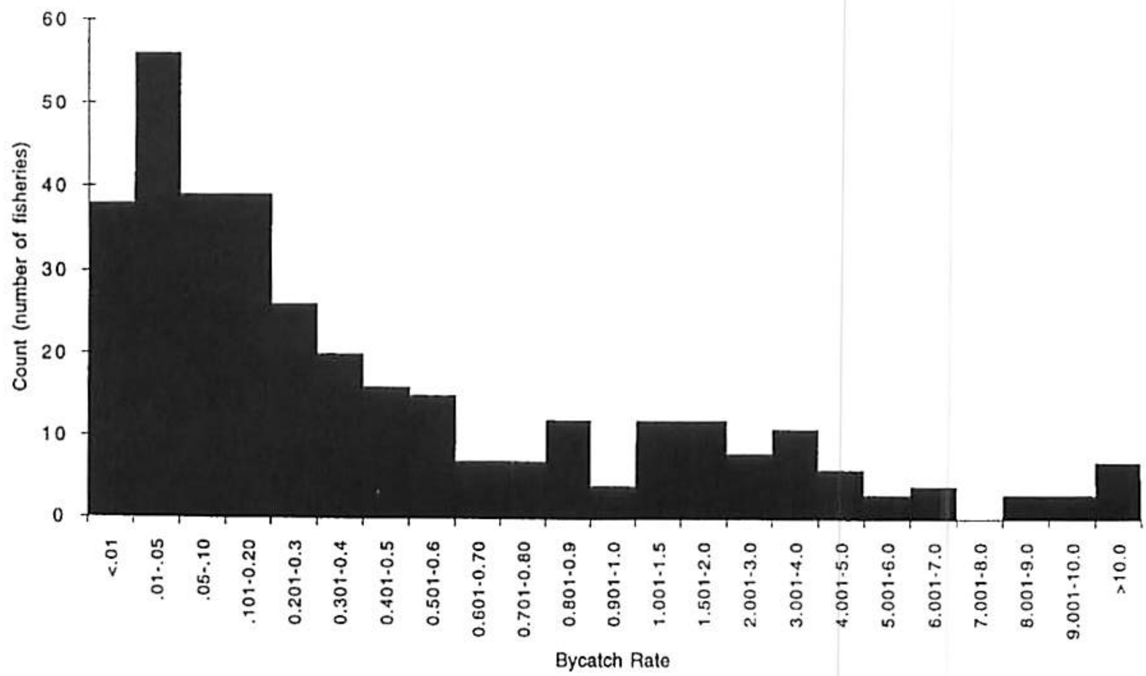
Ex. 1 Discard weight by major world region. Source: NRC bycatch database



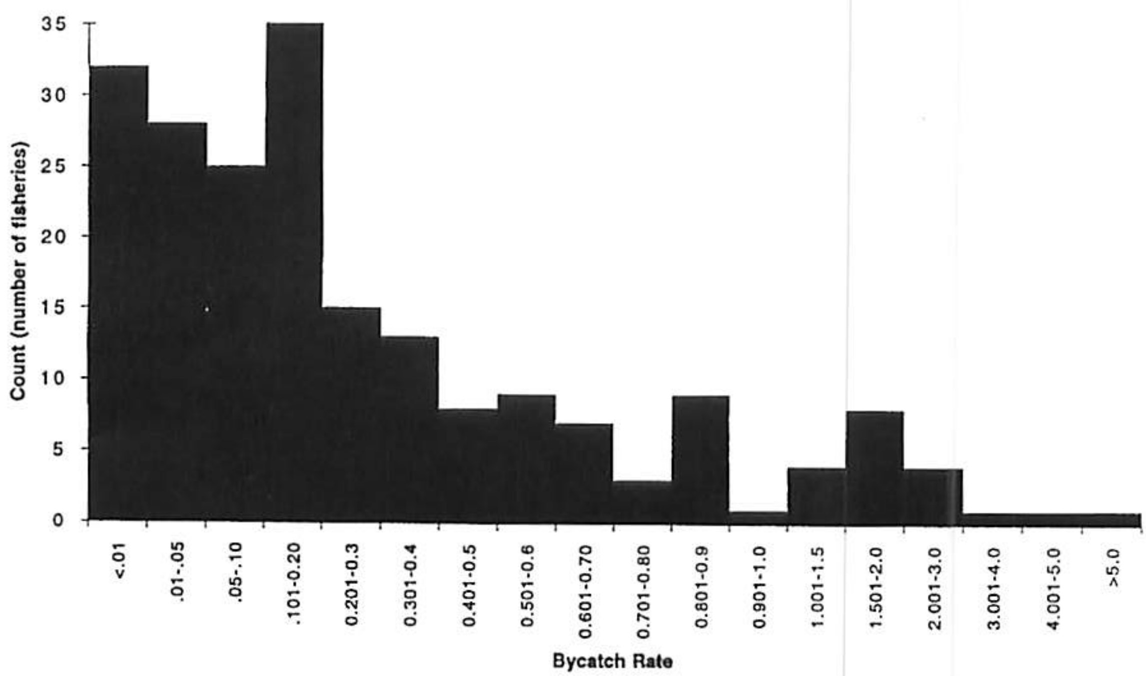
Ex. 2 Global marine discards of the basis of the FAO International Standard Statistical Classification aquatic Animals and Plants (ISSCAP) species groups.



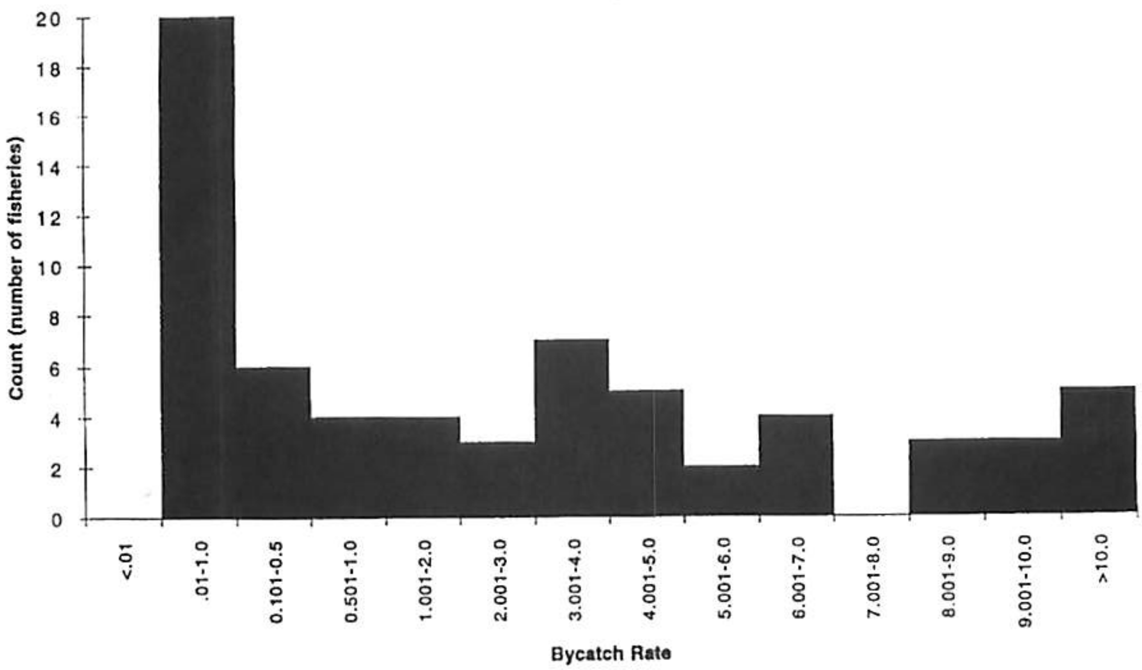
Ex. 3 **Distribution of bycatch rates by weight for all fisheries**
N = 348



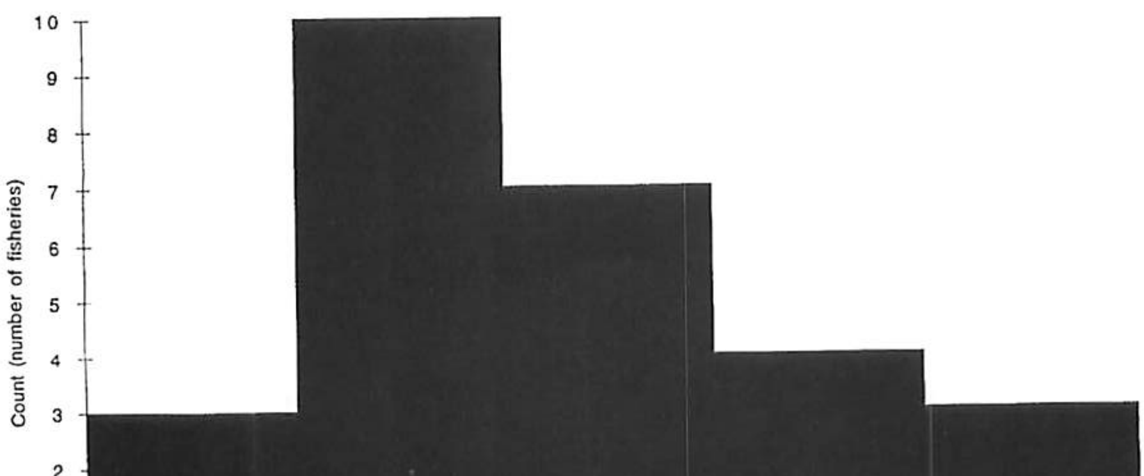
Ex. 4 **Distribution of bycatch rates by weight for trawl fisheries other than shrimp**
N = 204



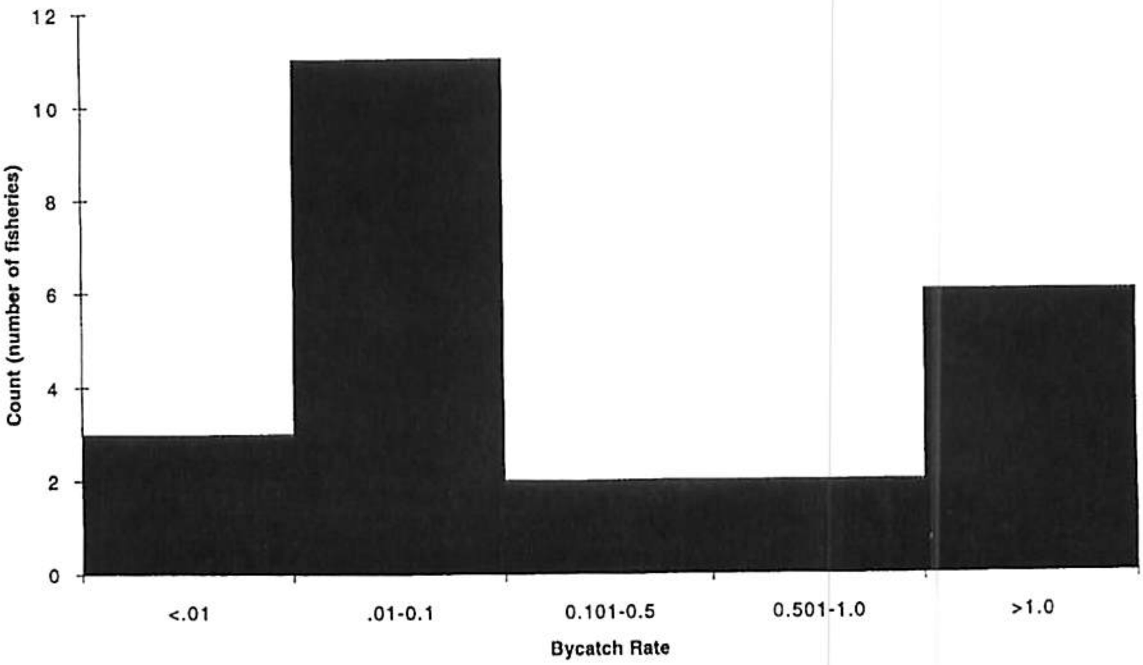
Ex. 5 **Distribution of bycatch rates by weight in shrimp trawl fisheries**
N = 66



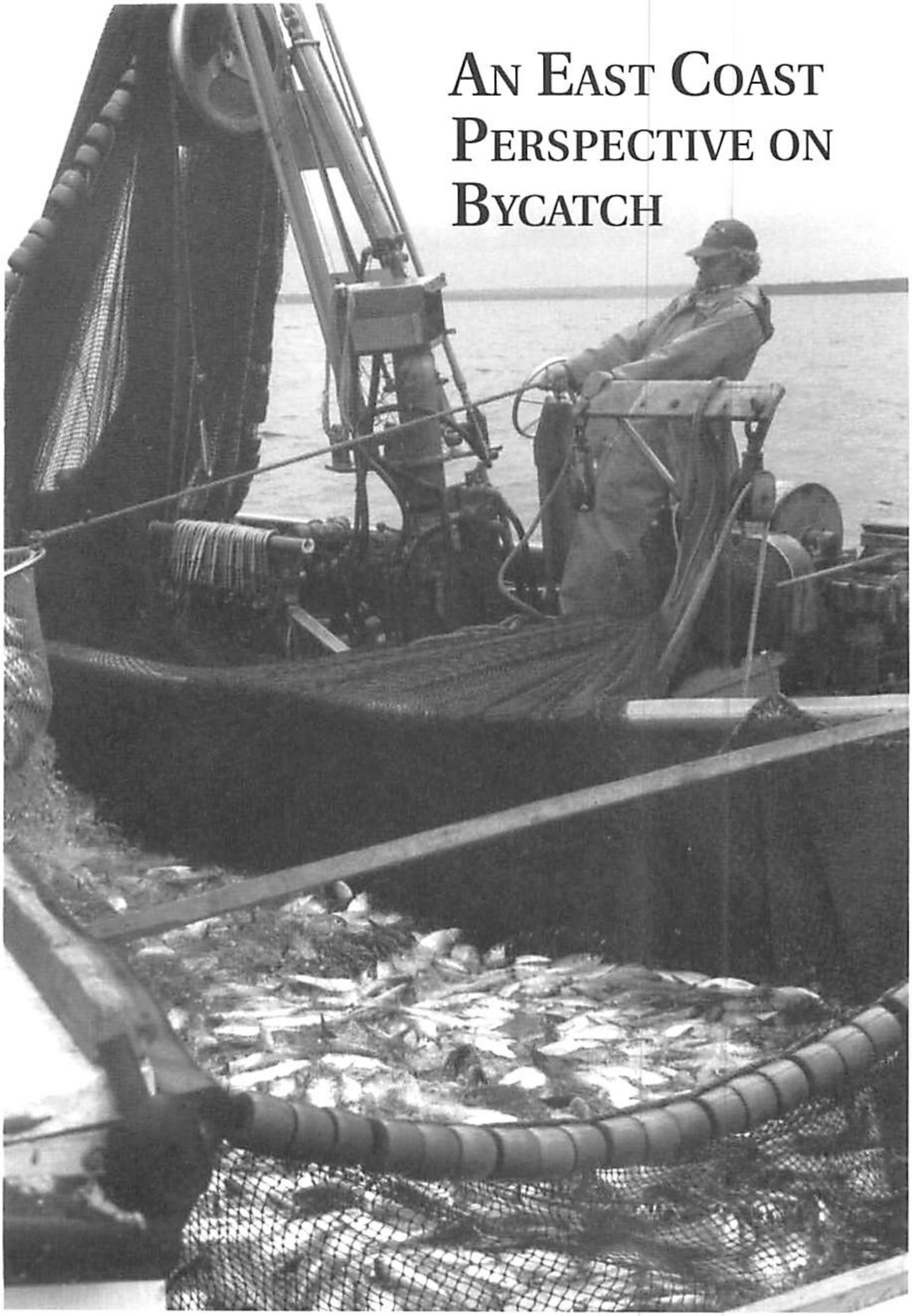
Ex. 6 **Distribution of bycatch rates by weight for longline fisheries**
N = 27



Ex. 7 Distribution of bycatch rates by number for gillnet fisheries
N = 24



An East Coast Perspective on Bycatch



New England Gillnetting

Ted Ames
Maine Gillnetters Association

Without a doubt, the whole issue of bycatch is a firestorm. Fishermen are being challenged as never before to make their gear more selective, selective enough to reduce bycatch to a very low level.

Bycatch problems can be solved. Even though each problem is unique and requires a different solution, the will and the technology available today should allow success. But it won't be easy. There are serious hurdles to overcome.

Anyone who's been reading the paper during the past five years is probably acquainted with the Gulf of Maine gillnetting industry's bycatch problem. Gillnetters in New England have had a bycatch problem with harbor porpoises for years, because the porpoises chase the same food that groundfish eat. Individually, fishermen don't catch that many, but when you add the totals up, it becomes arguable that too many are being caught to sustain the fishery. And while every instinct has been to argue the numbers, the truth is, population estimates of harbor porpoise aren't good enough to rebut. It's a no-win situation.

Most Gulf of Maine fishermen realized early on that reducing bycatch with time-area closures in this area was a dead end. Maine fishermen have a low, persistent bycatch rate. By the time these time-area closures reduced the bycatch rate to levels low enough to be acceptable to the environmentalists, we would have been forced out of business.

Through the whole process, fishermen have been hard-pressed, almost desperate: We had to solve the problem or go out of business. Gillnetting is the last small-boat fishing technology in the Gulf of Maine that has been able to compete with large trawlers. It's a really important issue. We probably should have given up long ago. But we didn't. And as luck would have it, we found a solution—the so-called acoustic "pingers," developed by Jon Lien and used in experiments in Jeffrey's Ledge just this past year by the National Marine Fisheries Service and New Hampshire gillnetters.

One solution found

These pingers actually work. Just listen to how well: Preliminary results show that both Jon Lien's experiment in 1993 and the NMFS study in 1994 reduced harbor porpoise bycatch in the range of 90 percent or better. As soon as the National Fish and Wildlife Foundation-funded study has completed the review process, we intend to petition the New England Fishery Management Council to use pingers during time-area closures. With luck, the New England gill net fleet will be using them this year. There are already 500 of them constructed and stored in a warehouse waiting for the season to open. And fishermen are committed to using them.

The same device might work in other situations, too. It might even be adaptable to midwater pelagic trawls in eliminating the marine mammal problem. But this is only the beginning. Marine mammals and harbor porpoises are only part of the problem. There's a whole spectrum of issues that have to be solved. Bycatch of a whole slew of nontargeted species has to be reduced. There's still a lot of hard work ahead.

Maine fishermen have always been on the oddball side: We've tried to reduce our own juvenile bycatch by supporting the Nordmore grate and supporting large-mesh nets for a long time. Our rationale has been this: We see juvenile bycatch as a horror show. At least half a dozen species of fish have been lost to fishermen in coastal Maine during the last 30 or 40 years. The bottom line is, there aren't enough fish to go around anymore. The quickest way to replace them is to reduce or eliminate juvenile bycatch.

Protecting the small fish

There's not a skipper in this room who hasn't had to dump a codend full of small fish at one time or another. We know we can't catch the babies and expect to have anything left. That's been proven over and over. We've caught the small fish that, had we missed them, would have grown into two codends' worth the next year. We're destroying next year's crop for nothing. Along the coast of Maine, you can see it most acutely.

When the Magnuson Act first came out, a group of us fishermen got together and tried to figure out ways to stop shooting ourselves in the foot. One of the options was to find ways to protect the small fish. Mesh size has been the focus of our efforts because that's the only way to control the size of the fish you bring on board. Increasing mesh size means you can't catch anything till it's larger. At first that didn't sit well among some fishermen. But eventually, people understood that smaller mesh meant smaller fish, and smaller fish bring smaller market price. In fact, why catch the peewees for 50 cents a pound when you can catch them a year later for 90 cents, plus gain the added weight? If 6-inch mesh means catching nothing smaller than 90-cent fish, imagine what larger mesh size would mean. Instead of junk, you'd come back with a whole tripload of larger fish.

There's nothing sacred about using a particular mesh size, but if everyone fishes with larger mesh, no one catches the little ones. In the end, we can all still catch fish. If the mesh is large enough so that fish can reproduce at least once before they're caught, not only do you have more valuable fish, you have fish spawning in traditional areas again. Then you don't have to go farther away to catch them; they're right there in your backyard. Next year's crop will be right there growing fatter for the next season.

The best part of using this type of approach is that, by protecting small groundfish in this way, we end up protecting every other species of fish that size as well. This, in turn, helps stabilize the whole biological community that groundfish depend on. We've got to rebuild this community that our commercial stocks come from if we expect to have sustainable catches.

Needless to say, there are bycatch problems. But there are ways to solve them. There's the 6-inch mesh. There are devices like pingers and the Nordmore grate. These successes are good, as far as they've gone. They allow us to keep fishing and at the same time protect the species we're after.

Small-mesh Bottom Trawl and Gear Modification

Fred Mattera
Point Judith Fishermen's Cooperative

First, a description of what fishermen perceive as bycatch: they look at undersized fish, juvenile fish, underutilized or unmarketable fish, undesirables, and regulated species they aren't allowed to retain. Essentially, what goes out the scupper and back overboard is bycatch.

What's being done about it? Several fisheries have been using different kinds of modifications in gear in order to reduce bycatch. Those fisheries are the whiting, butterfish, scup, and squid fisheries. What prompted them to initiate this gear modification? First and foremost, it was the recognition that something has to be done for the future stocks. There's no doubt about that. Everybody recognized the decline. So the question was, what does the industry do to reduce bycatch.

The second consideration was quality of fish. It's a lot easier to handle smaller quantities: the fish can be culled better and iced quicker. If you're bringing up large bags of fish, you're doing more damage to the fish, causing a less desirable fish in the marketplace.

About market conditions: There's no doubt that you get more money for larger fish. If you target the larger fish, eventually you will be paid more money. We're starting to see it now. We see it in the squid, whiting, and butterfish fisheries. It's to our benefit to get away from the 2-inch to 4-inch fish that bring 20 or 30 cents, and target the larger 50-cent to $1.50 fish.

Finally, there is wear and tear: wear and tear on the gear, wear and tear on you, on the equipment, and, most important, wear and tear on the crew. There's a fatigue factor that could, in turn, lead to injury.

Now let's talk about a few of the fisheries and the gear modifications. But first, it's important to recognize the shoreside net makers. These are the people who, along with the universities, have been instrumental in going forward with modifications. The fishermen have been dealing with them, sitting down and brainstorming—What do we do? How do we do this? What type of gear? What mesh size?—and they've been extremely helpful and influential in gear design.

Mesh size and modifications

In the whiting fishery, we have gone to a straight 3-inch codend. It's much more selective than using liners or using smaller mesh-size codends. One initiative last year was using a square-mesh tailpiece ahead of the codend. Doing that meant catching about 25 to 30 percent less than comparable vessels, but it allowed retention of about 90 percent of the target-sized (11-inch and up) catch. So this offers something to work toward for the future.

We have proceeded in the same manner in the butterfish fishery—codends are now 3 inches or 2.75 inches inside the knots. Thus, the gear has become very selective.

A lot of the boats going after butterfish in the winter months are freezer vessels. These vessels have blast freezers and plate freezers on board. But they can only handle so many fish within a certain time period because their cycles take five or six hours to handle, for some vessels 3,000, for others up to 5,000, pounds. It doesn't behoove them to bring 20,000 pounds onto the deck and only utilize 5,000 pounds, or pack up another 5,000 pounds, and throw the other 10,000 pounds over the side. They've recognized this, and they're working on becoming very, very selective.

There was some use, in a directed fishery for butterfish, of a square-mesh tailpiece ahead of the codend. It's very important to maintain the circumference equal to or greater than the terminus end of the net, right through to the codend. The smaller diameter square-mesh tailpieces were not as selective. This setup is very useful; it works well. But when you're in a mixed fishery, and you have squid along with the butterfish, you lose most of the squid.

In the scup fishery, the directed fishery for the most part has used everything, including 2- to 3-inch liners inside the codends and 3-inch or 4.5-inch codends. The best results were with the straight 4-inch codend. It allows the escape of squid, butterfish, and whiting, which, at times, interact. This is important in the Mid-Atlantic, where there is an abundance of small scup and mixed species.

What seems to be the biggest problem in bycatch with squid and scup is a mindset: The Mid-Atlantic fishery and the shoreside facilities, in essence, encourage fishermen to haul everything in. Boats come into these ports with 40,000 or 50,000 pounds, of which they sell 20,000. They may have four to eight people in the fish hole, and eight to 12 people on the cullboards, culling out discards. That's got to be stopped. That mindset has to be turned around, not just with the fishermen, but with the shore-side facilities also.

The directed squid fishery is one of the cleanest. Most fishing is done with 1.75-inch to 2.35-inch mesh. A lot of the Point Judith fleet uses 6 centimeter, or 2.35-inch, liners inside 5.5-inch or 4-inch codends. This works fairly well, but there's a lot of room for improvement. Some of us believe the only way to improve is to eliminate liners and go with the straight 2-inch codend inside the knots. This would eliminate liners for the most part, except in the *Illex* squid, mackerel, and herring fisheries, enhancing future enforcement capabilities.

This past winter, squid fishermen discovered that rope nets have become extremely selective. They were fishing in areas where bottom nets were also used, and the bottom nets were catching an awful lot of hake and whiting. But the rope nets were coming through and catching none of the mixed species whatsoever. So this is something else to look forward to in net design.

There isn't, in these areas, a problem with groundfish when using small mesh. There is, at times, a flatfish problem. But the design of these nets lets fishermen adjust the sweep, and this almost eliminates any flatfish problems.

The whiting fishery is investigating incentives to reduce bycatch. In whiting, there's an export market for anything with eyeballs and a tail. Six- to 8-inch fish are what the export market prefers; 10- and 12-inch fish are left on the grounds. A handful of fishermen are targeting the larger whiting. The rest are catching everything they can, using small mesh. NMFS has neglected to correct this problem. That has to change. Confidence spells compliance, and we need to create that.

Changing attitudes

These changes and modifications are definitely going forward to reduce bycatch. But the question is, how do we bring most—or all—the fishermen on line? What fishermen most want emphasized is that there has to be a change in temperament and ideology of all the players involved. Those players are conservationists, fishermen, and the National Marine Fisheries Service. Everyone has to work together. There are conservationists who, at times, sensationalize or fabricate facts. From experience in the codfish pair trawling, pelagic pair trawling, and drift net fisheries, we know that articles written about these fisheries are not accurate. And where NMFS is concerned, there is a perceived notion that their agenda is to eliminate the fisherman. Science becomes biased: That's been demonstrated in the fluke fishery; it's been seen in the bluefin tuna and red snapper fisheries, where reduced quotas have not paralleled the stock assessments. The science is forged to meet the management regulations.

These inaccuracies and negative perceptions have to be turned around. Peer review and public process must continue, and then everyone has to listen to what is being said. At a recent groundfish public hearing, 95 percent of the people were saying they didn't want a moratorium, and yet there is a moratorium. This erodes confidence. There has to be a better plan.

To see how things might work with everyone working together, you can make an analogy between a vessel and the groups that are involved with the fishery. When you build a boat, you have to start by laying the foundation; you lay the keel. That keel is the fisherman. That's the foundation, where it starts, the focal point. Next, you frame it and then put sheathing on it. That's the conservation groups: that creates a hull and forms the watertight integrity. Integrity is the key word. The last part is the main engine—the National Marine Fisheries Service. It's the driving force that will propel us forward. With all these parts working together, we can accomplish our goals in a realistic time frame.

Fishermen perceive as bycatch undersized fish, juvenile fish, underutilized or unmarketable fish, undesirables, and regulated species they aren't allowed to retain. Essentially, what goes out the scupper and back overboard is bycatch.

Atlantic Pelagic Longline Fishery

Nelson Beideman
Bluewater Fishermen's Association

The Blue Water Fishermen's Association represents commercial fishermen, vessel owners, fish dealers, and supply companies involved with Atlantic highly migratory marine species. These family-run small businesses are proud to carry on the tradition of providing healthy seafood for other Americans who cannot or do not want to catch their own.

BWFA was formed in 1989 to provide a united voice to respond to proposed management measures that would have effectively closed the U.S. swordfish fishery. BWFA members have always supported conservation measures that are practical, effective, and based on a reasonable interpretation of the available scientific data. BWFA is extremely active in voluntary scientific data and specimen collection programs, fish tagging, and in the fisheries conservation and management process. The association has developed a voluntary pilot program to donate dead swordfish—that fishermen are currently required by government regulations to discard—to hungry Americans, especially the poor and homeless in urban areas. This program is designed to help improve the available scientific information for the swordfish fishery.

There have been a lot of questions—and a lot of fishermen have a lot of questions—about the bycatch issue. We can't possibly answer all of them in the next few days. But maybe some of them we can start to come at with a little more fairness—especially the ones that relate to highly migratory species. There is a lot of conflict there among recreational fishermen, commercial fishermen, and different gear types.

One of the main questions is: What is bycatch in a multispecies fishery? Is the emphasis on improving species selectivity by gear, or is it on allocation? Is the problem catch, or mortality?

Quite frankly, for multi-species fisheries, many fishermen have been throughly confused by everyone's having a different perception of what bycatch is and defining what the pertinent problems are. Bycatch is one thing for this segment, but for another segment, that doesn't apply. Nothing applies across the board.

To most longline fishermen, bycatch is a dead wasted fish. Whether this waste stems from regulation or simple unmarketability, the definition and problem are one and the same. This should include all mortalities associated with any particular fishing operation, including hook mortalities and net excapement mortalities, etc. All mortalities in all fisheries need to be properly accounted for before our present scientific approach will be accurate and effective.

Much of the confusion stems from ever-changing user-group conflicts, especially in the highly migratory pelagic fisheries. Confusion among our fishermen is from managers not applying regulations across the board throughout the entire fishery, but just pinpointing the commercial fishery. Recreational fishermen have emphasized target versus nontarget species. Then when confronted with common-sense scenarios that picture their own fishery in the same black light as others, they immediately revert to the argument, "Well, if it's kept for personal consumption, it's no longer bycatch, even if it wasn't a target species."

A dead fish is a dead fish. If it is not being counted, it is a problem to the science. If it is not being utilized properly, it is swiftly becoming a problem to the public and thus our industry. All East Coast fisheries are involved to some degree with bycatch, no matter how it is defined.

Here's a little quiz to see how familiar folks are with Atlantic pelagic fisheries. Can you identify the pelagic fishery that corresponds with each of these pie graphs depicting species composition? *(See graph page 28.)*

Fishermen as well as the public aspire to the common-sense "waste not, want not" goal and continuously adjust their fishing gear to maximize their targeted catch. Hook fishermen are especially aware of incidental catch because every hook taken by an unmarketable species is unavailable to catch a targeted species.

Reducing waste in all U.S. fisheries is a formidable task that will take a long time to achieve. The technology and the research resources that are required are simply not available. The species-specific regulatory approach favored by NMFS and state managers often results in increased regulatory waste, even though these agencies are attempting to address allocation conflicts among users. Fisheries management must progress toward a more effective multispecies and ecosystem-based approach. Initiating a holistic management system will require considerable resources; however, postponing this effort will gain nothing. Managers must apply this approach to fisheries management.

Our legislative leaders should firmly mandate a national policy directive to alter NMFS's reliance on regulations that result in waste. The directive must also allow the managers the flexibility to work with users to develop effective programs and to phase in changes in regulations that will, to the extent practicable, minimize waste in specific fisheries.

The following bycatch and utilization policy objectives are fundamental and straightforward and must be applied to all U.S. fisheries:

1. In the first place, minimize the catch of fish that cannot be utilized.

2. Minimize the mortality of those fish that are caught but cannot be utilized.

3. Maximize to the extent practicable the utilization of those fish that are captured dead.

Pelagic longline

There is great potential for pelagic longline. Pelagic longline is a very flexible gear. The nature of longline fishing and its gear components, as well as variations of technique, allows this gear to be changed readily, and by making subtle changes, fishermen may obtain beneficial effects to avoid unwanted hookups. This fishery's primary target species are more valuable when retrieved alive; therefore, tag and release is often an option for unwanted interactions. We also collect other scientific information and samples under controlled conditions. But the first focus has to be harvesting fish for food. Group after group has suggested altering our gear this way and that way. Keep it shallow, make it deep. Catch big fish, says one agency; catch all small fish, says another. The gear is flexible, but let's be realistic.

Longliners are not opposed to gear engineering and innovation to make an already clean fishing method even better. This will require substantial industry involvement. To be effective, the process must have substantial two-way involvement from start to finish.

Responsible fishing practices

All fisheries will need to develop practical responsible fishing practices for avoiding and mitigating bycatch of prioritized species and unnecessary waste in each fishery. You will see more and more of the "how to" instructions to educate all fishermen in a fishery. The basic bycatch and waste solutions will inherently involve the actual harvesting level, especially in the pilot house.

Live releases, tag-and-release potential

One of BWFA's objectives since it was founded in 1989 has been to support research projects intended to enhance the conservation and management of the highly migratory species and to broaden public understanding of the significance of these fisheries to the United States. The association has worked to promote tag-and-release to our fishermen and even to other Atlantic harvesting countries. There is great potential for spreading a "conservation ethic" inherent in the release of small fish for science. Thirteen BWFA captains are among the top 20 taggers for the Southeast Cooperative Tagging Program. Also, the Billfish Foundation recognized BWFA's efforts in a special conservation award in 1994.

Many components

Each fishery must be comprehensively studied across the entire species complex that the fishery interacts with, fishery by fishery, area by area. One of the things about the U.S. Atlantic pelagic longline fishery is that it is subdivided into at least four basic components. Each component is a little bit different in type of gear and fishing style.

The U.S. pelagic swordfish and tuna longline fishery is distinct from other longline fisheries, especially the directed shark fishery—whose fishermen are also required to fill out swordfish information in case they should interact with a swordfish. Once these are recognized as separate fisheries, we then have to separate real differences among gear components, bait, style, and deployment within the U.S. pelagic longline fisheries.

The U.S. Atlantic longline fishery for swordfish, tunas, and pelagic sharks is composed of four basic smaller components separated by geographical location, gear techniques, time of year, and primary and secondary target species. There's the yellowfin tuna fishery in the Gulf of Mexico, the South Atlantic swordfish/tuna fishery, the Mid-Atlantic bigeye tuna fishery, and the distant water directed swordfish fishery. Each of those has distinct gear characteristics and deployment techniques that need to be understood.

In general, U.S. pelagic longline gear has evolved into ever lighter materials that have increased live retrievals of both our target and incidental catch. This helps to improve the quality of our seafood products and usually results in a higher price.

Obstacles and options

There have been obstacles, slow to overcome, in attempting to be proactive to address these issues. Our fishermen have repeatedly requested a temporary restriction on new entrants into the fishery in order to obtain a reasonable control on participation. The restriction would create an incentive to begin serious work on bycatch and other issues relevant to the long-term sustainability of the renewable resources we harvest. Our fishermen have been sitting on the edge of their seats for many years now, as one group after another places our livelihood and our futures under a microscope. Those in the fishery who have invested their lives in the long-term viability of this fishery are willing to work toward practical solutions to real problems. In contrast, new entrants may lack the experience to avoid bycatch and the skill to handle gear interactions with them if they occur. While there is open access to this fishery, it is difficult to begin the work necessary to resolve bycatch issues.

Some of the things the National Fisheries Institute (NFI) and Blue Water have been trying to do to promote a constructive, proactive approach in the Atlantic pelagic longline fishery have to do with our grant program. It might be interesting to explain some of these issues; however, quantitative studies of all users are necessary to set bycatch priorities in a fishery. The Atlantic pelagic longline fishery is being proactive by attempting to study and address bycatch priorities for this fishery. BWFA and the NFI have initiated steps, through a Saltonstall-Kennedy Grant, that we feel are necessary to prepare for a comprehensive management plan for the pelagic longline fishery. The S-K grant objective is to provide baseline information to members of the industry to encourage practical suggestions relating to operational changes that could minimize bycatch.

There are three phases to the overall study of this fishery:

1). Preparing quantitative information covering observed bycatch in the pelagic longline fishery. This includes placing into a usable format observer information on dead/live ratios for all species captured and retained, released,or discarded.

2). Organizing industry bycatch workshops to promote two-way information on avoidance and mitigation techniques and to develop the industry's ideas for setting species priorities and necessary research. This will include a questionnaire being developed by BWFA/NFI/NMFS to receive information on the fishermen's attitudes and their concerns and priorities on these issues.

3). If funding is available, assembling a panel of pelagic fishery experts, including the different interest groups and International Commission for the Conservation of Atlantic Tunas participants, that could comprehensively address these multispecies fisheries and bycatch priority issues. The panel's tasks would include:

- First, laying out the status of involved species and catch
- Accurately describing sources of mortality, including landings and discards from various user groups
- Reviewing known industry techniques for bycatch avoidance, decreased mortality, and utilization of dead catch
- Setting research priorities for potential avoidance and mitigation techniques
- Determining practical measures to implement the best available techniques to reduce bycatch of priority species.

It's going to be a long, hard road. But there is progress. When we first started circulating this quiz about composition of the different pelagic fisheries, there were at least one or two wrong answers from almost everybody. The fishermen did real well on their own fishery, but they did less well on other fisheries. The answers are on the following pages.

To most longline fishermen, bycatch is a dead wasted fish.

What is bycatch in multi-species fisheries?

Is the problem catch or mortality?

Figure A.

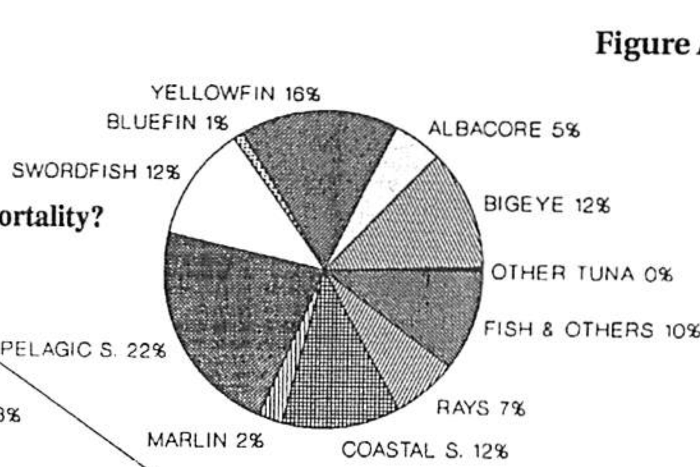


Figure B.

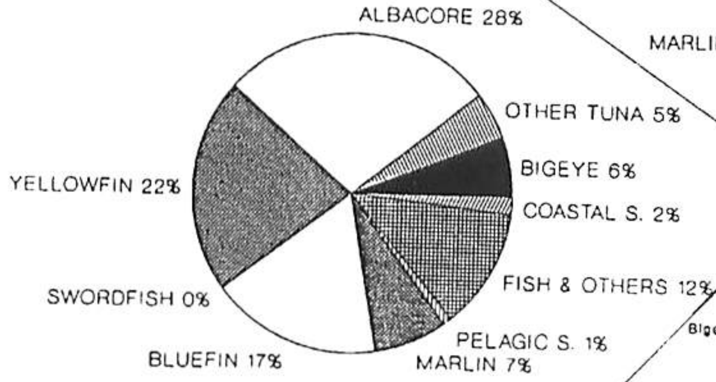


Figure C.

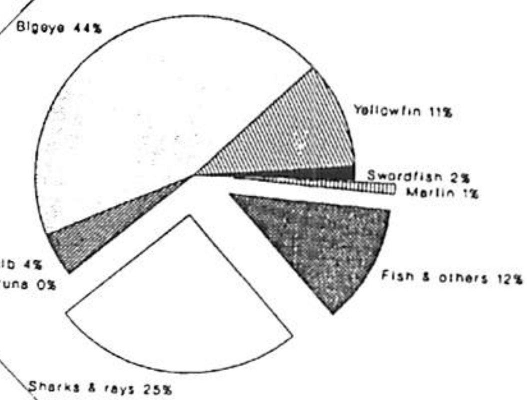


Figure D.

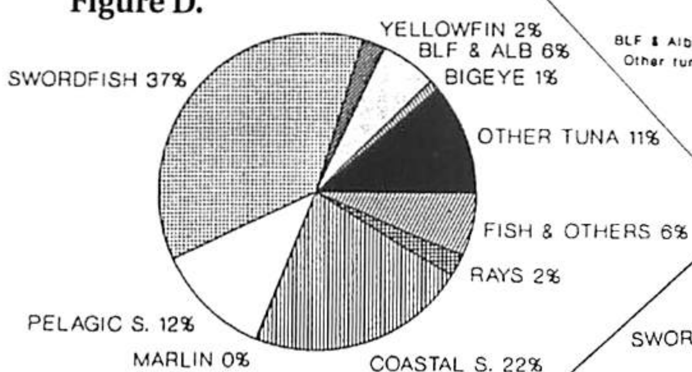


Figure E.

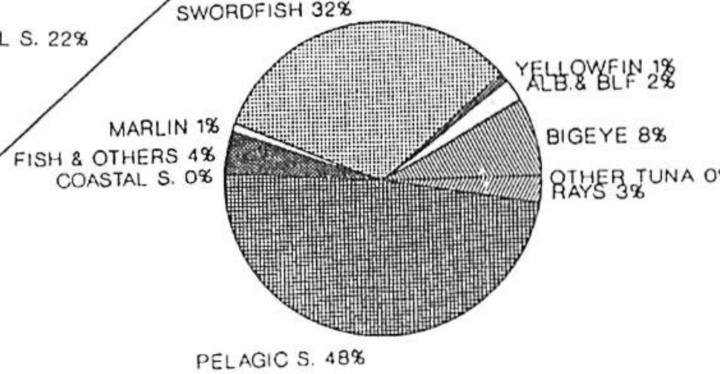


Figure A. NE US Longline Sets 91-94—Observed US sets 91-94 from Cape Hatteras to the US/Canadian boundary. Spc. Comp. 388 sets, catch 14,355

Figure A.

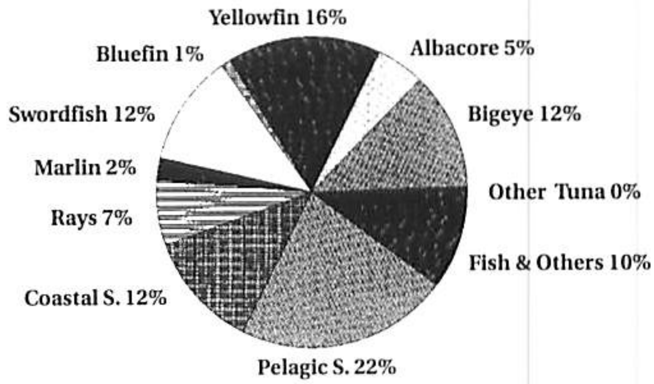


Figure B. Mid-Atlantic Region 1983 Spc. Comp. Offshore Recreational Fishery. Figley et. al.

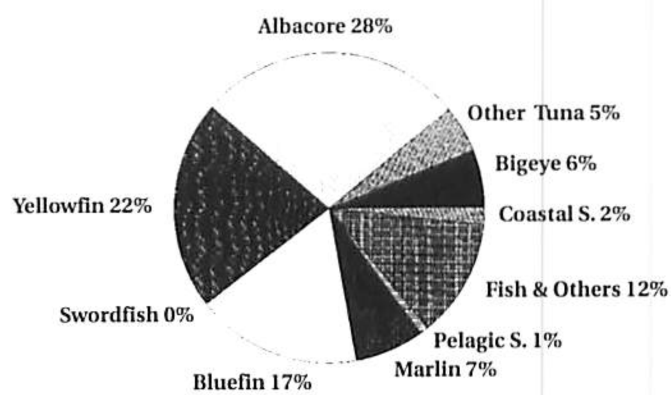


Figure C. Japanese Longline-NE US Deep Rig. 1,165 sets, catch 75,165. Hooks between floats>11. 65% alive. Observed Japanese longline sets off the US/NE -Cape Hatteras to Canadian/US boundary.

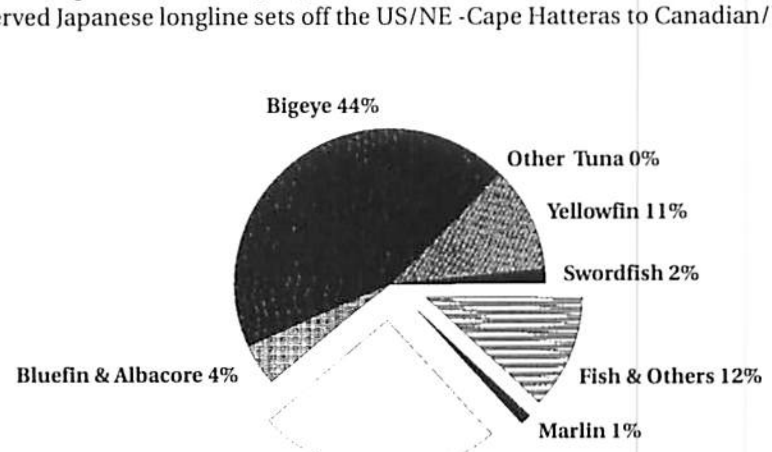


Figure D. NE/US Gill net 89-92. 207 sets, catch 6,026. NEFSC Observer Data. US observed sets on drift gillnet vessels operating off New England.

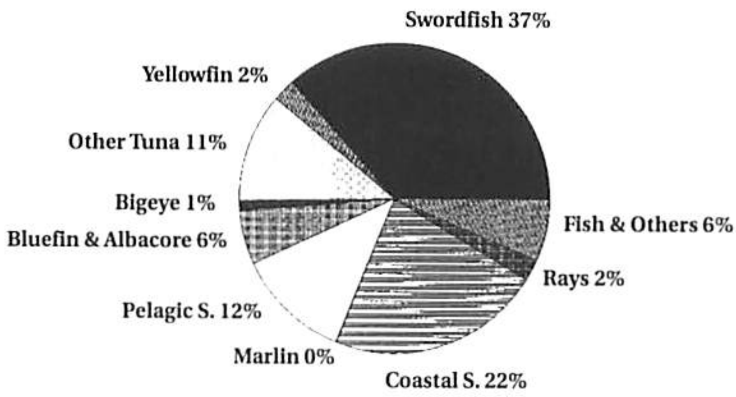
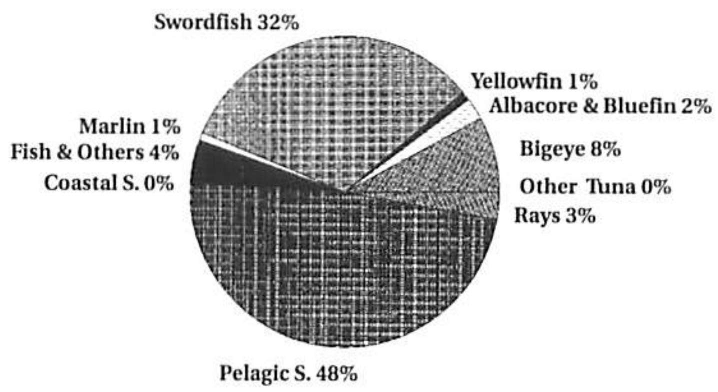


Figure E. GRB Longline sets 91-94. Spc. Comp. 170 sets, catch 11,085. US observed sets 91-94 on US vessels operating on the Grand Banks.



Biological Implications of Bycatch

S. A. Murawski
National Marine Fisheries Service
Northeast Fisheries Science Center

Abstract: *The importance of the bycatch issue stems from concern that significant mortalities of animals, whether intended or not, can threaten population, ecosystem, and fishery sustainability. Moreover, there are ethical issues arising from the capture of animals that are killed but not utilized. Kept bycatch—e.g. nontarget species—is often a significant component of the total value of fishery catches, particularly in the Northeast where many resources are at low abundance levels and true single-species fisheries are rare. Both kept and discarded bycatch may have significant implications for fisheries, determining the level of yields and their allocation among competing users. Population-level effects of dead discards may be manifest in the levels of abundance, spawning potential, and yield. Even if discards survive the initial gear encounter, their vital rates may change, or they may become more vulnerable to predation. Community effects, such as shifts in species dominance and alteration of energy pathways, may be significant, but these have not been well documented. Dead discards may also have great importance to the assessment and prediction of stock status, depending on the rates of bycatch and the type of assessment calculation being made. Various regulatory approaches may contribute to high bycatch rates. Open-access fisheries generally lead to "recruitment fisheries" and increased targeting of young (small) fish. In quota-controlled fisheries, excess capacity may result in a "race for fish," which may discourage fishing practices that minimize bycatch. The increased specialization of fisheries has led to greater user group conflict over bycatch. It is imperative that the biological consequences and fishery responses to regulatory measures be carefully considered in developing appropriate mitigation plans for bycatch management.*

Introduction

Bycatch and its management have become a central issue in fisheries regulatory fora throughout the United States and the world (Tillman 1993; Alverson et al. 1994; Warren [ed.] 1994; Kennelly 1995). The magnitude of bycatch, its exact definition, and its significance to fisheries, populations, and ecosystems are often equivocal. Nevertheless, clear public policy guidance has emerged that bycatch should be eliminated or reduced to levels approaching insignificance (however defined). The reauthorized Magnuson Fisheries Conservation and Management Act (MFCMA) contains a new national standard requiring bycatch minimization. Likewise, internationally, bycatch has become the focus of attention of organizations including the FAO, the United Nations General Assembly, and the European Union.

Bycatch is herein defined as the catch of nontarget animals, whether kept or discarded (see Alverson et al. 1994 for a complete set of definitions appropriate to the bycatch issue). The purpose of this paper is to outline the potential importance bycatch has for exploited populations, fisheries that depend upon them, and the ecosystems in which the populations exist. Additionally, I discuss several scenarios in which regulatory regimes per se may contribute to substantial bycatch problems.

Biology of Bycatch

The biological significance of bycatch can be judged from a number of different perspectives, including those of the population (e.g. of a particular species), of the fishery or fisheries that encounter the bycaught animal, and of the biological community (ecosystem) from which the bycatch is removed (Figure 1).

Kept Bycatch - Kept bycatch may have significant economic importance for fisheries in which the putative target represents only a fraction of the landed value of the total catch. Such is the case, for example, of the Northeast sea scallop fishery, where species including monkfish and flounders can make a substantial contribution to the gross revenues, particularly when scallop abundance is low. In this case, scallop dredges are not the optimal gear for harvesting the bycatch species, since escapement of small or undersized animals is probably very low, and thus the value of bycaught species is not maximized by harvesting with the scallop gear. Moreover, monkfish and flounder catches in the scallop dredge fishery intercept animals that are targeted by other sectors, including trawlers and gillnetters. Kept bycatch, then, can have substantial allocation effects. For mixed-species fisheries where the bycatch is harvested suboptimally, the effect may be to reduce the abundance and size composition of animals available for (competing) directed fisheries. Nevertheless, the ability to generate revenue from byproducts (e.g. bycatch), can be an integral part of a mixed-species fishing strategy and remains an important consideration in developing management options for many of the region's fisheries. Fishermen often cite the ability to retain bycatch, and to switch among alternative target 'mixes' as an important coping strategy in the face of fluctuating species abundances. Thus, retaining such flexibility has remained a high priority in the development of management alternatives.

Discarded Bycatch - Discarded bycatch has two alternative fates: It either survives the gear encounter, or dies (Figure 1). Animals surviving the initial encounter may, however, suffer chronic effects, such as temporary or permanent alteration of vital rates, including growth and onset of maturation. More problematic, however, is potential increased vulnerability to predation. Numerous observations have been made of live discarded animals, near the surface, being preyed upon by birds, mammals, and fishes. Even when these discarded animals escape initial predation, they may not be able to seek appropriate shelter or otherwise avoid predators as they would normally.

The community effects of discard survival may also be significant. If low valued discard species taken along with fishery targets survive, such a scenario may contribute to a change in species dominance within heavily exploited ecosystems. Discard survival is a likely contributing factor to the increased proportion of small elasmobranchs (spiny dogfish and skates) as a component of mixed-species groundfish catches off the northeast United States (Murawski 1994). Highly species-selective culls of the catch, combined with discard survival, may thus be more damaging to the productivity potential of ecosystems than moderate exploitation of species communities, landing all species caught.

If discarded dead bycatch is composed of animals below their optimum size for maximum yields, and prior to full maturity, the effect will be to reduce yield per recruit from the population and its average spawning potential (these effects result whether the catch is retained or discarded). Such is the case for summer flounder off the northeast United States (Figure 2). For this species, discards are primarily composed of undersized animals (e.g. ages 0 and 1), and are a non-trivial proportion of the total catch. Discards result in forgone yields and spawning potential, since most of the discard mortalities are of immature fish. Summer flounder discards result both from the trawl fishery and hook-and-line recreational fishing, and thus there may be important implications of these discards for the balance of yields to these two competing fishery sectors.

Community impacts of dead discards depend greatly on the magnitude of such mortalities, their distribution in time and space, and the ability of the ecosystem to assimilate them. Direct predation on fishery discards is often observed. To the extent that such discards represent food resources otherwise unavailable to predator or scavenger populations, such mortalities represent a prey subsidy. If such subsidies are a significant component of predator diets, they may result in higher predator/scavenger populations, and/or alterations in predator distribution patterns and vital rates. It has often been speculated that bird populations, in particular, may be stimulated by the fishery discards, and the discharge of offal. Identification of discards in the diets of fish populations is more problematic, owing to the inability to distinguish such fish from live captures in the gut contents of predators and scavengers. *In situ* studies have documented the responses of benthic scavenger populations (e.g. crabs and starfish) to the presence of fish and invertebrate mortalities from fishing activities. Such mortalities are generally utilized quickly. However, if the discharge of dead discards is sufficiently high in a localized area, it may overwhelm scavenger populations, resulting in decaying remains and attendant environmental problems in such areas. As with the breakdown of any animal remains, there may be higher biological oxygen demand, release of nutrients, possibly resulting in local-scale hypoxia, depending on specific conditions at the sea bottom. In the extreme, such conditions may result in yet other mortalities of sessile animals in the vicinity of such events. Ultimately, nutrients released from dead discards will be recycled within the ecosystem, but the pathways and impacts of such nutrients are not well understood for any ecosystem. A significant proportion of the primary productivity of some ecosystems is required for the support of fishery populations (i.e. averaging 8 percent, but ranging up to 35 percent for non-tropical shelf ecosystems), of which discards may make up a significant fraction (Pauly and Christensen 1995). The recycling of such discarded materials could, therefore, be a significant contributor to the energy budgets of some systems.

The allocation effects of dead discards can be critical to the outcomes for fisheries competing for the bycatch species. Even when a single fishery discards portions of a single target species catch, the effects may be large. Discards of large fractions of the catch, particularly of young fish, may result in considerable forgone yield and value (Murawski 1994). There are numerous cases for quota-controlled fisheries, wherein the aggregate quantity of bycatch is a limiting constraint to the full utilization of target species, often at great aggregate forgone yields (Smith 1993).

Unobserved mortalities due to gear encounters are potentially the most problematic of the "discard" issues, both from a scientific and a management perspective (Chopin and Arimoto 1995). Gear designs to improve "apparent" discard rates assume that animals escaping (e.g. through meshes) suffer negligible mortality. If, however, these mortalities are significant, then the basis for gear-based solutions may be compromised. Furthermore, since gear escapees cannot be enumerated by conventional fishery observer programs, the quantity of such mortalities cannot be monitored or included in stock assessment calculations. Based on preliminary research (Chopin and Arimoto 1995), escapee mortality should be considered where gear-based measures are used as a primary management tool. Appropriate survival studies are, then, a priority.

Bycatch Impacts on Assessment and Prediction

Accurate assessment of fishery populations requires that catch histories of animals be reconstructed with the greatest precision possible. It was often assumed in the past that if discards were more or less a constant fraction of the catch, they could be effectively ignored without serious harm to the conclusions of stock assessment calculations (e.g. estimates of stock size and fishing mortality). This assumption was invoked, in part, because of the dearth of data on fishery discards, and the fact that where such data did exist, their precision was generally much poorer than for the landed portion of the catch. Given the great expense of at-sea observer programs, there was little enthusiasm for pursuing information which, it was supposed, would offer little new in terms of the accuracy of stock forecasts.

More recent research, however, has challenged the conventional wisdom regarding the inclusion of discards in assessments (e.g. Anonymous 1986; Figure 3). Through a combination of simulation and data analysis, it now appears that: (1) discard rates can vary significantly, owing to a number of factors, and (2) the importance of discards to stock assessment calculations depends greatly upon the type of calculation being made, the constancy assumption, and whether or not discard proportion varies in predictable or unpredictable ways (Figure 3).

In the simple case of a short-term yield forecast (e.g. one year ahead), with the selectivity patterns of the fishery (partial recruitment) assumed constant and discards representing a constant fraction of the catch, the effects of including or not including the discards have little impact on the results (Figure 3). However, if discard rates vary significantly (e.g. due to the presence of strong but predictable year classes), then the inclusion of discards may have a significant impact on the results of short-term projections, depending on the fraction of the total catch that the discards constitute. If the discard rate is not predictable, then the prediction becomes more error-prone, but not necessarily biased. For long-term catch and biomass forecasts (e.g. yield and spawning biomass per recruit analyses), the inclusion of discard mortalities is much more important than the short-term forecast case (Figure 3). In this case, all sources of mortalities must be accounted for, particularly in the case where discard proportions are variable but predictable. When the selection properties of the fishery are changed (e.g. through increased mesh size, or alteration in the proportion of the catch accruing to various gears), then discards become an important element of the forecast, even when the discard proportions are assumed constant. Improvement of the selection pattern of gears is often intended to alter the fraction of animals discarded, and thus the magnitude of discards that could potentially enter the landings stream may be significant, depending on the overall rate of ex-

> ***Bycatch is herein defined as the catch of nontarget animals, whether kept or discarded.***

ploitation of the stock and the magnitude of recruitment.

Apart from the predictive side of stock assessment, discards may have important implications for the results of retrospective estimates of stock size and fishing mortality rates as well (Alverson et al. 1994). Generally speaking, failure to account for all mortalities will result in an underestimation of fishing mortality rates, with attendant underestimates of stock size, although the direction and magnitude of such biases are critically dependent upon specific data and analysis techniques. Unaccounted catches (e.g. discards and "black fish"), have been implicated as a major contributor to the "retrospective problem" wherein the fishing mortality rates are underestimated, often significantly, in the last year of a retrospective assessment (Sinclair et al. 1990). The general "goodness-of-fit" of retrospective catch-at-age models is improved, often considerably, with the inclusion of accurate catch data from all sources, including discards.

Obtaining unbiased and precise estimates of discard mortalities represents a significant technical, logistic, and financial challenge. As previously stated, obtaining such data may be considerably more expensive than obtaining corresponding landings information. Nevertheless, depending on the magnitude of discards, the fraction of the total catch they represent, and their variability over time, such data may be critical to our determination of exploitation status and the efficacy of alternative management measures.

Management Techniques Can Significantly Influence Bycatches

Reauthorization of the Magnuson Act includes specific requirements for the reduction of regulatory-induced discards and explicit consideration of the consequences of all fishery regulations on bycatches. All management schemes, regardless of whether they are based principally on direct or indirect controls on fishing mortality, have the potential to generate significant discarding that is due to the management measures (i.e. 'regulatory discards'). Several scenarios wherein regulatory discarding rates are known to be exacerbated by management measures are discussed briefly:

Scenario 1: Overfishing exacerbates bycatch - In this scenario, open-access fisheries and a lack of explicit controls on catch or fishing effort result in very high fishing mortality rates and declining stock sizes (Figure 4). The scenario is modeled after events in the New England groundfish fishery since the early 1980s. Because of declining catches and steady or increasing consumer demand, prices increase, which supports increased—or at least stable—fishing effort. Additionally, the "quality" of existing effort is improved through technological innovation ("technology creep"). The truncation of age structures results in increased reliance on incoming, but partially recruited, year classes. This differential targeting of strong year classes drives inter-annual variation in the rate of discarding (e.g., fraction of the catch). Indirect controls to limit the waste of small fish include calls for increased trawl mesh size, an increase in the minimum landing size, and perhaps closed areas to limit targeting of aggregations of small fish. However, if minimum fish sizes are set to minimize the catch of sublegal fish in the net, then some legal-sized fish will escape. Even assuming complete adherence to the minimum landing size, subversion of mesh and area regulations is a typical consequence, particularly if at-sea enforcement of such regulations is ineffective (Figure 4). This scenario results in, at times, very high discarding of target species, particularly when good year classes are spawned. Such recruitment events could present an opportunity for stock rebuilding, but only if fishing on them is minimized.

Scenario 2: The race for fish - This scenario depicts the case in which an open-access mixed-species fishery is regulated with binding target and bycatch species quotas. The example is applicable to Bering Sea and Gulf of Alaska trawl fisheries for groundfish. Because of the open-access nature of the fishery—despite large catches and fishery populations maintained at reasonable levels through quota controls—gross overcapitalization of the fishery occurs. Available fishing time per vessel declines as the fishery becomes more of a "derby", in which greater amounts of capital are used to competitively increase relative and fleet aggregate catchability. Even when aggregate bycatch is a limiting constraint on the fishery, there is little individual incentive to minimize bycatch, since responsible individuals would likely be penalized by lower target-species catches, as they search for areas/times and technologies to minimize bycatch rates. Thus, the bycatch rate is higher than would otherwise be the case if capitalization in the fishery more adequately reflected the productivity potential of the resource. If the fishery is constrained from achieving full utilization of the target species TACs, then bycatch rates can increase, owing to increased pressure to raise limiting bycatch constraints, or by subversion of the catch monitoring system. A consequence of closing fisheries due to bycatch quotas is that there may be considerable forgone target species yield, along with the transfer of effort to yet other fisheries, which may or may not be able to cope with increased fishing pressure.

Scenario 3: One man's trash... The third scenario depicts the case where fisheries become more specialized over time, particularly as an initial high value species is overfished, prompting a diversification of the fishery (perhaps in combination with the development of new markets or fishery products). There are many examples of the increasing specialization and diversification of fisheries to which this scenario applies. In the case of an initial high value target species exploited by an open-access fishery, nontarget species are initially discarded at a high rate. Increased fishing effort on the target results in further increase in effective effort, particularly as catch and stock size of the target species decline. In the extreme, the target species may shift as economic alternatives are exploited. New entrants to the fishery may bypass the initial target species in favor of a more abundant species for which the opportunities appear greater. The development of fisheries for species that are the bycatch of the initial target result in allocation conflicts among the fleet sectors. Furthermore, there may be suboptimal use of the bycatch species and overfishing owing to the intensity of landings and discards resulting from all fisheries. As a result, there may be suboptimal aggregate use of the resources available to regional fisheries.

Ameliorating the discard problems resulting from the three scenarios outlined above has proven problematic. Easy solutions to these problems do not exist. Clearly, open-access fisheries and grossly excessive harvesting capacities are an element of the problem. However, strategies to effectively control where, when, and how fish are caught are also fundamental to "solving" the bycatch problems of these fisheries.

Conclusions

Bycatches of fisheries potentially can have major implications for the biology and productivity of species and ecosystems, and can determine the balance of yields accruing to fisheries linked by common species. Kept bycatches may be important sources of income, particularly when target nominal species decline in abundance. Accurate accounting of landings and discards by fleet sectors can be used as the basis for determining the full effects of fisheries on exploited stocks and for evaluating the potential biological and economic consequences of various strategies to minimize bycatches (particularly of dead discards).

Accounting for the magnitude of discards, particularly where they represent a significant proportion of the fishery catch, is pivotal to accurate retrospective and predictive stock assessments. Measuring the quantity of such discards and their biological characteristics is expensive and difficult. In recent years, increased availability of discard data from at-sea observers has proved important to the design of programs to minimize such discards. Long-term strategies to reduce discarding will require an iterative approach, combining the implementation of new management measures with sufficiently precise monitoring to evaluate potential improvements in the bycatch rate of fisheries. Goals for bycatch management have not been generally considered, but they will become increasingly important as managers attempt to define how close to zero bycatch is achievable, given the institutional, scientific, and industry resources necessary to accomplish the job.

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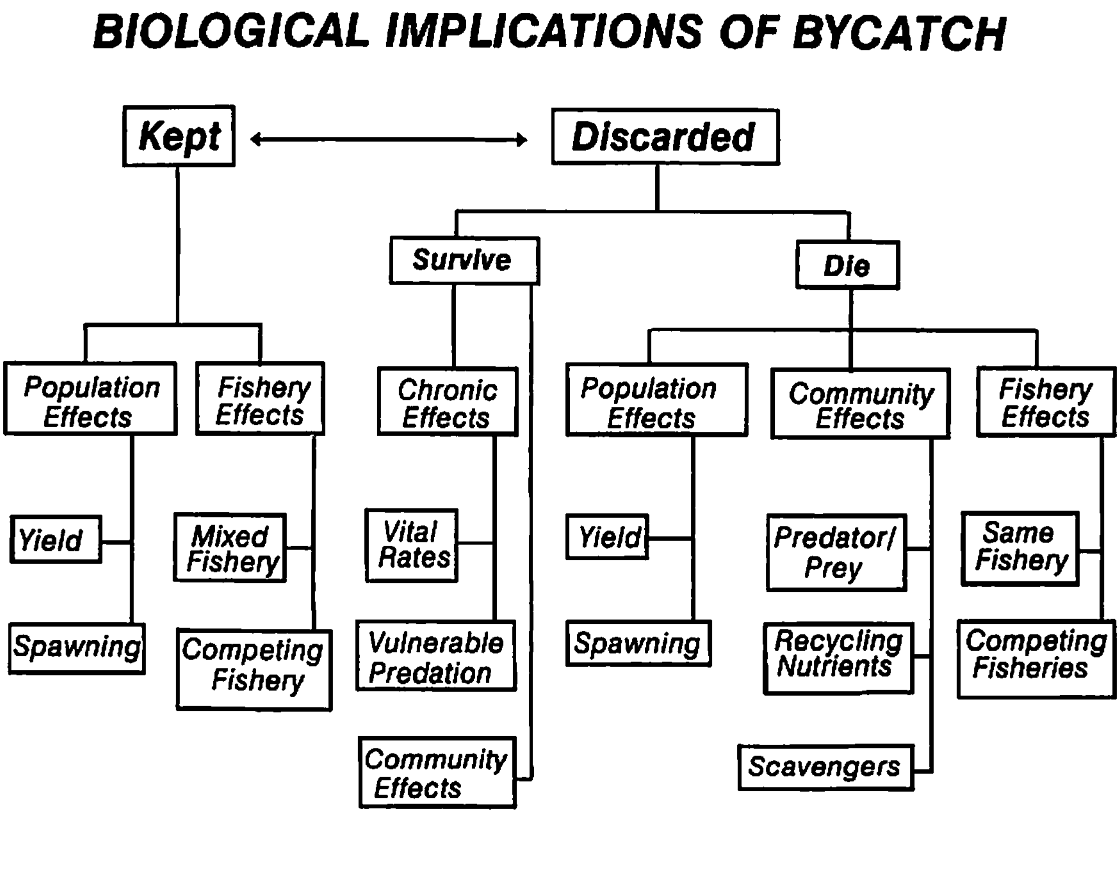

Figure 1. Schematic of potential biological processes influenced by kept and discarded bycatch. Various effects are categorized based upon their impacts on populations, fisheries, and communities (ecosystems).

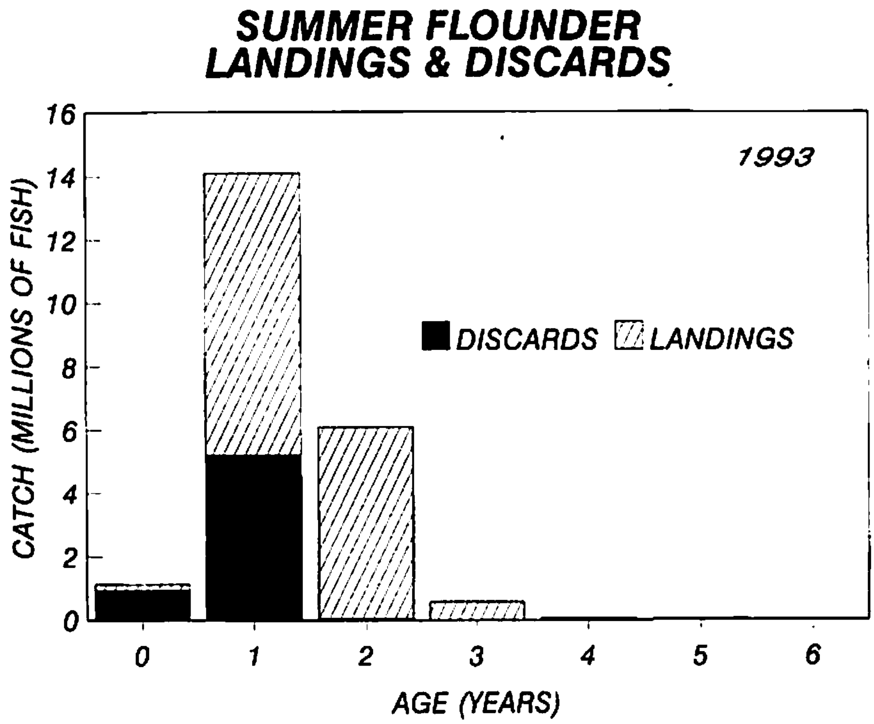

Figure 2. Catch (in millions of fish) of summer flounder off the Northeast USA in 1993. Catch data are presented by age, and include dead discards plus landings.

IMPACT OF DISCARDS ON FISHERY PREDICTIONS

PARTIAL RCT.	ASSESS. CALC.		CONSTANT PROPORTION	VARIABLE PROPORTION: PREDICTABLE	VARIABLE PROPORTION: UNPREDICTABLE
CONSTANT (e.g., CATCH FORECAST, YPR, SSB/R)	SHORT-TERM FORECAST		0	**	0 + error
	LONG-TERM CATCH FORE-CAST	RELATIVE YIELD	*	***	* + error
		RELATIVE BIOMASS	*	**	* + error
CHANGING (e.g.,MESH ·ASSESS.)	SHORT-TERM LOSSES-GAINS		**	***	** + error
	LONG-TERM LOSSES /GAINS	RELATIVE YIELD	**	***	** + error
		RELATIVE BIOMASS	*	*	* + error

0 = NO; * = SMALL; ** = MEDIUM; *** = MAJOR

Figure 3. Potential impacts of dead discards on single-species stock assessment calculations (figure is from Anon. 1986; constructed by J. Shepherd).

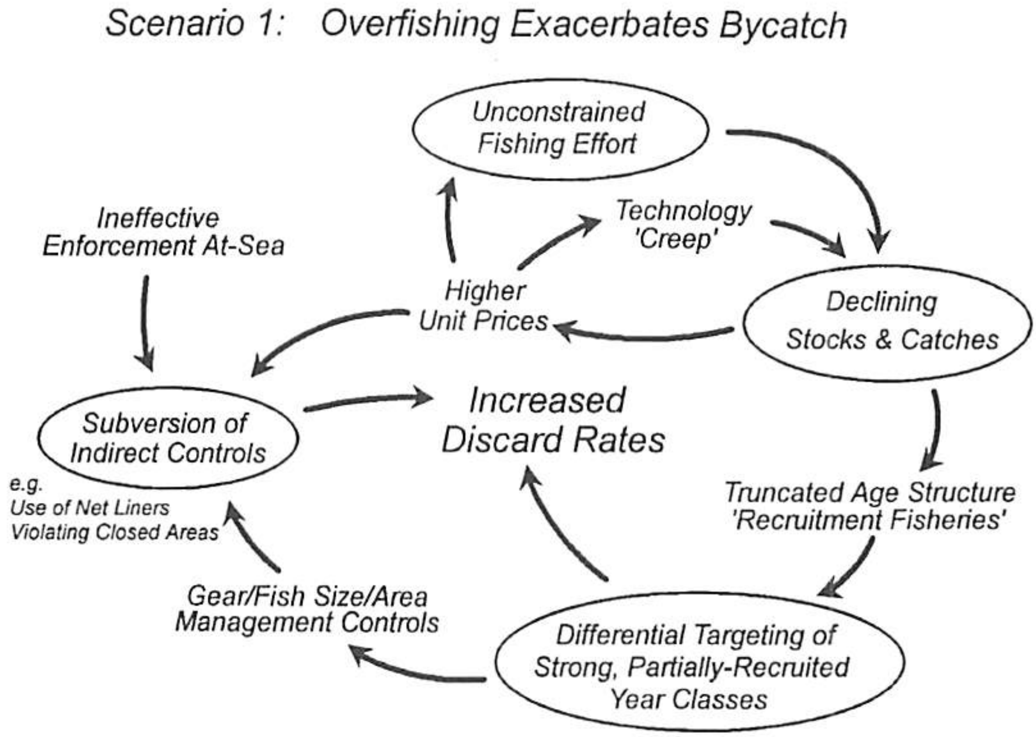

Figure 4. Fishery and regulatory factors contributing to increased bycatch in open-access fisheries controlled by indirect management measures.

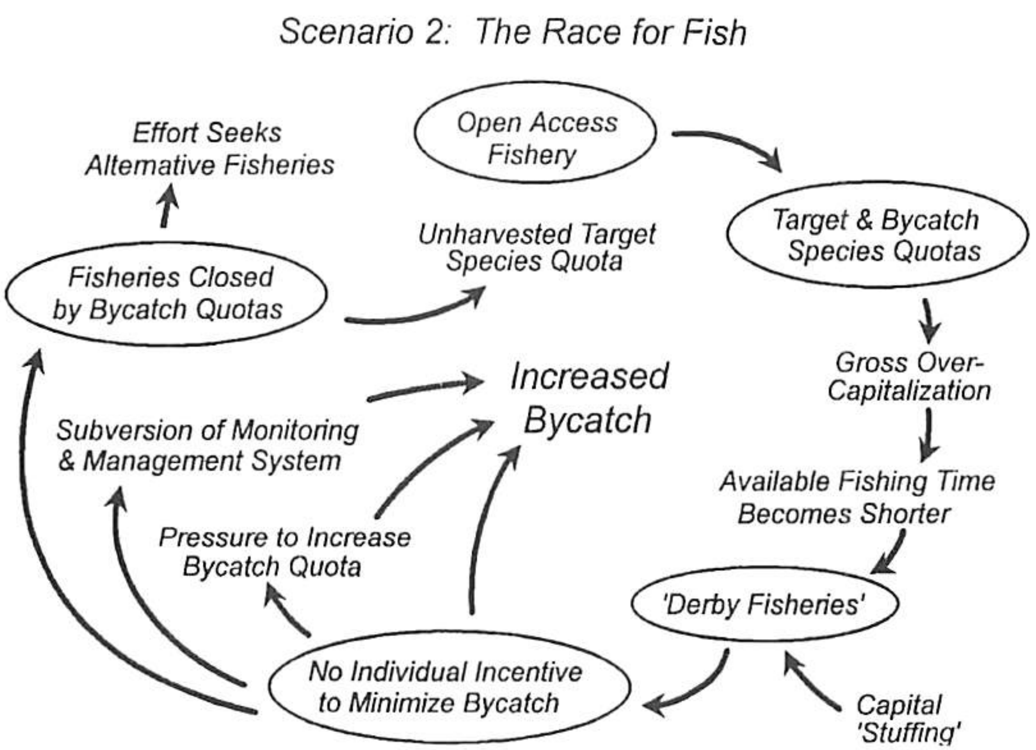

Figure 5. Fishery and regulatory factors contributing to increased bycatch in open-access fisheries controlled by quotas on the target and bycatch species.

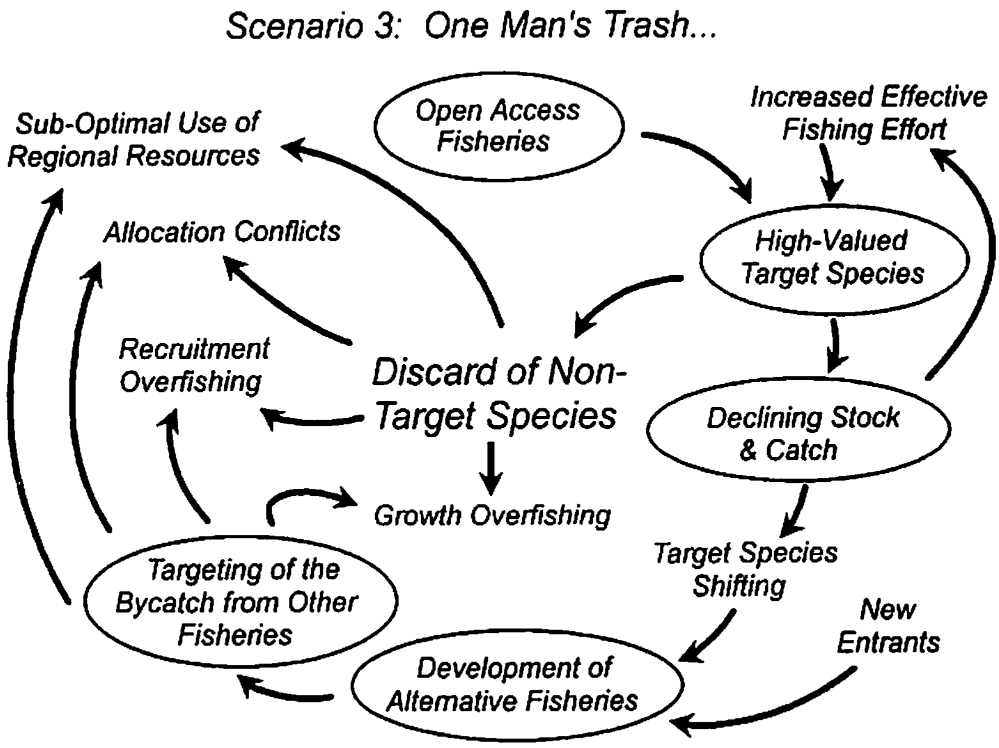

Figure 6. Fishery and regulatory factors contributing to discard of nontarget species as fishery diversity and complexity increase. Resulting management and biological consequences include suboptimal use of mixed-species fishery resources, increased allocation conflicts, and greater potential for overfishing.

Strategies to Reduce the Incidental Capture of Marine Mammals and Other Species in Fisheries

MARTÍN A. HALL
Inter-American Tropical Tuna Commission

Abstract: *Catching unwanted species or individuals has been a cause of inconvenience, loss of income, and even danger to fishermen for thousands of years. However, increases in human population, industrialization of many fisheries, full utilization or overexploitation of most marine living resources, and a growing awareness of the potential ecological impacts of the problem have brought the issue of bycatch to the forefront of fisheries science. A recent review (Alverson et al. 1994) gives an idea of the magnitude of the problem for different types of gear and regions. That study also shows that reliable data are scarce or nonexistent for most fisheries and that problems are apparent for those that are closely monitored. Increased data collection is needed to identify the problems, diagnose the causes, and search for solutions.*

Bycatch problems have specific characteristics for each gear type, fishery, habitat, etc., but there are some aspects that are the same for all of them. One of the objectives of this paper is to describe these basic features and the ways that solutions to bycatch problems can be sought. In addition, this paper suggests a classification of bycatch and shows how different approaches to solutions apply to different classes. Another subject of this paper will be a general characterization of the strategies that can be used to mitigate the problem of bycatch.

"Bycatches" were defined by the participants at the National Industry Bycatch Workshop held in Newport, Oregon, as "that portion of the catch returned to the sea as a result of economic, legal, or personal considerations, plus the retained catch of nontargeted species (McCaughran, 1992)." That definition is confusing because it mixes what is waste with what is an additional source of income to the fishery. The catch of nontargeted species may be desirable to the fishermen: These species may have prices similar to or higher than the target species, as would be the case if a group of swordfish were caught in a net of sardines. This bycatch may be quite beneficial economically, while throwing fish back into the ocean usually isn't, and therefore is not desirable.

A set of definitions for bycatches and discards was produced at the Oregon workshop; however, none of the schemes proposed has been accepted by the majority of authors dealing with the subject. The following set of definitions is proposed as being clearer than the previous ones.

- Capture - all that is physically retained inside the net or in any other type of gear
- Catch - the fraction of the capture that is retained, usually because it has economic value, but occasionally for legal reasons. It can be subdivided into target catch—the species that was the primary objective of the operation—and nontarget catch, which is other species
- Bycatch - the fraction of the capture that is returned to the sea dead or injured to an extent that death is the most likely outcome
- Release - the fraction of the capture that is returned to the sea alive, and in a condition such that survival is expected
- Marketable catch - the fraction of the catch that the fishermen can sell
- Reject - the fraction of the catch that is rejected by the buyers, and is discarded in or near the port
- Yield - the fraction of the marketable catch that reaches the consumers
- Processing waste - the fraction of the marketable catch lost during the elaboration, preparation, transportation, packaging, etc. of the fish

Classification of bycatches

Not all bycatch situations are equally important from the ecological point of view. The fishermen may or may not have some control on the level of bycatch. In general, most bycatch situations can be classified into some basic types, based on different criteria. Bycatch may be classified:

a) According to the spatial pattern of the bycatches (concentrated or diffuse): Some bycatches occur in well-defined areas of a fishery—examples include most migratory species and species with small ranges; others occur throughout the fishing grounds

b) According to the temporal stratification of the bycatches (seasonal or continuous): The bycatch can be seasonal, as during migration or nesting seasons, or it can occur year-round, among species that are continuously present in the fishery

c) According to the level of impact, which creates the following subclassifications:

• Critical bycatches - those affecting a species in danger of extinction

• Nonsustainable bycatches - those that cause a decline in the abundance of a species, and if continued over time, could lead to the endangerment of the species, although there is no imminent threat of extinction

• Sustainable bycatches - those that a population can sustain without declining in abundance

• Biologically insignificant bycatches - sustainable bycatches whose magnitude is such that they practically have no impact on abundance

• Ecosystem-level impacts - bycatches that affect a large variety of species in an ecosystem, rather than a main species or group of species

• Charismatic bycatches - bycatches of species that are especially valued by a society because of religion, superstition, or the attribution of a human-like moral standing. The response of the public to these bycatches is frequently disproportionate to the biological impact

d) According to the frequency of occurrence (rare or common)

e) According to the level of control fishermen have (controllable or uncontrollable): There are many different levels of control. The bycatch level in more passive gear, such as gill nets or longlines, can be controlled, at least in part, by the configuration of the gear and location and form of deployment. Trawl hauls can be aborted under certain circumstances, thus reducing the bycatch. But there is a continuum of control levels, and the degree of control of the bycatch in a fishery will indicate whether training programs for fishermen can be effective.

f) According to the degree of predictability (predictable or unpredictable): Bycatches, such as those of rare species, tend to be unpredictable because our databases are insufficient to describe their distribution in a quantitative way. Species with highly variable recruitment may show up in the bycatches at very different levels in different years. Or the behavior or ecology of a species may be modified by some external factors, for example, flooding, or El Niño.

g) According to the ecological origin of the bycatch (associated species or random encounters): The species that constitute the bycatch of a fishery may be caught because they are associated in some way with the target species. Or there may be a "chance" bycatch of individuals that happened to be in the area enclosed by the net or that wandered into the net during its deployment. This is possibly the most important classification, because the presence or absence of an ecological link may suggest different ways of dealing with the problem.

Some basic strategies to mitigate bycatch problems

Given that the total bycatch is the product of the total effort times the average bycatch per unit of effort (BPUE), there are two ways to mitigate bycatch problems—reduce effort or reduce the BPUE.

Reducing effort results in negative impacts on the fisheries, unless a type of gear is replaced by a more benign one. Reducing BPUE is a more desirable solution: It allows the continuation of the fishing activity while reducing the negative impacts. It can be achieved through technology, education, regulation, etc. Observer programs are very important for identifying the causes of incidental mortality, and this information makes it possible to develop the research and education programs needed to mitigate the problem.

There are several lines of defense to reduce BPUE:

A) Actions to reduce incidental captures

First line of defense - Decisions by fishermen or regulations concerning gear, areas, and seasons: Before deploying the net or other type of gear, fishermen make many decisions that may affect the bycatch. They may choose to avoid some areas or seasons with high bycatch rates; they may modify or change the type of fishing gear used to reduce the incidental captures of nontarget species. Alternatively, regulations may be passed making some of those choices mandatory, or banning some gears, areas, etc.

Second line - Decisions by fishermen or regulations concerning deployment conditions: When the gear is being deployed, another set of choices (or regulations) can come into play. The time of day, the duration of the deployment, the fishing depth, the position with respect to currents or other oceanographic or topographic features, are all factors that may affect bycatches.

B) Actions to increase the release of bycatch

Third line - Release from the net (procedures and equipment): In the eastern Pacific, a procedure called backdown is used to get dolphins out of nets. In the western North Atlantic, techniques have been developed to release whales caught in gill nets. The Turtle Excluder Devices release sea turtles from inside trawls.

Fourth Line - Release from the deck (procedures and equipment): It may be possible to change some of the conditions prevailing on deck, such as shade, temperature, or running water, to reduce the negative effects of the capture on survival, or to develop equipment to facilitate the handling of the animals, reducing injuries or traumas.

C) Actions to turn the bycatch into catch

Fifth Line - Utilization: Once an individual caught incidentally is dead, it can either be returned to the sea or utilized. From the ecological point of view, utilization may be wiser in some cases. Given that the ecological costs of fishing have already been incurred—fuel consumption, pollution, bycatches, damage to the habitat, etc.—the protein or any other product extracted from the bycatch may replace other alternative sources of the same product and reduce the ecological impact of the other exploitation.

Conclusions

The strategies to mitigate bycatch problems are determined by the statistically simple nature of those problems. With only two "levers" available, the solutions will have to be sought in one of them. The options available are quite diverse, and further technological and scientific developments will add more. Scientists must work to identify the factors that cause high bycatches, such as environmental conditions, including currents and turbidity; gear characteristics and "behavior;" and behavior and ecology of the species involved. This knowledge must be transferred to the fishermen to improve their decision-making processes.

The lines of defense identified here provide a wide range of possibilities for mitigating bycatch problems. Bycatches result from a combination of environmental, biological, ecological, and gear factors. It is vital to identify them, and to assess their relative importance if measures needed to mitigate the problems are to be undertaken.

> ***"Bycatches" were defined...as "that portion of the catch returned to the sea as a result of economic, legal, or personal considerations, plus the retained catch of nontargeted species."***

Bane or Boon: Taste, Finances, and Anthropomorphizing Affect Beliefs About Bycatch

MADELEINE HALL-ARBER
MIT Sea Grant College Program

Abstract: *Bycatch and discards occur in a wide variety of fisheries around the world and can be particularly problematic in overfished areas. While recent technology and innovative gear designs have eliminated bycatch in some fisheries, not all participants in the fishing industry view the elimination of bycatch as a necessary or desirable goal. This paper will look at the effects of sociocultural and socioeconomic factors on fishing industry participants' and outsiders' views on bycatch. It will be suggested that food traditions, dependency on the sea, economic position, and the "cuddle factor" each play a role in defining bycatch attitudes.*

Here in the Northeast, fishermen are facing management of bycatch with a great deal of trepidation. The problem with fisheries here is that they are much too well integrated. The cod and haddock apparently *like to* swim together, not to mention the pollock, whiting, hake, various flounders, etc. In fact, all of the 10 species managed by the Multispecies Management Plan mingle near the bottom.

When the stocks were in good shape, bycatch was not viewed as a problem. In fact, the bycatch was called "shack," and many captains let their crew members sell the shack and divide up the proceeds separately from the targeted species, so it served as a kind of bonus (no boat share or other costs were taken out). This was possible because there was enough of a catch of targeted species to cover expenses and make a reasonable profit. Bycatch then was a boon to the crew.

Even during that period of decent catches, however, bycatch was not all bonus. With each load, plenty of unmarketable fish came up—bycatch that was discarded. Some of this bycatch consisted of species that were unappealing or unknown to the American palate. Efforts to export fish were limited to a relatively few entrepreneurs; most fishermen were doing fine with the familiar groundfish. At the same time, mesh sizes were still relatively small, so escapement of juveniles was limited and discards high. With hindsight, most people involved in the fishing industry recognize that the ramifications are being felt now of the biological costs to the resource and the economic benefit forgone by our formerly cavalier attitude towards bycatch and discards.

Attitude is a key

Attitude and culture are keys to understanding motivation in both fishing and management decisions. Every culture has a structure or pattern that sets boundaries and expectations for the individuals born into that culture. Consequently, every human being starts life already inextricably bound to others with particular beliefs, values, symbols, social organization and institutions, artifacts, and cultural resources.

Some central aspects of culture that are considered by anthropologists are time orientation, man-nature orientation, and status-power orientation. Each of these affects behavior. For example, Americans historically have looked with pleasant anticipation towards the future (1). We like to move forward at a fast pace. The future will be bigger, brighter, and better. On the other hand, as Margaret Mead pointed out, our tendency is to think only about the immediate future, not really very far ahead. Coupled with this immediate-future orientation is a belief that we can gain mastery over nature.

In contrast, some cultures venerate the past and emphasize harmony with nature. The Wampanoag, for example, believe that for everything taken out of the earth, something must go back (2). While they venerate their ancestors, when they talk of the future, they talk of preserving the resources of the earth for seven generations to come. They also impart a sense of personal responsibility to the members of their culture, so that each individual shares the responsibility of maintaining the earth. (Until the Europeans came, the Wampanoag held their resources in common, having no concept of private property.)

Americans' immediate-future orientation and mastery-over-nature belief may have contributed to the fishing industry's ignoring the potentially negative impacts of high bycatch and discards. Furthermore, even if or when scientists indicated that overfishing was occurring or that bycatch and discards were too high, they may have been ignored due to another cultural attribute of Americans, our status-power orientation. Americans are committed to shared decision making. We've long been exceedingly proud of our democracy. But a corollary of that pride is that we don't necessarily equate authority with validity (3). So, just because an authoritative source, such as a National Marine Fisheries Service scientist, says it is so, not everyone will believe it is so.

Food preferences play a role in what is regarded as marketable bycatch and what can only be discarded. Certain foods are readily recognized as characteristic of particular cultures, or even nations: Think, for example, of sushi and sake; calamari and Chianti; or shillerlocken and beer. Nevertheless, it is important to point out that culture is not static. Change is a part of the human condition, and culture affects how change is induced, perceived, and adapted to. Orientations can shift over time, and, after all, even tastes change, or people find out that what they thought was trash was actually someone else's treasure.

Fish and other sea critters that many people used to turn up their noses at are now considered delicacies among the gourmets of the world. For example, although they can be poisonous and they manufacture iron and jewels in their body, sea cucumbers are a favorite with the Chinese (4). A few years ago, who would have thought that sea urchins would number among Maine's highest valued seafood products? The roe evidently has a caviar-like appearance and a bittersweet flavor. More importantly, it can sell for over $50 per pound in Tokyo (5). (It also is popular in Europe and Greece.)

Change in the catch and in management

Whereas marketable bycatch was once a boon for the crew members of fishing vessels, now every bit of income is needed to pay for the trip expenses and to derive a modicum of profit. In addition, because of lower stock levels, trawlers' tows are much longer and cover a much wider stretch of bottom, so while there may be a lower quantity, there's more variety in the species taken in each tow. The differences between targeted species and bycatch have diminished.

Consequently, anxiety over recent trends in fisheries management is growing. In the emergency action that was taken by NMFS under advice from the New England Fishery Management Council, vessels are prohibited from fishing in portions of the Gulf of Maine, Georges Bank, and southern New England except under a days-at-sea allocation or in a fishery that has less than a 5 percent discard of cod, haddock, or yellowtail flounder. Furthermore, regulated groundfish cannot be retained.

There's a major problem with the implementation of this regulation, however. While recent technology and innovative gear designs have eliminated bycatch in some fisheries, official bycatch or discard data is not available for most fisheries. What that means is that the fishermen can't go into these fertile fishing grounds to chase those previously underutilized, underappreciated, or alternate species they're encouraged to harvest to supply the market of the different cultures mentioned before. The problem is that there is no way to prove they won't catch—and be forced to discard—more than 5 percent of cod, haddock, or yellowtail.

The purpose of setting bycatch limits, of course, is to discourage fishermen from targeting regulated species on the sly while claiming they are targeting something else. But, as already noted, fish swim together, and unless there is a camera on the net or hook, it is only when the gear is retrieved that the catch is revealed.

The forced discard of bycatch—whether because it is a regulated species or because it does not meet minimum size requirements, and whether imposed by market or by management—is a controversial issue. Any fish with a bladder is likely to be dead once it reaches a vessel's deck. Shoveling these fish overboard, at best, returns some nutrients to the ecosystem, but may also sour the bottom if a large enough quantity goes over in one spot. There's also an immeasurable emotional cost to fishermen, which can be surmised from the despair with which some speak of opening a net to find large numbers of juveniles or regulated species that then have to be discarded.

Some fishermen have suggested that a more appropriate way to deal with bycatch is to allow the fishermen to bring in their bycatch and donate the regulated species to Second Harvest or other charities. Other fishermen have suggested that a focus on specific species is precisely the problem with the stocks. (The first management regulation imposed was in 1639 when the Massachusetts Bay Colony ruled that neither cod nor stripped bass could be used as fertilizer.) Because the U.S. market has long favored cod, haddock, and yellowtail, fishermen have filled their holds with only the desirable species and have dumped the rest, causing a skewing of the resource complex over time.

A side effect of the discarding of undesirable species is thought to be an increase in the numbers of dogfish and skates. Because they do not have bladders, these species are able to survive a visit to a fishing vessel deck. The acknowledged shift in the biomass is a matter of concern to fishermen, since dogfish and skates are predators of juvenile finfish, are not widely marketable, and can damage nets. To try to break this cycle, some fishermen suggest that discards should be prohibited, that fishermen should just bring in everything. This way, their fishing trips would be shorter, would use less fuel and lower other expenses, and the catch would be a more natural mix.

Out of the Northeast

Not all participants in the world's fishing industries view the elimination of bycatch as a necessary or desirable goal. Cultural and economic factors affect fishing industry participants' and outside observers' views on bycatch.

In their technical report for the United Nations' Food and Agriculture Organization (FAO), Dayton L. Alverson, Mark H. Freeberg, Steven A. Murawski, and J.G. Pope found that the views about bycatch and discards "may vary sharply between countries as the result of sociocultural differences, their dependence on marine resources as a source of protein for their population, religious beliefs, and historical customs (6)."

For example, they point out, shrimp fishermen of Indonesia who are wholly dependent on shrimp for their income regard our embargo on their shrimp due to turtle discards as unfair and totalitarian. However, to U.S. environmental groups, which regard sea turtles as endangered, it is a necessary and appropriate action. Regardless of other cultural differences, shrimp fishermen in the Gulf of Mexico would probably sympathize with the Indonesian fishermen.

By 1989 federal regulations required the use of Turtle Excluder Devices (TEDs) on offshore shrimp trawlers (7). There is sharp disagreement between policy-makers and shrimpers about the effect of TEDs on shrimp yields. Fishermen claim that, under normal working conditions, the TEDs become jammed with debris and bycatch, causing shrimp to be deflected out of the net. Losses are estimated at 33.8 percent on average. NMFS observers on TED-equipped vessels reported highly variable losses ranging from 5 percent to 45 percent by pound, but in the data published with the regulations, NMFS suggested that losses were only 4 percent. There is also strong disagreement on the universal need for TEDs. Fishermen claim that turtle encounters are much rarer in the Gulf than in the South Atlantic (3.1 captures per 1,000 hours of trawling in the Gulf compared to 45. 6 captures in the South Atlantic).

In Bayou La Batre, 27 of the 69 vessels surveyed in 1990 by researchers Mark Moberg and Christopher Dyer were no longer fishing in 1992. Though competition with imported shrimp from Asian aquaculture operations certainly contributed to the loss of their economic viability, the researchers suggest that TEDs were a major contributing factor.

Environmentalists in the Gulf region are also criticizing shrimping operations for their bycatch of finfish. Meanwhile, in other parts of the world, shrimp fishermen specifically request the development of shrimp trawls that also take finfish, because of added potential sales. Environmentalists in the Gulf claim that too many juveniles are taken in the trawls, but shrimpers talk about the large numbers of recreational fishing boats that follow them around because the discarded bycatch attracts species that the recreational boats target (8). Anglers traveling to the coastal regions of Texas spend more than $350 million per year on food, lodging, transportation, and equipment such as rods, reels, and bait containers. With the multiplier effect, the economic impact to the state is worth $838 million, not counting wages, salaries, and taxes (9).

This digression from the cultural realm to the economic emphasizes that the two are related. Economic impacts affect whether or not an innovation will be accepted. Contrary to some environmentalists' claims that the shrimpers are simply stubborn and unwilling to change, researchers have found them extremely innovative. Long before TEDs became mandatory, many shrimpers tried to modify the devices so that they would work in less-than-ideal conditions. Fishermen only resist innovations they believe impair their livelihoods (10). This became clear in the Northeast with the introduction of the Nordmore grate. As shrimp fishermen found that it worked as intended—keeping juvenile finfish out while retaining shrimp—they stopped resistance to it. Now, many are pleased about having a "clean" catch, believing they're saving time and fuel.

Another Success in the Northeast

In most of the United States, marine mammals' intelligence, social organization, communication, and presumed "innocence" have broad appeal (11). Whales, for example, are said to have been ascribed a "uniquely special" status: Western cultures segregate biological life into three bundles: human, whales, and all other biological life. This is not true, however, in every society. Whales are hunted for meat in Peru, Chile, Sri Lanka, Greenland, and even among certain Native American populations in the United States (12). Marine mammals are also regarded as competitors for scarce resources by many fishermen in Canada, in the North Pacific, and here in the Northeast.

Nevertheless, the Marine Mammal Protection Act requires efforts to reduce the bycatch of marine mammals. The groundfish sink gill net fishery faces time-area closures to reduce bycatch of harbor porpoises—a development that could create havoc with gillnetters' ability to make a living. Fortunately, they have been working closely with a biologist who came up with pingers to warn off the harbor porpoise. The results of a well-designed scientific experiment look extremely promising and will be discussed later in this conference.

Another related topic is porpoise-free tuna catching. Methods to reduce the catch of porpoise have been remarkably successful. The next challenge in that fishery appears to be a reduction in the catch of juvenile tuna, as well as sharks, turtles, etc.

Conclusion

Time constraints prevent going into detail about topics introduced here. For instance, one of the interesting aspects of fisheries in the Northeast is that they are propagated by some quite distinctive ethnic groups within the American population. A consideration of culture and its effect on fishing behavior would surely provide insights that could lead to improved communication among scientists, managers, and fishermen on all topics, including bycatch and discards. But, keep in mind that cultures are constantly changing and adapting.

With modernization has come an assumption that there is always a technological fix. Unfortunately, the unintentional impacts of technological fixes are evident among the bankrupt shrimpers of Alabama and the numbers of juvenile tuna swept up in the nets, albeit without porpoises.

Alverson et al. found that cultures with a high degree of dependency on seafood as a protein source for their population tend to be less wasteful in their bycatch management: Bycatch is utilized (13). Lest that concern you when you contrast your culture's food preferences with the sea robins, sculpins, and other unusual looking creatures that are part of the bycatch mix, remember, it was not so long ago that lobsters were used as fertilizer and as bait for cod and striped bass—selling in colonial days for a penny each.

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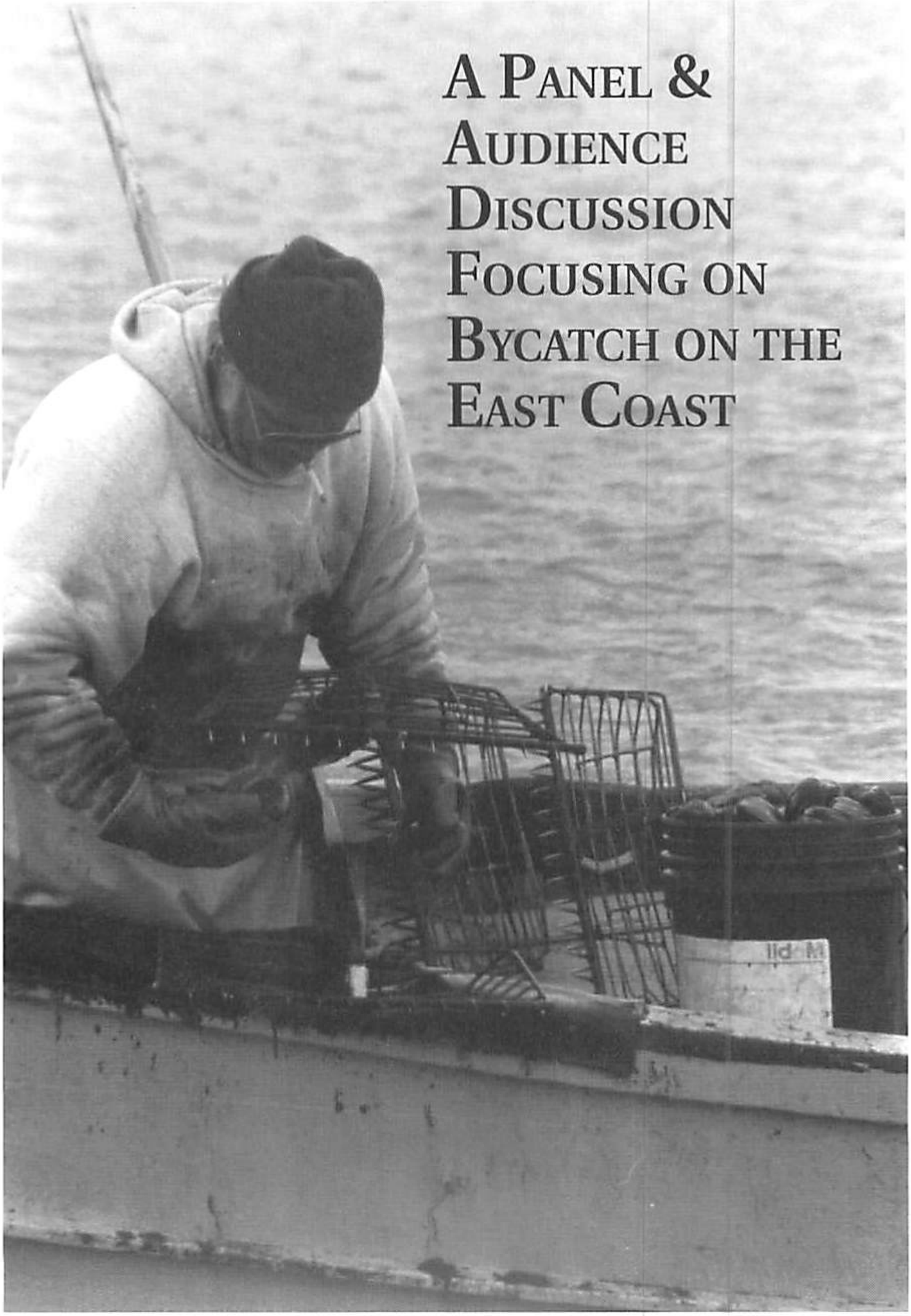
A Panel & Audience Discussion Focusing on Bycatch on the East Coast



Is Bycatch a Problem on the East Coast?

A Moderated Panel

Moderator
Patrick Field, The Consensus Building Institute, Inc.

Fishing Industry Representatives -Ted Ames, executive director, Maine Gillnetters Association; Fred Mattera, *Travis and Natalie*, Inc.; Nelson Beideman, executive director, Blue Water Fishermen's Association

Conservation Representatives - Gerald Leape, Greenpeace; Suzanne Iudicello, vice president for programs, Center for Marine Conservation; Eleanor Dorsey, marine biologist, Conservation Law Foundation

Management Representatives - Phil Haring, New England Fishery Management Council; Rich Seagraves, fishery management specialist, Mid-Atlantic Fishery Management Council; Andy Kemmerer, regional director, NMFS, Southeast Regional Office

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Field: Traditionally, when things get tight, people often take positions and hunker down. People often get stuck in what we call the iron-clad triangle—industry in one corner, regulators in another corner, and environmentalists in the third corner. It's hard to listen, and it's hard to talk to each other. Everyone feels stuck and frustrated.

This conference provides an opportunity to engage in constructive dialogue. We can be frank about our differences and look for common solutions. If that can be done—and it definitely can be done—we get something called a consensus-building circle, where people actually sit down at the table together and have a frank, honest, and constructive dialogue. They can hash things out in a frank and respectful way and listen for common-ground issues. This opens the way to figuring out what the problem is, determining what is getting in the way of solving the problem, and then deciding what can be done to solve the problem.

With that in mind, I'll start out by asking each group a question or two, and then after the groups get a chance to speak their minds I'll open up the discussion to questions from other groups and from the audience as well.

The first thing I want to do is this: Nelson (Beideman) put out an interesting definition of bycatch and I would like him to relay that to you.

Beideman: Simply, the problem and definition of bycatch is three words: wasted dead fish. In the highly migratory pelagic fishery a majority of commercial fishermen look at bycatch as wasted dead fish. That is a little different than what everyone has been talking about as far as target versus nontarget species, but that is what I really believe bycatch is.

Field: With that as the starting point—wasted dead fish—the question I am going to pose to each of the three groups is: Is bycatch on the East Coast a problem. If it is a problem, what exactly is the problem and what is the scope of the problem? Let's start with the environmental group—although I want to note that categorizing by group is not a good idea, as everyone has a similar interest in the resource. We are all stewards of the resource.

Kemmerer: There are two other groups that are not represented here, one being recreational fishermen, who have uniquely different concerns; and the other being the public, who are stewards of the resource as well. We are missing two very central elements to the picture.

Nature of the problem

Field: I want to note before we start that we put the fishermen in the middle because they feel the squeeze from both sides.

Now back to the question. Is bycatch a problem on the East Coast?

Dorsey: My organization is an environmental group involved with New England issues, and I've been involved with bycatch issues as they pertain to New England groundfish fisheries. We have been focusing on the biggest fishery management issue in New England, that is the directed fishery on groundfish and the depletion of stocks of cod, haddock, and yellowtail flounder.

Bycatch is part of the overfishing problem. The type of bycatch that is the biggest problem is the discard of juvenile groundfish in the otter trawl fishery for groundfish. Large mesh size is going to go a long way to alleviate the problem. There are some instances where large mesh may not stop the harvest of juveniles of certain year classes. Therefore, the only way to stop massive slaughter of a year class is to close areas where those fish congregate. This has been something that the (New England Fishery) Management Council has been trying to do but has not succeeded, so there is a regulatory problem. Another problem is the capture of juveniles in the small-mesh fishery. The Nordmore grate is a nice example of technology used to solve that problem. A third bycatch problem is the capture of harbor porpoise in sink gill nets. This is a case where a low bycatch rate causes a large biological problem. Also, the same gill nets that have a big problem with porpoise bycatch easily have the least problem with bycatch of juvenile groundfish of the three main gear types that catch groundfish. I am very encouraged by the results of the pinger experiments. There is one more bycatch issue that I have not heard anyone refer to, and that is the bycatch of rocks. In some areas, mobile fishing gear—otter trawls and scallop dredges—catch rocks, and gradually over time the bottom relief gets flattened out, to the detriment of other fisheries. Gillnetters and longliners target rocky areas where fish gather. Another issue is that the mobile gear scrapes off attached organisms, such as anemones, sponges, tube worms. Juvenile groundfish take shelter in, and in some cases, adults use, these organisms for food. Therefore habitat destruction by mobile gear is another issue that, even though it is not the topic being discussed here, needs not to be overlooked.

Haring: From the point of view of the groundfish, bycatch is a problem because of the ubiquitous nature of groundfish. They are everywhere. Groundfish are caught in all fishing activities as either target or nontarget species. The mobile gear that is being used to target groundfish is not selective. A trawler can't fish for a certain species or a certain size fish because the fish all live together. Stocks are so low that the total allowable catch (TAC) on cod, haddock, and yellowtail founder is extremely low. Therefore the TAC would be exceeded by the incidental takes of these species in fisheries other than those directed specifically towards groundfish: scallop dredge, squid vessels, monkfish draggers, etc. The problem is so severe that the fishing industry is going to change drastically in the next two years. Total allowable catch needs to be reduced by 80 to 85 percent from 1993 levels. The council has implemented emergency actions already this year. Amendment 5 went into effect a year ago and was supposed to alleviate the overfishing problem by reducing the fishing mortality rate by 50 percent. By the time the plan was implemented, it was too little too late; stocks were continuing to decline.

Now the council is working on Amendment 7 to the groundfish management plan. That amendment will reduce the fishing mortality rate to levels approaching zero, particularly on yellowtail flounder and haddock. The reason zero mortality cannot be achieved is because it would affect other high-value fisheries—scallop dredges, for example—that have groundfish as a bycatch. Implementing zero morality on stocks such as yellowtail flounder would in effect close down the $15 million scallop fishery that doesn't even target or want yellowtail.

Field: Because regulations on directed groundfish fisheries affect other fisheries that have incidental takes of groundfish, how are fishermen communicating amongst themselves and among fisheries on how to deal with the problem of overfishing, since the regulations are going to affect everyone?

Ames: They aren't.

Mattera: I haven't participated in groundfishing for the past few years. The last time, I pair-trawled for cod, a very selective fishery that was too efficient. I caught hundreds of thousands of pounds of cod, of which I didn't see 100 pounds of undersize bycatch. But now we have no more pair-trawling for cod. Bycatch is not wasted dead fish; overregulated fish alive and kicking on deck is bycatch. You (regulators) need to shut it down completely. It's unfair to allow one fishery, such as scallops, an incidental take of a regulated species while not allowing a directed fishery any takes of a regulated species. Shut the fishery down completely and then give me guidelines I can work with, live with, and survive with.

Field: I would like to expand this discussion and touch on other areas besides New England. I understand there is a red snapper problem in the Gulf of Mexico?

Kemmerer: Red snapper is a very popular recreational fish as well as a very valuable commercial fish. Not only has the stock size been affected by overfishing, but there is a very high level of bycatch of age 0 and age 1 fish in shrimp trawls. Snapper are mainly a reef fish; however, when they are small they live on the sand/mud bottom with brown shrimp. The young snapper is often as small as or smaller than the shrimp, making grates ineffective. They are also hard to get out of the net. They like to aggregate on structures, so they don't leave the net, once inside. Most of the fishing mortality on snapper is due to bycatch in the shrimping industry. The goal of 20 percent spawning stock biomass is not attainable unless the bycatch in shrimp trawls is controlled. Even if all directed fisheries on snapper are closed, 20 percent SSB cannot be achieved.

Shrimpers don't even see the fish. Young fish are up to 4 inches long, and only two to four are captured per trawl hour. Taken all together with the high fishing effort on shrimp, there are 36 million small fish taken annually. That is a difficult point to get across to industry.

Interestingly, The Fisheries Service and industry have come together to develop the TED. And now we are coming together to solve this bycatch problem. And solve it we will! It is an interesting problem in that we are dealing with a fish that does not want to leave the net.

Overregulated fish alive and kicking on deck is bycatch.

Ames: I have been fishing for quite a few years. In my lifetime groundfish have been wiped out three times in the Gulf of Maine—in the 1950s, in 1965 to 1970 by the foreign fleets, and now by ourselves. The mechanism is the same every time: Vessels designed to harvest millions of pounds of fish are fishing with small-mesh gear in a restricted area. We have eliminated part of the problem already; we have 6-inch mesh, we have the Nordmore grate. Stocks are coming back. The fishing community supports efforts to eliminate the problem. The key is to plug into the community to hear what is being said.

Seagraves: The bycatch problem has been made worse by poor management, or in some cases, lack of management. The first thing that has to be done is to solve the overcapitalization problem. Mid-Atlantic stocks are in fairly good shape, but there is a rising concern that displaced fishermen will come into the area, causing a strain on the stocks.

Kemmerer (to Ames): Where is the incentive to reduce the bycatch of one species that is not a targeted species in the fishery?

Ames: Fishermen are going through a learning curve as well as everyone else. Maine has competing fisheries. Maine is trying to implement an apprentice program that will require all starting fishermen to learn their responsibility to the environment and the effect their fishery has on other fisheries.

Dorsey: It is a big problem to get fishermen involved when they don't see a monetary incentive. Many Gulf of Maine fishermen were opposed to the Nordmore grate because it eliminated the take of adult groundfish, species they could sell. That is a real problem.

Beideman: Education is needed. Not all fishermen understand the concept behind maximum sustainable yield. Education goes a long way in helping fishermen understand. When regulators tell fishermen that their fishery is going to be shut down because of bycatch, that is very difficult for a fisherman to understand. If fishermen are educated about the issues, they become involved. They want to be involved. Fishermen work for the American public. If the American public didn't want fresh seafood, we wouldn't be here today.

Habitat and management

Field: Now that we have the problem laid out, I would like to take 5 or 10 minutes to take audience questions.

Comment: The public does not look at bycatch as wasted dead fish. The public views bycatch as a violation of a public trust. As an example, look at the high seas drift net. It was a multimillion-dollar fishery that, because of public dissent, was shut down. We have to be careful because we as fishermen are a very small minority.

Comment: Bycatch is not the problem. Bycatch mortality is the problem. The public and press need to be educated. In Louisiana there is a campaign to ban the nets. Recently a bottlenose dolphin was captured in a gill net and photographed. Until then no one had ever seen a dolphin in a net. Now, that picture is showing up in every newspaper and magazine, and the public perception is that all gill nets entangle and kill dolphins.

Question: I would like an innovative answer to the question, What is the relative size of the bycatch problem compared to habitat destruction?

Kemmerer: We know how to measure the impact of bycatch as it relates to stock size; we can put observers on the boats and count the fish. But we don't know how to measure the impact of habitat destruction, and that is a real problem.

Haring: No one is denying that reversing habitat destruction is part of the solution. The short-term problems are that it's hard to make the connections between habitat degradation and production of the resource.

Also, what can be done about habitat degradation? Is controlling pollution enough? Is restricting development along the shoreline enough? What needs to be done to control the complex ecosystem? Trying to manage all of these variables is extremely complex.

Seagraves: The Mid-Atlantic council has a habitat policy, but what does that mean? It's very easy to point the finger at habitat destruction, but how well have laws like the Clean Water Act and Coastal Zone Management Act worked?

Iudicello: We really do a disservice by trying to create a hierarchy that says, "We don't want to deal with bycatch because it really has to do with something else, like changes in the weather, or there is really something else going on and it's not me."

The Clean Water Act was designed to clean up rivers and estuaries. But 25 years after its passage, 75 percent of all shellfish beds are still closed due to pollution. What are we doing about it? Most conservation groups don't deal with fisheries issues, but they work on other habitat degradation issues. They go after industrial polluters, foresters, coastal developers, and others that cause loss of fisheries habitat by degrading rivers, estuaries, and coastal habitats. Conservationists work for habitat renewal.

Leape: Conservationists need help from fishermen. Congress is trying to weaken the Clean Water Act. We have many ongoing campaigns trying to clean up the environment, but we need your help.

Field: Here is a potential bridge that fishermen and environmentalists can come together on, working to improve the habitat.

Question: Will fisheries be managed by the "lowest common denominator" in mixed species fisheries? That is to say, will fisheries be managed by the species that takes the longest to rebuild?

Iudicello: There are fisheries where that is already happening. The salmon fishery in Alaska is managed by weakfish management. Alaska also manages bycatch quota—when the bycatch quota is met, then the directed fishery is shut down.

Dorsey: There may be a solution to the bycatch problem for cod and haddock. Trawls can be modified to catch cod and let the haddock go.

Ames: The 6-inch mesh does fish by the lowest common denominator. It catches fish that are around 22 inches and lets the smaller ones go.

Mattera: It is impossible not to catch any of a regulated species. Some juveniles will always be captured.

Ames: Six-inch mesh and closed areas are beginning to work. Browns Bank has had a good year-class of haddock. But it will take a few years.

Haring: The driving stock in southern New England is yellowtail. At an exploitation rate of 20 percent, which is as close to zero as can be achieved reasonably, that's equal to 130,000 pounds. That's two orders of magnitude below what that stock needs to support itself. Anyone catching yellowtail as a bycatch will take away from that very small total allowable catch.

Trust, cooperation, education

Field: I want to change the focus a little bit and pose the questions, What are some of the resources that you can bring to the table to help work together with the people who are solving the problem? What do you need to do, and what do you think other people need to do to tackle some of the issues and to work together to come up with some practical solutions? Starting with the conservationists. . .

Leape: There are a number of things that can be done. First of all, the environmental community can participate in the education network. We can also help to try to bring people together. That's why Greenpeace has decided to put people in fishing communities, because that is where the answers will come from, not from Washington. Give financial incentives to fishermen who fish cleaner and root out the dirty fishermen.

Don't look at us as a threat. We want to work with you. We have the same goals and objectives. None of us are against fishing. We want to work with you.

Iudicello: Fishermen need to have personal knowledge and trust not only of environmental organizations but also of individuals within these organizations. Very few of you know who I am, know anything about me or my personal experiences. I have heard a lot of assumptions about who we are and where we are coming from and what our positions are. All I'm asking for is the opportunity to participate in and listen to these discussions. We need to get rid of the labels—environmentalists, industry, regulators—break the triangle, and work together.

One of the things environmental groups can bring to the table is information about what works in terms of leadership, communication, and bridge-building with people. We tend as advocates to be good communicators, and we can work with you or against you. We can bring a lot in terms of raising public awareness, working with you to shape issues and images, and working with policy makers.

Dorsey: One more role that environmentalists can play is the role of intermediary between fishermen and scientists. Often there are times when fishermen don't understand what scientists are saying in the literature, and we can bridge that gap.

Seagraves: We need consistent funding for sea sampling to obtain basic data for catches and bycatches for regional assessments. We need more technology and modeling to predict and improve selectivity. Also, at-sea enforcement is very costly. We need to work closely with the community so fishermen can feel like they are part of the solution, and they in turn can self-enforce a lot of the fishing activity.

Kemmerer: What we bring to the table is the capability to work with industry and the willingness to also work with the public as well as environmental and recreational groups. We have a tremendous amount of technical capability. A lot of fishermen don't realize how much our scientists want to work with them.

Haring: I see the solution to the bycatch problem as one of information and education. The conservation groups are very successful at raising money and lobbying the councils to implement management regulations. They could also inform and educate fishermen on how to reduce bycatch. Fishermen need to be educated on how to fish clean. As an example, the northwest Atlantic whiting fishery is now closed under the emergency action because of the high bycatch of regulated species. However, there are some whiting fishermen who know how to fish clean and catch only whiting. All whiting fishermen should be taught how to catch only whiting. More money is needed for observer programs. There is a lack of at-sea information, and this is a time when more information of catch and bycatch is needed.

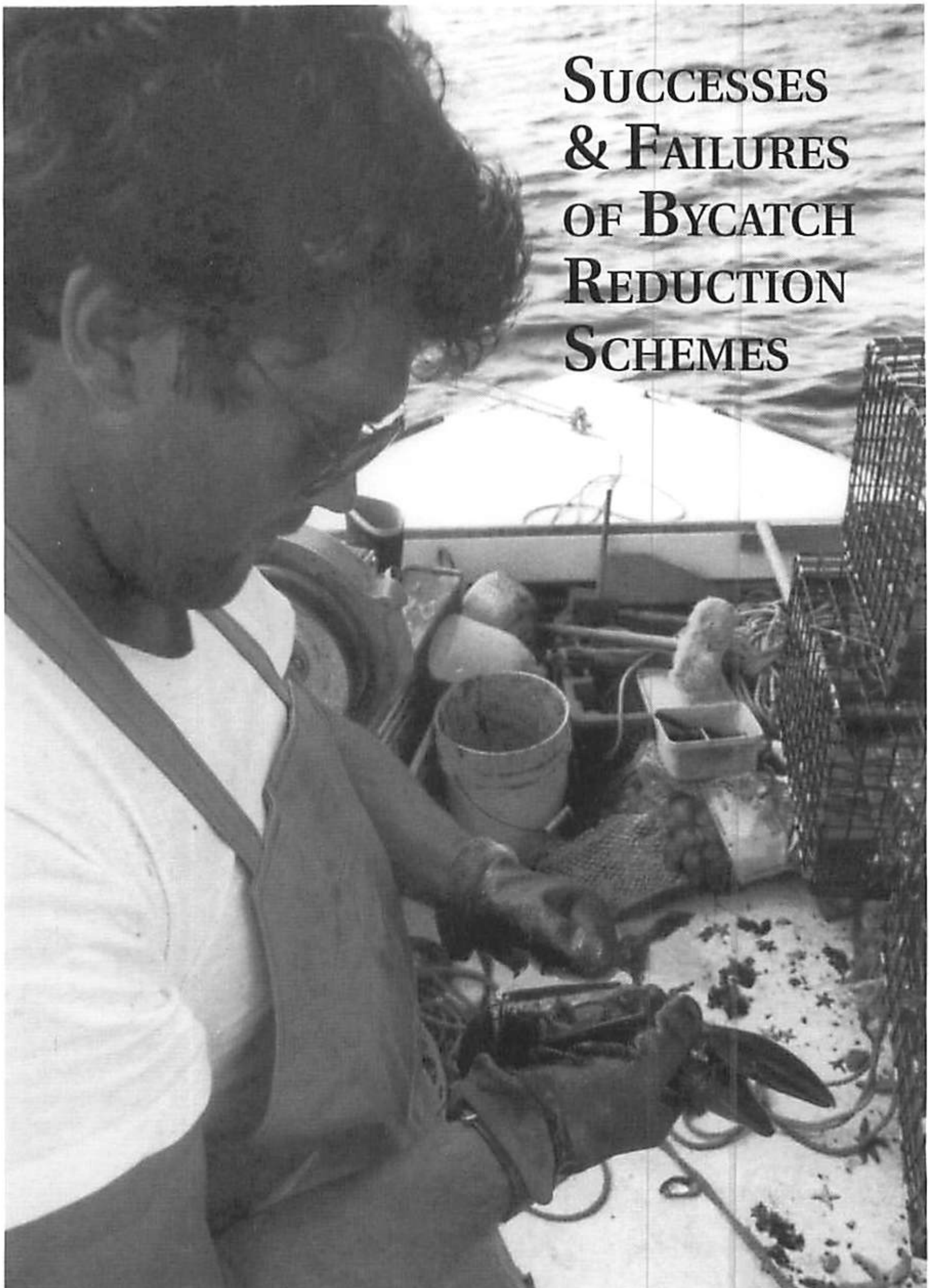
Fishermen need to be motivated to comply with regulations and to be educated as to why compliance is in their best interest and why noncompliance leads to emergency and long-term closures of fisheries.

Beideman: The solutions will come from industry. NMFS needs to be more flexible and allow fishermen to try new things, to come up with solutions. Environmental groups and regulators need to recognize the progress that fishermen have made on gear development that has reduced bycatch. More "how to" instructions need to be distributed to fishermen on ways to reduce bycatch.

Ames: Fishermen have an intimate, hands-on knowledge of our environment. Fishermen are very knowledgeable about the habitat in which we make our living. We are small businessmen. One too many regulations from management, or one lost debate to conservation, means that many industry members are going to lose their boats, their homes, and their livelihoods. We need to address issues at the local level.

Mattera: We have to create a bridge and build trust among industry, conservationists, and regulators. I encourage active participation, I encourage conservation engineering, I encourage experimental fisheries. I hope more funds become available for programs that create experimental fisheries. I would like to have conservationists come on board with us and see how we live and see how the gear works. I would like to have NMFS fund experimental fisheries and ease the regulations in order to try new, innovative techniques. At least let us try.

NMFS needs to tap the international community and use the information that is already available. It's time to end the redundant experiments. It's also time to prosecute the violators: two strikes and you're out. Get rid of the perpetual violators. It erodes the trust in NMFS by honest fishermen who see violators get away with dishonest practices.



Successes & Failures of Bycatch Reduction Schemes

Lobster Fishery

Industry-generated Success in the Lobster Fishery

Bob Smith
Rhode Island Lobstermen's Association

The lobster fishery is one that has been successful in reducing bycatch. It hasn't been easy; it's taken a long time. But this is an important issue, and it's important that people understand that most of this success has come from the industry.

Go back 100 to 120 years in the lobster fishery to see where it started. It started with minimum size, when lobsters were worth roughly 10 cents a pound. And it was biologists and fishermen together who suggested that something really should be done about the juveniles. At that time, they chose minimum size as the factor for determining juveniles, or acceptable size for harvesting. The deciding factor changed over 40 years or so. At first the measure was length of lobster, total; then it went to carapace length; then back to total length. In the final analysis, they decided on carapace length, measured from the back of the eye socket on the body of the shell to the rearmost portion of the body where the tail connects. Today's measurement is 3.25 inches.

With that decision, lo and behold! bycatch was created. It wasn't a juvenile bycatch; it wasn't a bycatch mortality; it was a bycatch returned live to the sea. Regulation requires that anything under 3.25 inches, as soon as it's measured, is returned to the sea alive. At roughly the same time, a measure was passed that all legal egg-bearing lobsters must be returned to the sea. Sometimes there would be four or five of these in each pot—not sublegal egg-bearing lobsters, which are thrown back anyway, but legal egg-bearing lobsters. All of these are released back into the sea.

As time went on, the fishing industry began to look for ways to deal with bycatch without handling it so much. Old-style lobster traps had spaces between the laths of only .75 inch to 1 inch. That didn't let the majority of sublegals out. To reduce handling of the bycatch, the industry came up with a plan to move the bottom lath up from the bottom of the trap. This would leave a gap of 1.25 to 1.75 inches from the bottom of the trap to allow sublegal lobsters to crawl out. This was an industry move. From there, lobstermen went to fishery managers to say that, since some fishermen weren't doing this, they thought there should be a regulation requiring it. The result: a regulation stating that there will be escape vents in every pot. These vents did let most sublegals out. It's amazing how quickly they find that hole and get out. Some lobstermen have gone so far as to have three or four vents in a pot so they don't have to handle the lobsters.

From there, as the industry changed from wood to wire traps, lobstermen became concerned about ghost-trap fishing. With wire traps, there was no way for adult lobsters to escape if traps were lost. So lobstermen worked for another measure, which we call the biodegradable vent. One way to create the vent is to build a wooden pin into the trap opening, which, by regulation, is 3.75 inches square. Over the course of six to nine months, borers eat the wood till the pin falls out, and the trap is rendered unfishable. Another approach is using a piece of wire that will corrode in a few months, dropping the door open and making the trap unusable. This was another measure the industry came up with to try to solve the bycatch problem.

The amount of effort in the Northeast lobster fishery by commercial fishermen is substantial. There are between 12,000 and 14,000 licensed, active fishermen between New Jersey and Maine working in boats of 16 to 50 feet in nearshore waters, and up to 100 feet in the offshore fishery. Most fishing takes place in the nearshore, between the shore and 40 to 45 miles off the coast. Then in the recreational fishery, there are roughly 20,000 fishermen licensed, among the states, with approximately 10 pots each that can be set.

> ***Biologists and fishermen together...chose minimum size as the factor for determining juveniles, or acceptable size for harvesting...[and] lo and behold! bycatch was created.***

With that much effort, 1994 was a record year, with a record catch of over 65 million pounds. Multiply that by $3, on average, to see what this fishery is worth—what it's worth because of the success of eliminating bycatch alive. There are estimates that the catch might even be double the 65 million figure.

These numbers just give you an example of what can result if you can eliminate discard of juveniles from any fisheries. The potential is substantial. And it can bring great benefit to fishermen and to those who use the product.

Lobster Fishery

The Lobster Fishery: Escape Vents and Bycatch Issues

Michael J. Fogarty
National Oceanic and Atmospheric Administration
National Marine Fisheries Service

Developments over the last several decades have markedly improved the selectivity characteristics in the trap fishery for the American lobster, *Homarus americanus*. The use of escape vents, mandated in several states since the late 1970s and throughout the U.S. fishery since 1985, have resulted in sharply reduced catch rates for sublegal-sized lobsters with presumed positive effects on the survival of lobsters below the minimum legal size. The use of escape panels, particularly when coupled with the use of time-release degradable links, has important implications for reducing mortality associated with lost gear (the 'ghost fishing' problem). Escape vents of various designs have also been employed to control bycatch rates of commercially important species, including *Cancer* crabs and black sea bass.

Escape vents reduce the retention of sublegal-size lobsters, thereby reducing the probability that they will be injured or killed in aggressive encounters within the trap, and reducing the displacement and risk of predation for sublegal-sized individuals released at the surface. Comparisons of the size composition of unvented and vented traps in a number of studies have clearly indicated the dramatic impact of vents on the catch of sublegal lobsters (J. Krouse, Maine Department of Marine Resources, personal communication; Figure 1). This effect is particularly strong in wire traps, which now dominate the fishery.

The use of escape vents has also resulted in significantly increased catch rates of legal-sized lobsters relative to unvented traps (e.g Fogarty and Borden, 1980). A reduction in trap saturation effects mediated through lower frequency of aggressive interactions has been credited with this widely documented phenomenon. These higher catch rates have important implications for fishing mortality rates in the lobster fishery (Fogarty and Borden, 1980). Further, the use of escape vents has increased the efficiency of fishing operations (by reducing culling time, for instance), with indirect effects on overall levels of effective fishing effort.

Bycatch can also be regulated through the use of escape vents designed with respect to the morphology of the species incidentally caught in the traps. For example, rectangular escape vents retain legal-size lobsters while permitting the escapement of many crab and fish species. Alternatively, circular escape vents can be used that permit the retention of both lobsters and targeted crab and fish species. In the northeastern United States, *Cancer borealis* and *Cancer irroratus* are the dominant crab bycatch species. Studies of dominance hierarchies among these species are consistent with observed patterns of bycatch (e.g Richards et al., 1983). In particular, the catch of both *Cancer* species is reduced with increasing catch rates of lobsters. Conversely, lobster catch rates are not affected by crab catches.

The use of escapement panels in lobster traps is a clear success story in conservation engineering. The effectiveness of escape panels is a direct result of the sharp retention characteristics of the vent, which permits high escapement of sublegal-sized lobsters with high retention of legal-sized individuals.

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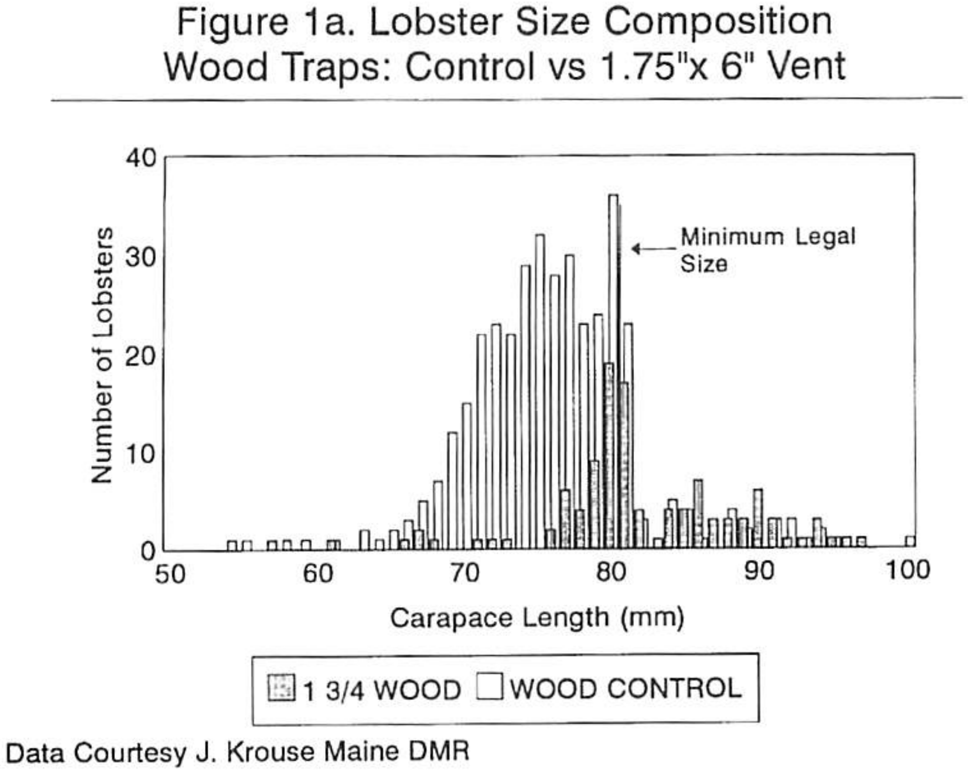
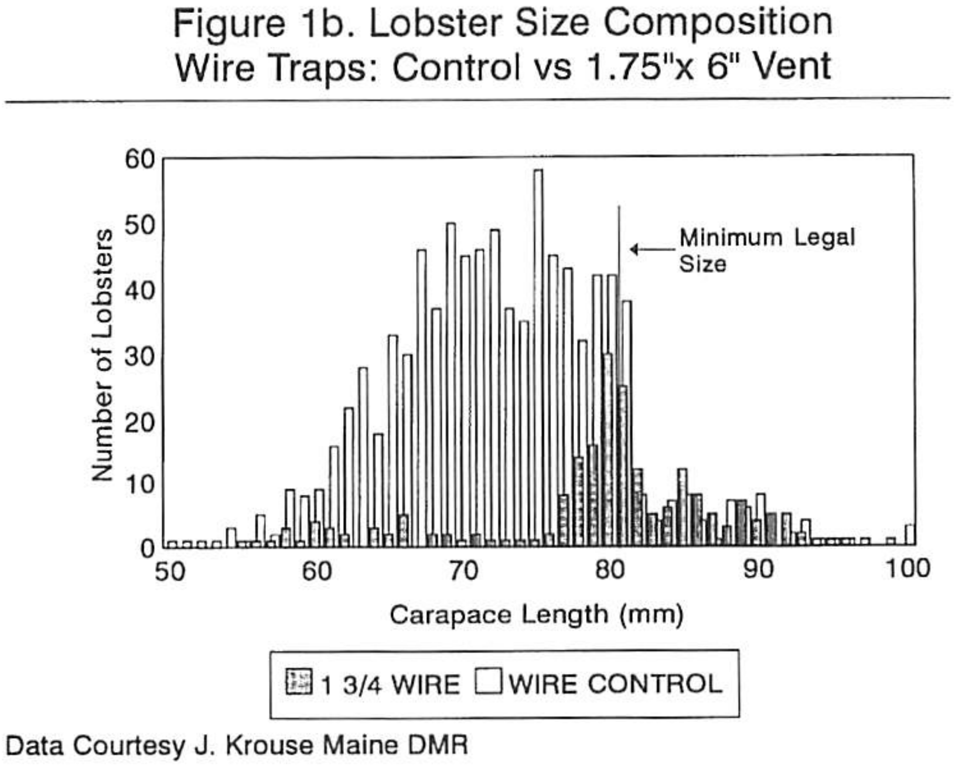
Figure 1. Size composition of American lobsters for control (unvented) and experimental (1.75" x 6" vents) for (a) wood traps and (b) wire traps. Data courtesy of J.S. Krouse, Maine Department of Marine Resources, W. Boothbay Harbor, ME 04575.





NORTHEAST WHITING FISHERY

Overfishing, Predation, and Other Problems in the Northeast Whiting Fishery

JAMES LOVGREN
Point Pleasant Fisherman's Cooperative

The Northeast whiting fishery is one of the most valuable fisheries for the few remaining species that are abundant enough to catch. It wasn't always that way. Fifteen years ago, few boats targeted whiting, except for the day boats out of ports like Point Pleasant and Belford, New Jersey, and Gloucester, Massachusetts. Most boats didn't bother saving whiting because they were cheap, hard to handle, and didn't have a long shelf life; they simply were not worth icing up and taking up valuable space.

But with the expansion of the fleet in the late 1970s and early 1980s, and with the decline in groundfish stocks, some boats started whiting fishing to end their Georges Bank trips. Five hundred boxes of whiting paid their expenses. Sometimes they got lucky and hit the price right. Whiting can be $1 a pound one day and 10 cents the next; it is the most price-volatile fish on the market. It soon became apparent that, if you caught enough whiting, the trips with good prices would even out the trips with the bad prices. Soon, a lot of boats were whiting fishing. The result, until recently, has been increased whiting landings.

Writing on the wall

In the late 1970s, New Jersey dominated the whiting fisheries, landing over 10 million pounds a year. In 1980 and 1981, Pt. Pleasant Co-op packed over 7 million pounds of whiting each year. But by the mid-1980s, the writing was on the wall. Co-op boats spent more time fishing the offshore waters around the Hudson Canyon than in day trips to the mud hole. Although landings remained steady throughout the '80s, what wasn't shown by the statistics was that we were traveling 80 miles to catch fish we used to catch 10 miles away.

By the 1990s the inshore whiting fishery in the New York Bight was almost nonexistent. Even the waters of the continental shelf were producing substantially less fish. Pt. Pleasant Co-op went from catching 70 percent whiting to catching 70 percent squid. Whiting landings for two years in a row have been less than 1 million pounds.

What does this mean? It means that the whiting are overfished. Other factors that may be influencing their decline haven't been identified. Because the size of the stock has decreased dramatically, so has the fish's migratory range. Also, whiting—which have a life span of up to 15 years—seldom have a chance to reach that age anymore. The stock is dominated by 1- to 3-year old fish.

Obviously, the major culprit is overfishing. But it is not just U.S. vessels that are catching the whiting. There is a large fleet of foreign vessels working on the Northern whiting stocks northeast of Georges bank. The impact these factory trawlers are having on the whiting stocks is not known, but it is probably enormous.

First, look at some other factors that are affecting the populations of whiting and other species. It must be understood that the present marine ecosystem of the North Atlantic is in a state of chaos. The populations of every major fish species have been drastically affected in the last 30 years by the combination of overfishing, pollution, loss of habitat, and industrial uses of the resources. These problems are familiar, and most are being successfully dealt with, although the loss of habitat is probably the most important factor—and these vital estuarine waters are forever lost.

Role of predators

What has been overlooked in all our fisheries plans and studies is the basic predator-prey relationship. Big fish eat little fish, little fish eat spawn, etc. What happens when fisheries management plans protect large predatory fish, such as striped bass? Is the decline of the shad fishery the result of the predation of this recovered species? Large schools of bass are roaming the estuarine waters, feeding on the young of many other species that do not have the same protection.

Twenty years ago, it was unusual to see a whale while fishing offshore in the winter. Now whales are a nuisance. As soon as fishermen start to haul back the gear, a pod of pilot whales comes charging the boat. It's like a dinner bell to them. The whale, dolphin, and seal populations have all exploded in the last decade, which is great for them, but not so great for the rest of the fish in the ocean. Whales eat a lot.

When Canada closed its commercial fishery for cod a few years ago, the fishery managers thought they had found the key to rebuilding the stocks. Unfortunately, they found that the stocks were still declining. That's when they discovered the havoc the seals were wreaking with their ravenous appetites. So this year, Canadians are going back to the club. A measure like this wouldn't be necessary if cod were abundant. But cod are not abundant, and a simple thing like predation has a much greater effect than it would have if the ocean weren't in a state of chaos.

This next idea is guaranteed to be very controversial, but it bears looking at seriously. For 100 years, sewage sludge was flushed, dumped, and piped into coastal waters. Everyone knows the damage that was caused: fish kills and beach closings. But anybody that fished along the Jersey shore would tell you that the most productive fishing areas were the ones along the sewage outfall pipes.

The mud hole was one of the most productive fishing grounds on the East Coast for 100 years. It was also right next to the infamous 12-mile sludge dump site. Coincidentally, when the sludge wasn't dumped there anymore, the fish stopped coming there. When the dump site was moved to the 106-mile site, there was great fishing in the adjacent area of the continental shelf. Since that site was closed, there haven't been many fish there. Remember, sludge is a nutrient. It's food, pure and simple. With sludge dumping stopped, hundreds of millions of pounds of food have been removed from this ecosystem. Wouldn't it be ironic if cleaning up the ocean actually did more harm than good? This is not a suggestion to open up the pipes and start dumping again. It's just a comment that the people here today are the ones who should be looking at the possibility that we have seriously affected the marine ecosystem by denying the fish the food they were accustomed to. Those sites were full of worms, grass shrimp, sand eels, and all the basic organisms a food chain develops around. Think about it.

Interlinked fisheries

The whiting fishery is a small-mesh fishery, and in many cases is also the major component of the mixed-trawl fishery. It will be without a doubt the most difficult fishery to regulate due to the species interaction with other species of fish. There are clean whiting fisheries—Cultivator Shoals is certainly one of them. In our mud hole, the months of January and February were also no-bycatch months. But inshore in the fall and spring, when fish are migrating, the intermingling of species is unavoidable—and welcomed by fishermen. In the fall, fishermen can sometimes catch as much squid as whiting. Also caught are ling, butterfish, porgies, fluke, flounder, dogfish, weakfish, monkfish, lobster, and an occasional cod. These species all combine to make a payday.

The squid and whiting, on average, are about 75 percent of the landings in this inshore fishery. Unwanted species are small dogfish, skate, and conger eel, which are all hardy, bladderless fish with a high survival rate. During the spring migration, besides whiting, there are dogfish, monkfish, fluke, flounder, ling, grey sole, and lobster. Although this is a small-mesh fishery, there are very few undersized fluke or flounder present, as this fishery is conducted outside the range of the juvenile flatfish, which do not migrate very far from their estuarine birthplaces until they are larger. Bycatch in the spring would be the same small dogfish, skate, and conger eel as before, but with some juvenile ling mixed in.

The Pt. Pleasant boats fishing for whiting have in the last two years cut bycatch of juvenile whiting, ling, and butterfish by about 75 percent, sometimes more. These boats have voluntarily begun using 2.5-inch codends, or 4.5-inch bags with 3-inch liners. Both have been effective. The biggest fear—losing too many squid through this bigger mesh—was unfounded. As long as there were other fish in the bag, the squid would seem to attach to them and stay entrapped. But if you were to fish solely for squid with a 2.5-inch bag, you would quickly be out of business. This is where the major problem lies. The whiting and squid fisheries are so interlinked in the fall and winter, it would be hard to manage them separately, except in the case of squid processing boats.

When you go out to the Hudson Canyon in the winter targeting whiting and squid, you don't know which one you'll catch more of. You might also inadvertently catch porgies, butterfish, or mackerel. These are the key species in the mixed-trawl fishery. Although porgies will eventually have a larger required mesh size than whiting, you might get a 50-box tow of nice porgies while whiting or squid fishing. This could, if the price is right, be the biggest trip of the year for you. But, according to the porgy management plan, you would have to discard the porgies as unwanted bycatch.

Which brings up a serious bycatch problem: Bycatch is unwanted fish that are discarded because they have no market value. Government bycatch is marketable fish, sometimes very valuable, that are thrown over dead because of closed seasons, quotas, wrong mesh nets on the boat, or lack of the proper permits. Bycatch of any kind is not desired, but watching dead cod, fluke, swordfish, or other such fish go overboard dead is a crime. It is certainly not conservation. The National Marine Fisheries Service should institute a policy of catch-and-keep, rather than discard. If the season is closed, or the vessel doesn't have the correct permit, allow the boat to bring in the fish and donate it to a food bank to help the growing number of poor in America. Pay the boat and dock only for the expense of handling the fish.

Other uses of bycatch

It is important to remember that any unwanted bycatch is not wasted by nature. Other species of fish, along with gulls and gannets, feed on the discards. It is important to reduce the amount of juvenile fish caught of any species, but "100 percent clean" is impossible for all but the largest species. Cod lay millions of eggs because only a handful will reach the age of reproduction. This is true with almost all fish. It's natural selection. Chances are that the juvenile fish that are discarded as bycatch would not have reached spawning age anyway. They are food for others, always have been, always will be.

Another thing to consider is that, if the not-in-my-back-yard movement hadn't happened, there wouldn't be such a bycatch problem because there would still be fish-meal processing plants up and down the coast, and our bycatch would then have value.

One way to reduce bycatch would be to limit the number of crew on the boat. Less men on a boat means more work for everyone, but bigger mesh makes less work. Another way would be to eliminate finfish sorting machines on boats. The butterfish stocks have been decimated because some boats were working on small fish because they were picking out enough big fish to make it pay. A 10,000-pound tow might yield 1,000 pounds of good butters. If these had to be hand-picked, no one would sit back, but with a sorting machine, the work is easy enough to make these boats stay and keep destroying the stocks.

Mesh size has been the most effective way to eliminate bycatch. It is, along with juvenile time-area closures, the best management tool developed. The problem is that one size does not fit all. Smaller boats are at a disadvantage when mesh sizes are implemented because the sizes have been developed with high-horsepower, big vessels in mind. An 85-foot, 850-horsepower boat may catch whiting effectively with a 3-inch mesh, but a 60-foot boat with 300 horsepower cannot. The boat can't pull hard enough to pull the meshes tight. Without some kind of plan that addresses this discrepancy of size and horsepower to mesh size, the independent family fisherman is doomed, and the big company boats take over.

The smaller boats have little impact on the fisheries and just as much economic impact on shore as the bigger boats. Smaller boats are self-regulating by their weather dependency alone. This is nature's way of fish conservation. Unfortunately, today the bigger boats fish in almost every kind of weather, keeping constant pressure on the fish stocks, and keeping market values lower.

It would be useful to have a mesh-size study to see what is the appropriate mesh for certain size boats. This is a matter of survival for many boats that have depended on this fishery for years. It would be a shame for them to be put out of business, while many of the boats that did the most damage got rewarded.

Bycatch is unwanted fish that are discarded because they have no market value. Government bycatch is marketable fish... that are thrown over dead because of closed seasons, quotas, wrong mesh nets on the boat, or lack of the proper permits.

NORTHEAST WHITING FISHERY

The Fall Whiting Fishery of Cape Cod Bay and Massachusetts Bay

H. ARNOLD CARR, DANIEL MCKIERNAN, JESSICA HARRIS, AND DAVID MCCARRON
Massachusetts Division of Marine Fisheries

Overview of the fishery

During the past five years, Massachusetts Division of Marine Fisheries (MDMF) biologists have been studying the small-mesh trawl fishery in upper Cape Cod Bay. Each fall, whiting are caught in abundance in depths of 22 to 30 fathoms in upper Cape Cod Bay and Massachusetts Bay south and west of Stellwagen Bank. However, most small trawlers (under 60 GRT) favor fishing close to Provincetown for the protection afforded during rough seas as well as the convenience of shorter distance to travel to unload fish daily.

Fishing in this area is conducted in state waters as well as federal waters and is subject to two different regulatory regimes.

MDMF prohibited small-mesh trawling for whiting in 1991, based on limited sea sampling with observations of high discards of undersized American plaice. At the request of Provincetown dealers and fishermen, MDMF issued "experimental fishery" permits in 1992, 1993, and 1994. During 1992 and 1993, about 20 trawlers from Provincetown, Gloucester, and New Bedford targeted whiting in upper Cape Cod Bay from mid-October through November. All participating fishermen agreed to fish with restrictions such as:

- weekly declaration to stay in the fishery
- fishing only in a designated area
- regulated species bycatch limitations of two standard totes
- gear restrictions: minimum mesh of 2.5 inches in 1992 and 1993 and 2.75 inches in 1994.

Characterization of the Fishery

Fishermen's catch reports and sea sampling data provide MDMF with good estimates of the catch and discards of this fishery, as well as the landings' overall economic value. During 1992, reported landings totaled 1.25 million pounds, representing about $300,000 in ex-vessel value, and in 1993, totaled 0.75 million pounds, representing about $275,000 (Tables 1 and 2). The retained catch has been dominated by whiting, along with red and white hake.

About two-thirds of the catch is usually discarded due to species' low ex-vessel value or due to regulations regarding size. Dogfish, herring species, ocean pout, longhorn sculpin, skate and lobster are among the dominant discarded species.

Regulated multispecies groundfish exceeds the recently adopted federal "5 percent" standard. Flounder species, especially American plaice, dominated the regulated species discard, while winter flounder is more common in the landed catch.

Plaice discards in 1992 averaged 48.8 pounds and in 1993 averaged 81.1 pounds per hour. We've detected a pattern during the two sea sampling years: By the end of the fishery, winter flounder and yellowtail become more common in the catches and plaice bycatches decline.

So we propose all three common and valuable regulated flounder species be combined to describe a composite index of flounder discards. For the eight trips in 1992 the average discard rate observed was 62 pounds per hour and in 1993, the rate was 112.5 pounds per hour.

Lobster bycatch is another problem particular to trawl fisheries within Massachusetts territorial waters, since state law prohibits the take of lobster by net. Furthermore, this area commonly sees concentrations of soft and paper-shelled lobsters during the fall months, and discard mortality is undoubtedly high.

Sea herring have been observed discarded in large amounts during early October, and we suspect these large catches may be signs of spawning aggregations coincident with the sea herring spawning closure (October 1 through 21) when directed herring fishing is prohibited. We concluded that large catches were inappropriate during the spawning closure, so we postponed opening the fishery until after October 21 or until after catches subside. At the urging of some cooperative fishermen, we mandated larger mesh (2 .75 inches) in 1994 to reduce the catch of herring.

During this period, MDMF and the URI Fisheries program continued research on trawl designs that were based on work done on similar groundfish in the North Sea and on work MDMF had done over recent years (Carr et al.). URI used one trawl it developed, while MDMF used another trawl design. Although MDMF was not able to fish its trawl as much as it preferred, initial data acquired suggested that this trawl design had promise for this small-mesh fishery.

The 1994 Whiting Fishery

In 1994, new regulations were put into place that prohibited the retention of any multispecies when engaged in a small-mesh fishery. Prior to the opening of the inshore whiting fishery, MDMF met with fishermen to discuss what must be achieved in bycatch reduction if a fishery was to be allowed. Among the issues discussed were a codend mesh size (stretch) of 3 inches, a reduction in the lengths of the legs, and a lighter sweep. These actions would reduce the catch of small whiting and herring, the herding of flatfish, and the catch of lobster and flatfish, respectively.

Fishermen convinced MDMF that they could sharply reduce bycatch by making the legs and ground cable of bare wire and not chain, limiting the length of the legs and ground cable to 25 fathoms, lightening the trawl sweep to a single chain sweep of $^{5}/_{16}$ inch chain with no less than 18 links per foot, and using a 2.75-inch stretch-mesh codend. Also agreed on was a minimum size for whiting of 10 inches, with a 10 percent tolerance.

> ***About two-thirds of the catch is usually discarded due to species' low ex-vessel value or due to regulations regarding size.***

The fall fishery was conducted under these terms, except that one boat was contracted to use the MDMF-modified whiting net. This net originated from a Wilcox whiting net. The prime difference is in the sweep and number of floats on the headrope (Figure 1). The sweep was modified so that it had dropper chains and a sweep chain. The length of the sweep chain primarily determines how far that chain fishes behind the footrope. Although the length of the dropper chains aids in positioning the sweep chain, their main function is to allow the footrope to fish off the bottom. The length of the dropper chains (Figure 1), therefore, does not depict the actual height of the footrope off the bottom.

MDMF contracted the commercial trawler F/V *Northstar*, owned and operated by Carlos Verde, a 40-year veteran of a variety of commercial fisheries, to use the MDMF experimental whiting net. The contract period was for a maximum of five days.

1994 Fishery Results

The MDMF experimental commercial whiting trawl, a modified Wilcox trawl with 3- to 5-foot dropper chains extending from the foot rope to a chain sweep, was fished on the state whiting grounds west of Provincetown, Mass. Initially, six floats on the center and three floats on each wing were attached to the head rope. A 3-inch stretched diamond-mesh codend was used. Due to weather problems and the short season of this fishery, only two trips and 10 tows were completed.

Four tows were completed on October 20, 1994 (Table 5). During the first tow the net had six floats on the center of the headrope and three floats on each wing, and the sweep was in front of the footrope. The tow was made on mud bottom and had to be towed at the surface to rid the net of mud. The catch was "dirty", or nonselective, with 300 pounds of lobster discarded. To correct this, the sweep was lengthened by 3 feet on each side. After the second tow of the day, a 6-inch piece of chain was added to each wing to try to maximize the openings of the wings. This helped herd the whiting toward the net while allowing the mouth of the net to continue to ride above the bottom and allow the escape of groundfish.

At the beginning of the day on October 24, one float was added to each wing and the first dropper chain on each wing was shortened by six links—approximately 6 inches—making these dropper chains approximately 4.5 feet long. Two two-hour tows were made and then a codend cover was placed on the codend to determine the amount of herring and small whiting that was escaping through the codend. Four one-hour tows were made with the codend cover.

The configuration of the net on October 24 achieved the best reduction in groundfish bycatch, as low as .58 percent discard of regulated species (Table 6). Allowing the wings to achieve maximum vertical spread while keeping the mouth of the net off the bottom appears to minimize whiting loss and maximize bycatch loss. An interesting result of this work appears to be a higher efficiency at one-hour tow durations than two-hour tows. The mean whiting caught per hour for one-hour tows was 243 pounds, versus 131 pounds for two-hour tows. The number of tows conducted does not allow for rigorous statistical analysis; however, the results are promising and show that further work is both necessary and likely to be successful.

Recommendations

The future of this small whiting fishery requires a sharp reduction in bycatch. This can be accomplished by establishing a series of regulations such as:

The trawl - The trawl must fish just off the bottom. A chain sweep of the trawl must be modified by using a series of vertical chains—dropper chains—between the sweep and the footrope. This chain sweep must be rigged to lie behind the footrope; therefore, the chain sweep must be longer than the footrope. The headrope of the net must also have sufficient floats to complement the sweep and keep the net fishing just off the bottom (see Figure 1). Some improvements to this type of sweep are pending more work; for example, dropper chains may be sufficient with no chain sweep.

The legs of the trawl must be fashioned of bare wire and must be no longer than 20 fathoms combined. The forward part of the leg must have a bunt bobbin attached to lift the wire off the sea bottom.

The mesh of the net should be a minimum of 3 inches stretch, except in the codend, which will have 2.75 inches in 1995 and 3 inches in subsequent years.

A grate similar to one deployed by DFO Canada may be necessary when cod, haddock, and pollock become abundant. The grate would provide further means to reduce the bycatch of larger fish that do not escape at the mouth of the trawl.

Bycatch - No lobsters, groundfish, sea herring, or alewives shall be aboard—possessed or landed.

An active, random law enforcement presence is strongly encouraged to provide further incentive to reduce bycatch by modifying the trawl to fish dirty.

Whiting - The minimum size for the whiting should remain as it was during the 1994 fall season.

Added note: MDMF permitted one vessel to fish the MDMF whiting net during the fall of 1995. The catch results were very similar to the results in Table 6. The fisherman using the net is quite optimistic about the future of fishing for whiting with this type of modified net.

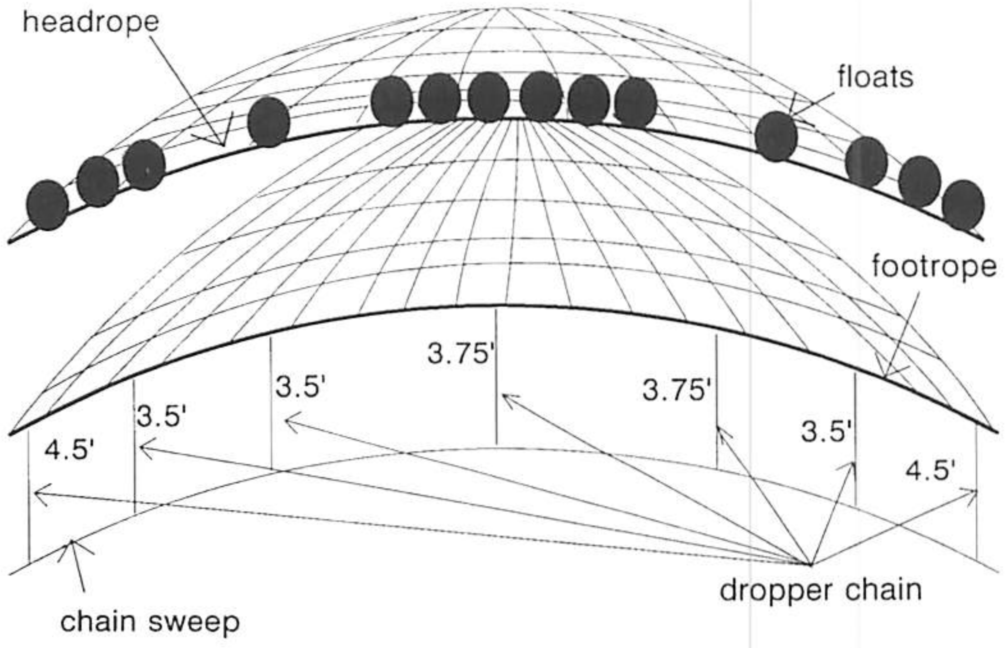


Figure 1

Table 1. 1992 Reported landings and values by species ranked by weight.

SPECIES	POUNDS	PERCENT	PRICE	VALUE	PERCENT
WHITING, MED. & SM.	584212	47.4%	$0.24	$142,769	48.8%
WHITING, KING	250943	20.3%	$0.39	$98,706	33.7%
HAKE, RED LRG,	176047	14.3%	$0.10	$17,623	6.0%
HAKE, RED REG	115767	9.4%	$0.07	$7,683	2.6%
DOGFISH	57681	4.7%	$0.07	$4,038	1.4%
OCEAN POUT	10615	0.9%	$0.10	$1,062	0.4%
HERRING	8550	0.7%	$0.00	$0	.0%
FLOUNDER, WINTER	**6272**	**0.5%**	**$0.80**	**$5,016**	**1.7%**
MONKFISH	4223	0.3%	$1.13	$4,789	1.6%
SCUP	4039	0.3%	$0.49	$1,959	0.7%
COD	**3902**	**0.3%**	**$1.00**	**$3,918**	**1.3%**
SQUID, ILLEX	3460	0.3%	$0.13	$442	0.2%
FLOUNDER, AM. PLAICE	**2899**	**0.2%**	**$0.74**	**$2,151**	**0.7%**
GROUNDFISH, UNCLASS	1606	0.1%	$0.47	$755	0.3%
BUTTERFISH	821	0.1%	$0.25	$205	0.1%
FLOUNDER, UNCLASS	**705**	**0.1%**	**$0.83**	**$588**	**0.2%**
SKATE, GENERAL	608	0.0%	$0.25	$152	0.1%
MACKEREL	492	0.0%	$0.23	$115	0.0%
FLOUNDER, YELLOWTAIL	**366**	**0.0%**	**$0.92**	**$336**	**0.1%**
FLOUNDER, SUMMER	302	0.0%	$1.03	$313	0.1%
BLUEFISH	145	0.0%	$0.05	$7	0.0%
FLOUNDER, WITCH	**15**	**0.0%**	**$1.67**	**$25**	**0.0%**
POLLOCK	**10**	**0.0%**	**$0.78**	**$8**	**0.0%**
SEA BASS	2	0.0%	$0.83	$2	0.0%
	1,233,681	100.0%		$292,662	100.0%
REGULATED GROUNDFISH	**15,775**	**1.3%**			

Table 2. 1993 Reported landings and values by species ranked by weight.

SPECIES	POUNDS	PERCENT	PRICE	VALUE	PERCENT
WHITING, MED. & SM.	474,802	63.5%	$0.35	$164,185	57.5%
WHITING, KING	84,165	11.2%	$0.71	$59,574	20.9%
HAKE, RED	135,475	18.1%	$0.15	$20,162	7.1%
DOGFISH	3,435	0.5%	$2.91	$9,996	3.5%
FLOUNDER, WINTER	**9,259**	**1.2%**	**$1.08**	**$9,996**	**3.5%**
MONKFISH	4,383	0.6%	$1.00	$4,396	1.5%
SCUP	5,032	0.7%	$0.51	$2,556	0.9%
COD	**2,934**	**0.4%**	**$1.02**	**$2,995**	**1.0%**
SQUID, LOLIGO	24,450	3.3%	$0.38	$9,381	3.3%
FLOUNDER, DAB	**955**	**0.1%**	**$1.05**	**$1,005**	**0.4%**
BUTTERFISH	619	0.1%	$0.25	$155	0.1%
FLOUNDER, WINDOWPANE	**25**	**0.0%**	**$0.20**	**$5**	**0.0%**
SKATE, GENERAL	326	0.0%	$0.33	$108	0.0%
MACKEREL	1,488	0.2%	$0.10	$149	0.1%
FLOUNDER, YELLOWTAIL	**827**	**0.1%**	**$1.00**	**$828**	**0.3%**
FLOUNDER, WITCH	**15**	**0.0%**	**$3.33**	**$50**	**0.0%**
POLLOCK	**40**	**0.0%**	**$0.68**	**$27**	**0.0%**
WOLFFISH	2	0.0%	$1.50	$3	0.0%
TOTALS	748,230	100.0%		$285,568	100.0%
REGULATED GROUNDFISH	**14,055**	**1.9%**			

Table 3. Catch and discard by weight from eight sea sampling trips during October 7 - December 1, 1992

SPECIES	KEPT	DISCARD	TOTAL
WHITING	18,759	11,490	30,249
SPINY DOGFISH	8,975	12,435	21,410
SEA HERRING	0	18,482	18,482
RED HAKE	3,317	1,236	4,553
MIXED HAKE	3,203	1,023	4,226
WHITE HAKE	**0**	**109**	
AMERICAN PLAICE	**284**	**3,000**	**3,284**
OCEAN POUT	289	1,954	2,243
LONGHORN SCULPIN	0	1,569	1,569
LOBSTER	148	1,263	1,411
SKATE	40	1,125	1,165
4 SPOT FLOUNDER	0	803	
ALEWIFE	0	634	
BLUEBACK HERRING	0	21	
RIVER HERRING	0	6	
MONKFISH	535	87	622
WINTER FLOUNDER	**110**	**466**	**576**
ILLEX SQUID	70	422	492
POLLOCK	**0**	**475**	
WINDOWPANE FLOUNDER	**1**	**250**	**251**
ROCK CRAB	0	243	
COD	**146**	**94**	**240**
LOLIGO SQUID	5	213	218
SCUP	127	8	135
YELLOWTAIL FLOUNDER	**39**	**93**	**132**
BUTTERFISH	20	109	129
AMERICAN SHAD	0	103	
4-BEARD ROCKLING	0	102	
ATLANTIC MACKEREL	51	22	73
TORPEDO RAY	0	60	
SEA ROBIN	0	47	
WRYMOUTH	4	31	35
SEA RAVEN	0	32	
FLUKE	10	2	12
REDFISH	**0**	**3**	
HALIBUT	3	0	3
GREY SOLE	**0**	**2**	
CUNNER	0	1	
*****SUMS*****	36,136	58,015	94,151

REGULATED SPECIES **5,072 (5.4 %)**

Table 4. Catch and discard by weight from eight sea sampling trips during October 13 - November 23, 1993

SPECIES	KEPT	DISC	TOTAL
WHITING	8,375	2,144	10,519
SPINY DOGFISH	500	5,307	5,807
MIXED HAKE	3,006	1,803	4,809
OCEAN POUT	210	2,366	2,576
SEA HERRING	0	2,433	2,433
AMERICAN PLAICE	**87**	**2,343**	**2,465**
LOBSTER	0	1,203	1,203
RIVER HERRING	0	798	
MIXED HERRINGS	0	131	
MISC.	0	736	
WINTER FLOUNDER	**148**	**513**	**661**
LOLIGO SQUID	190	457	647
MIXED SQUID	40	0	40
LONGHORN SCULPIN	0	590	
ROCK CRAB	0	562	
CRAB	0	6	
ILLEX SQUID	0	458	
YELLOWTAIL FL	**37**	**405**	**442**
4 SPOT FLOUNDER	0	376	
SKATE	32	267	299
SHARK&SKATE	0	114	
BUTTERFISH	0	214	
POLLOCK	**0**	**213**	
MONKFISH	138	34	172
WINDOWPANE FL	**0**	**150**	
COD	**103**	**29**	**132**
SCUP	76	9	85
SEA ROBIN	0	65	
AMERICAN SHAD	0	34	
WOLFFISH	12	0	12
FLUKE	0	11	
ATLANTIC MACKEREL	1	10	11
WRYMOUTH	0	10	
4BEARD ROCKLING	0	7	
	12,955	23,798	36,788

REGULATED SPECIES **4,063 (11.0 %)**

Table 5. Discards from the Provincetown fishery from data gathered by the MDMF Fisheries Dependent Investigations Project

	1992	1993	1994
Weight of total sample and number of tows	94,151 lb 31 tows	36,788 lb 17 tows	17,132 lb 20 tows
% Multi spp in catch (discards + kept)	51.28 %	33.98 %	32.34 %
% Discards (including all multi spp except whiting)	77.47%	74.55%	57.59%

Table 6. Comparison of the catch during the two sampling trips using the modified Massachusetts Division of Marine Fisheries modified Wilcox trawl

	Oct 20, 1994	Oct 24, 1994*
Avg. Whiting per hour	80 lb (kept) 5.24 (discarded)	130.55, 243.05 lb (kept) 12.95, 22 lb (discarded)
Avg. Lobster per hour	15 lb	2.48, 2.23 lb
Avg. Am. Plaice per hour	14.23 lb	
Avg. Winter flounder per hour.	1.1 lb	
Avg. Sea Herring per hour	1.28 lb	
Avg. River Herring per hour	7.33 lb	2.25, 15.4 lb
Total Discards (%)	32%	23.43%
Discard of Multi Spp (except whiting)	6%	1.62%
Discard of Regulated Species	6%	.58%

* Two two-hour tows and four one-hour tows were made.The different numbers are from these different tow durations, respectively.

Gulf of Maine Shrimp Fishery

A Fisherman's Perspective on the Nordmore Grate

David Goethel
New Hampshire fisherman

From a fisherman's perspective, certain portions of the grate system have been modified from what was originally shown in the literature to enhance performance. First, we have built our own grate out of stainless steel rods, with a half-inch frame and alternating quarter-inch and three-eighths-inch steel rods. This improves water flow through the grate and keeps the grate from rusting. Second, many problems with the grate system are related to the funnel that shoots the shrimp at the grate. The grate will not work without the funnel. Many fishermen fail to realize this. Fishermen in our area have found that placing the terminal end of the funnel 3 to 4 meshes farther away from the grate decreases the chances of clogging the area between the funnel and the grate without noticeable loss of shrimp. Cutting several "siders" on each side of the terminal end of the funnel seems to allow large skates and monkfish to pass through the funnel and out of the system rather than plugging it up.

Third, the angle of the grate is important to shrimp retention. In this grate, the angle is increased slightly from 45 degrees to about 48 to 50 degrees. This seems to improve shrimp retention with no noticeable effect in bycatch. The one exception would be in areas with high concentrations of skates, where lowering the angle seems to make it easier for skates to escape. Shrimp retention is decreased with the lower angle, but a grate plugged with skates retains no shrimp at all. Fourth, the natural lift created by the increased water flow of a four-seam net requires only two floats on the grate. With two-seam nets, flotation must equal the weight of the grate.

Fishermen have experimented extensively with placement of the grate system. By placing the grate right side up in the traditional manner, you retain scallops, stars, whiting, and skates. With the entire system flipped over—that is, with the funnel attached to the top of the extension and the escape hole in the bottom—stars, scallops, and skates fall out the hole, but many more herring pass through the grate. A significant, but still not large, number of flatfish also pass through the grate. Why more flatfish are retained isn't clear. There is, however, no apparent difference in shrimp retention.

Now that water flow through the codend is greatly reduced, codend loading has become a problem. One solution seems to be lengthening out the extension behind the grate. A rough rule of thumb would be to have the length of the extension behind the grate equal to the original length of the extension. For example, if the net before grate installation had a 100-mesh-long extension, then after grate installation the extension behind the grate should still be 100 meshes. Making the distance between the grate and the terminus of the codend too short will result in a noticeable decrease in retention of shrimp.

Another innovation fishermen have come up with is installation of a 10-mesh piece of nylon (90-thread or greater) in the top and bottom of the extension, centered on the top and bottom rims of the grate. Nylon is significantly stronger than poly and has more "give," reducing the blowouts in these high-stress areas.

Sometimes there are problems with welds breaking on the grates when boats are towing in water deeper than 70 fathoms. The easiest solution is to carry steel bars and stainless hose clamps to effect temporary repairs. Two problems not solved yet are twists in the extension ahead of the grate—a particular problem for "eastern rigged" draggers—and the problems associated with putting rigid grates on net reels that were not designed for them.

'Phenomenal' sorting success

The sorting success of the Nordmore grate is truly phenomenal in terms of groundfish. The only groundfish that are retained in any measurable quantity are sublegal American plaice. Herring and whiting are significantly reduced, but not eliminated. One note of interest: Pollock apparently rigorously charge the bars of the grate. In the codend there have been pollock that you would not believe could possibly pass through a 1-inch space.

Many fishermen believe that when concentrations of shrimp are high—in excess of 500 pounds per hour—significant amounts of shrimp escape out the hole. Concentrations such as these are extremely spotty, and this is a hard concept to prove or disprove. But stories persist of certain individuals who have been known to circumvent the law doing significantly better than the fleet average on any given day. Perhaps research effort should be directed to this problem.

Other applications where a grate system may be successful would include any fishery in which what you are trying to keep is smaller then what you are trying to eliminate. The system will not work in a mixed fishery, where different species charge different areas of the twine. For example, herring, when they run into the grate, will swim up; whiting will swim down. So, whether the hole is at the top or the bottom of the net, only one of these species will be retained. Also, the grate will have only limited sorting success where sorted species are similar in size, such as large whiting and juvenile groundfish. In these types of fisheries, time-area restrictions would be more effective management regimes.

On a long-term basis, the only real solution to bycatch is removing excess harvesting capacity from the fleet. A boat removed permanently from the fishery has no bycatch and no discards. In the northeast United States, the current program of slow death by regulation is ethically and morally wrong because it inflicts harm on viable as well as nonviable fishing operations, accelerating the destruction of all fisheries.

> ***...the only real solution to bycatch is removing excess harvesting capacity from the fleet. A boat removed permanently from the fishery has no bycatch and no discards.***

GULF OF MAINE SHRIMP FISHERY

Reduction of Finfish Bycatch in the Gulf of Maine Northern Shrimp Fishery: Research on Gear and Implementation

DANIEL F. SCHICK AND MICHAEL BROWN
Maine Department of Marine Resources

Abstract: *Traditionally, the bycatch of market-size finfish in the Gulf of Maine northern shrimp fishery was an expected benefit to the fishermen. The discard of submarket-size fish was an undiscussed issue. As minimum groundfish mesh size increased, some fishermen began targeting finfish with shrimp nets. To counter this, the first limits on bycatch—25 percent by weight of the shrimp catch by day and 10 percent by month— were imposed in 1986. Shrimp-finfish separator trawl experiments were begun in 1984. Several variations were tested in the mid-1980s with limited success. Of these variations, two gear types were selected, and commercial trials were conducted in 1988. These were a large-mesh panel behind the footrope and a radial escape section in the extension. Research results for the 1988 separator trawl trials showed a maximum of 30 percent release of juvenile flatfish through the large-mesh panel and minimal release of nonschooling groundfish through the poly flapper. A combination of large mesh panel behind the footrope and poly flapper escape hole in the extension was required in the fishery in 1989. A larger-mesh panel was tested with fishermen in 1990 and produced another 10 percent release. The required mesh size and the size of the panel were both increased from four rows of 6-inch mesh between the corners to five rows of 12-inch mesh between the corners in the lower belly between 1989 and 1990.*

During this time, fishermen were encouraged to investigate systems that would reduce bycatch and scientists would ride with them to test these systems. Most of these involved modifications to the extension and were not very successful. A descending large-mesh panel in the bellies did demonstrate reduction in large fish, but the mesh in the panel needed to be reduced to be effective for small and mid-sized fish.

Research started on the Nordmore grate in 1991, with several trials conducted through the winter of 1992. The Nordmore grate system experiments showed over 95 percent retention of shrimp and over 95 percent release of finfish by weight. Due to its dramatic improvement in efficiency over other separator devices, the Nordmore grate system was required in the fishery during December, April, and May of the 1992–93 season and all season in 1993–94 and 1994–95. The fishermen accepted the device remarkably well, as the conservation value was readily apparent. Also, nuisance fish, such as the longhorn sculpin, were readily ejected, and picking the pile of shrimp clean was much less time-consuming. Lobsters were ejected on the bottom, reducing their frequent trips to the surface common in the shrimp fishery.

Some problems remain. There are some species-by-species differences in the efficiency of the Nordmore grate. Finfish that are not strong swimmers and are close to the same size as the shrimp can be retained by the system. Silver hake, Merluccius bilinearis, *between 8 and 15 cm total length can be retained in larger numbers by the Nordmore grate system than by the control net. Small flatfish, such as young American plaice and gray sole, can also be retained in higher than desirable numbers. Also, the Nordmore grate may have changed the selection curve for northern shrimp in the codend, allowing greater numbers of smaller shrimp to be retained. Further attempts to improve the selection characteristics of the shrimp net involve the use of square mesh in the codend behind the Nordmore grate.*

Introduction

The small-mesh otter trawl fishery for northern shrimp in the Gulf of Maine has its beginnings in the 1920s in Gloucester, Mass. An exploratory cruise in the late '30s showed commercial quantities of shrimp, and a small fishery developed. Limited market acceptance and World War II kept the fishery from expanding until the shrimp population was greatly reduced during the 1950s by very warm water conditions. As the Gulf of Maine cooled in the 1960s, the northern shrimp population increased and a fishery quickly developed, with a peak landing of 12,000 metric tons in 1969. The population declined rapidly in the early '70s with rising sea temperature and increasing effort. The first management efforts to restrict the fishery were imposed in 1975. Summer fishing was banned due to poor product quality and harvest of immature shrimp, and a minimum mesh size of 1.75-inch stretch mesh was created. The fishery was closed in 1978 and opened gradually in the early '80s. Landings have fluctuated between 3,000 and 6,000 MT since then, being supported primarily by occasional strong year classes of shrimp (Figure 1).

A northern shrimp in the western Gulf of Maine exhibits several migrations during its life history. It is hatched in winter in inshore, relatively shallow (20°–50°F) water and migrates slowly offshore as a juvenile. It matures first as a male at $2^1/_2$ years while offshore in 80°–100°F, mates during the summer, and remains offshore going through transition into a female. As a female, the shrimp mates at age $3^1/_2$, extruding her eggs onto her pleopods in September, and then migrates inshore in December to release her larvae at age four. She will remain inshore through March, migrate offshore, and repeat the cycle one year later. The fishery for northern shrimp has taken advantage of these migration patterns, with smaller vessels fishing for the shrimp inshore during the winter and larger vessels fishing over a more extended season and area.

Bycatch of market-size finfish in the shrimp fishery was accepted as usual practice through the mid-'70s. The discard of juvenile, or submarket, individuals of market species of fish and of nonmarketable species was simply not an issue, yet this discard accounted for considerable mortality. Bycatch and discard started to become an issue when groundfish stocks started to decline in the early '80s. The shrimp fishery produced bycatch/discard levels that were unacceptable to the New England Fisheries Management Council (NEFMC), the regulatory body charged with managing the groundfish resources in the Gulf of Maine. Historically, one of the accepted methods of reducing mortality of juvenile fish was to increase the minimum mesh size. This has been done several times in the Gulf of Maine, and in the past some fishermen resisted these changes by continuing to fish for groundfish while using shrimp nets with the relatively fine mesh. To curb this practice, the ASMFC Northern Shrimp Section created a regulation in January 1989 that limited bycatch, or landed nontarget species, to 25 percent by weight of the shrimp per day and 10 percent by weight of the shrimp landed per month. It was hoped that the fishermen would modify their gear and fishing locations so that they would not catch a high percentage of groundfish and would thus reduce the waste of discard—throwing back fish that are too small to market or are over the permitted limit for the day. The regulation encouraged cheating through unreported landings and did not appreciably change the locations of traditional fishing activity. Thus the recorded landings data did not accurately reflect the bycatch, and the discard remained unrecorded. In response, and in reaction to pressure from the NEFMC, the ASMFC Northern Shrimp Section made the fishery a zero-bycatch fishery in 1993. The fishery has remained a zero-bycatch fishery until this year, when a limited amount of silver hake has been allowed as bycatch.

Documentation of the bycatch/discard problem has occurred through a sea sampling program whereby samplers are placed aboard commercial vessels and all fish caught are noted, whether they are landed or not. This five-year effort mounted by the National Marine Fisheries Service's Northeast Fisheries Science Center has given unprecedented accuracy to the data defining the problem (Clark and Power, 1991). An earlier study by Howell and Langan (1992) also documented bycatch and discard in the Gulf of Maine offshore northern shrimp fishery.

Bycatch/discard is a variable problem depending upon time of year and location of the fishery. Inshore winter shrimping does not catch juvenile, or adult, groundfish, but offshore shrimping, which often occurs concurrently with the inshore fishery, does involve considerable bycatch/discard of juvenile and adult groundfish.

The reduction of bycatch and discard of juvenile groundfish in the shrimp fishery in the Gulf of Maine has been an issue for many years. Initial work was done by the Department of Marine Resources (DMR) in the mid-1970s by testing an ascending panel in the bellies that led to a second codend. The shrimp would flow through the large mesh of the panel and be caught in the primary codend. The finfish would be guided up the panel and out through an escape hole into a second codend. The separation of shrimp and fish was successful, but the ascending panel would catch trash and this would disfigure the net so that everything would ball up ahead of the panel. During the mid-80s further work on separating finfish was conducted by DMR and the National Marine Fisheries Service, Northeast Region. This work involved testing several designs that had been developed in other small-mesh fisheries of the world and developing further those designs that proved promising (Figure 2). Two of these designs were successful enough to become required in shrimp nets: the poly flapper and the large-mesh panel behind the footrope.

The poly flapper was a diamond-shaped hole in the top of the extension piece with the cut mesh left hanging in the space as a flapper. The large-mesh panel was a series of large (eventually 12-inch) meshes replacing shrimp mesh in the lower belly behind the footrope. These devices took advantage of differing behavioral patterns between shrimp and fish. The purpose of the poly flapper was to allow some species of roundfish—cod, pollock, etc.—to escape the net while the flapper retained the shrimp. The large-mesh panel purportedly allowed flatfish to dive back down through the large mesh and escape the net while the shrimp floated over it back into the net. This panel appeared to work in reverse if the design of the net did not cause the lower belly to slowly rise from the footrope. Several other devices that took advantage of behavioral characteristics, or physical separation of shrimp and fishfish, were tested by the Maine Department of Marine Resources, Massachusetts Division of Natural Resouces, URI, MIT, the NMFS Northeast Region, and others. The results of many of these early trials have been reported by Schick (1992). In essence, some were much better than others, but none were wildly successful. The best reductions in bycatch were in the neighborhood of 30 percent, and all involved some shrimp loss as well.

In the late '80s a hard panel— a grating of parallel bars—was developed in Nordmore County, Norway. This grate was mounted at a 45-degree angle in the extension of the net, with an escape hole in the net in front of the grate (Figure 3). This device, which has become known as the Nordmore grate, proved far superior to any device previously tested in the separation of shrimp and fish and the exclusion of fish from the trawl net (Larsen, et al. 1991).

Results and Discussion

Testing of the Nordmore grate system by the NMFS-NER's Fisheries Engineering Group during 1991 and 1992 proved the grate's effectiveness for the fish assemblage present in the Gulf of Maine. The results showed over 95 percent loss of finfish by weight and over 95 percent retention of shrimp (Table 1) (Kenney et al. 1992). The grate was instituted into the northern shrimp fishery for April and May 1992, and beginning in December 1992, the grate was required for the whole season. In 1993, an exception to the requirement of using the grate was made for the period of January through March inside Maine state waters, as few groundfish were present at that time. This exception was dropped in 1994.

The Nordmore grate is a physical separator; that is, it separates finfish from shrimp due to their different shape and size, using bar space as the size delimiter and water pressure to force the shrimp through the grate. The excellent release of finfish as seen in Table 1 is seen across the length spectrum for flatfish, with a high percentage of even small flatfish escaping the net (Figure 4). Most of the fish species exhibited similar release. Separation starts to break down when the fish are of similar size to shrimp and are not strong swimmers, or are otherwise unable to escape contact with the Nordmore grate. Small silver hake, *Merluccius bilinearis*, between 8 and 15 cm were in general caught in greater numbers with the grate than without the grate (Table 1). The length frequency of the silver hake in the NMFS 1992 test series shows more silver hake retained in the codend with the $^3/_4$-inch bar-space grate than the control codend and somewhat less silver hake retained in the codend with the 1-inch bar-space grate than the control codend (Figure 5). The trials in 1991 with the $^7/_8$-inch grate showed considerably more small silver hake retained in the codend with the $^7/_8$-inch grate than in the control codend (Figure 6).

In a majority of the test tows conducted with the Nordmore Grate in 1992, the shrimp catch was greater with the grate than without (Table 1). The overall length distribution of shrimp from the two Nordmore grates (both $^3/_4$-inch and 1-inch bar spacing were tested) does not differ greatly from the control (Figure 7). An examination of just the male shrimp length frequency—around 15 to 20 mm carapace length—reveals more shrimp of that size range retained by the codends behind the grates (Figure 8). The increased retention of these smaller shrimp is a concern because they are below the target size—greater than 22 mm—that the minimum mesh-size regulation controls. This indicates that the Nordmore grate may be affecting the mesh selection curve for shrimp in the codend. One possible explanation for a shift in the mesh selection in the codend consists of two components. First, with the finfish effectively excluded from the codend by the grate, the average size of the ball that accumulates in the codend is smaller with the grate in place than without the grate. The smaller ball does not stretch the diamond mesh as much ahead of the ball, and the average mesh opening may therefore be less. Second, the grate acts as a partial block to water flow through the extension to the codend, reducing the flow of water out through the mesh openings ahead of the ball. Thus the forcing function of water pressure is less and the mesh opening is less. This would account for the shift in the mesh selection curve toward increased retention of small shrimp. These same forces would probably affect the silver hake the same way and would explain the increased retention of smaller fish in the codend.

Recent comparisons of diamond-mesh and square-mesh codends may indicate a possible solution to the problem of mesh selection shift: using square-mesh codends behind the Nordmore grate to improve the mesh selection curve. In studies conducted in Iceland, Thorsteinsson (1989) found that 0-group cod, haddock, and whiting were released through square mesh much more readily than through diamond mesh of the same stretch measure (Table 2). There was also a loss of shrimp weight through the square mesh, but the count per kilogram of shrimp was greatly reduced, showing that it was primarily smaller shrimp released (Figure 9).

In this same study, the length frequency for 11- to 15-cm haddock shows a greater release with the square mesh without an apparent shift in size of fish retained (Figure 10). On the other hand, whiting in the 8- to 11-cm range show a much greater release with square mesh compared to diamond mesh than do the whiting in the 12 - to 18 - cm range (Figure 11). This differential release of the smaller whiting shows the same, sharper size selection curve as is seen in the shrimp length frequency (Figure 9). In another study, Fonteyne and M'Rabat (1992) found no difference in the retention of sole, a flatfish, between diamond-mesh and square-mesh codends (Figure 12). Presumably this would not be a severe problem in the Gulf of Maine northern shrimp fishery, since the Nordmore grate releases a high percentage of all size classes of flatfish (Figure 4).

A study funded by the NMFS Fishing Industry Grant (FIG) Program is currently underway to look at the shifts in mesh selection with the use of the Nordmore grate and to try various size square-mesh codends behind the Nordmore grate to reposition and sharpen the size selection curve for shrimp. The square-mesh codend with the best selection curve for shrimp will be tested on the finfish assemblage to see if the release of whiting, and possibly other species, is improved as well.

It was hoped that the fishermen... would not catch a high percentage of groundfish and would thus reduce the waste of discard —throwing back fish that are too small to market or are over the permitted limit for the day.

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TABLE 1. NORDMORE GRATE STUDY; CATCH SUMMARY FOR 20 TOWS
From: Kenney, J. et al., 1992. Nordmore Grate Catch
Comparison Experiments in the Gulf of Maine Shrimp Fishery

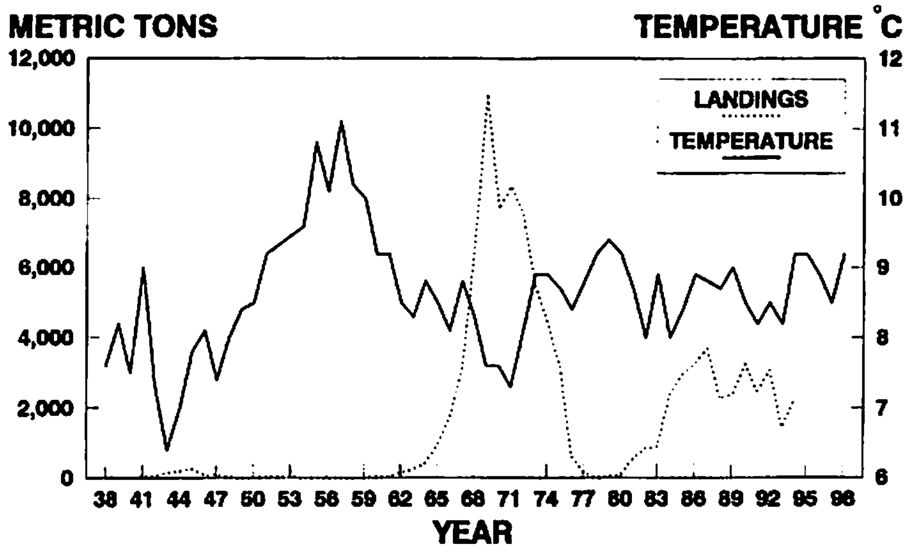
F/V *Mary Ellen* Jan. 6-10, 1992 (ME_2_ALL)

Tow No.	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52
GEAR	3/4	C	C	3/4	3/4	C	C	3/4	3/4	C	C	3/4	1"	1"	3/4	C	1"	C	3/4	1"	C	3/4
DATE	01-06	06	06	06	07	07	07	07	07	07	09	09	09	09	09	09	10	10	10	10	10	10
	FOUL SET		64	65	63	65	65	65	60	59	62	64	64	65	66	65	45	46	46	46	47	48
total catch	14.95	163.05	105.00	93.25	76.25	162.05	184.60	82.75	66.25	115.75	141.00	62.00	52.50	69.25	59.75	149.50	103.00	134.95	68.25	105.75	145.50	102.75
shrimp	12.00	68.00	58.00	85.50	64.00	68.50	74.50	73.50	58.50	37.50	58.00	49.50	42.50	53.00	50.00	42.50	93.50	66.00	64.00	98.50	90.50	99.50
blackback	0.15	3.00	5.50			5.00	1.80	0.25		3.25	2.00			0.25		2.25	0.25	4.00	0.25	0.50	5.25	0.50
cod		1.00	2.50	0.25		9.00	2.50	0.25	—	0.25	2.50	0.25	0.25	—	0.25	22.00	0.25	2.20	—	0.25	0.25	
dab	0.30	3.50	2.00	—	0.25	2.00	4.80	0.25	0.25	1.75	4.00	0.25	0.50	—	0.25	4.00	0.25	0.75	—	0.25	1.00	0.25
graysole		0.90	—		0.25	0.50	1.00	0.25	0.25	0.25	0.75	0.25	0.50	0.25	—	1.00	0.25	0.25	—		0.25	—
haddock		0.25	—			—	0.25			0.25	0.25										0.25	
hakes	0.05	18.00	3.00	0.25		10.50	13.50	0.25		3.50	9.50	0.25	1.25	1.25	•	12.50	0.25	1.25		0.25	0.50	
pollock		0.40				0.25	0.50				1.00		0.25	0.25		1.00	0.25	0.25				
redfish		0.20	0.25				0.25				0.25											
whiting	1.30	29.00	15.00	6.50	11.50	30.50	30.00	7.50	6.00	12.00	20.00	10.50	6.00	13.50	8.00	20.00	5.75	8.50	3.25	4.50	2.75	1.75
yellowtail		4.60				2.50	4.50			2.75	4.00					2.50		2.00	0.50		2.25	
Total reg spc	1.80	60.85	28.25	7.00	12.00	60.25	59.10	8.75	6.50	24.00	44.25	11.50	8.75	15.50	8.50	65.25	7.25	19.20	4.00	5.75	12.50	2.50
alewife				0.50																		
eelpout		•				—																
herring	1.10	0.60	1.25		0.25	0.80	0.25	0.25	1.00	0.25	1.75	0.75	0.50	0.50	1.00	0.25	0.75	0.50	0.25	0.50	0.25	0.50
mackerel		0.80														0.25			—			
monk		0.80	0.50			1.00	1.50				0.50			—		1.00	—		—			
rockling		•		0.25	—			•		•	•	0.25	•		•	1.00						•
sculpin			—			0.75	—			0.50						0.75		•		0.50	4.00	
scup	0.05	0.20	—	—	—	—	—	•	0.25	•	•				•				—			•
sea raven		2.80	3.50				1.25			1.00						2.50		•			0.25	•
searobin		0.40						•		0.25	•						0.25					
skate		27.00	13.50	—		30.50	48.00			51.50	35.00		•	—		36.00	1.00	43.50		0.25	38.00	0.25
squid		0.70	—											0.25								
windowpane						0.25				0.25							0.25	0.25		0.25		
•		0.90						0.25		0.50	1.50		0.75		0.25			5.50				—
Total Other	1.15	34.20	18.75	0.75	0.25	33.30	51.00	0.50	1.25	54.25	38.75	1.00	1.25	0.75	1.25	41.75	2.25	49.75	0.25	1.50	42.50	0.75

Figure 1.

MAINE SHRIMP FISHERY

LANDINGS vs. TEMPERATURE



TEMP IS LAGGED FOUR YEARS

Table 2.

Average catch of shrimp(kg) and small fish(#) in square and diamond mesh codends in autumn 1988.

	Isafjardardjup		Hunafloi	
	Diamond	Square	Diamond	Square
Shrimp(kg h^{-1})	376	299	434	381
Shrimp count (kg)	442	302	503	337
Cod 0-gr.	130	8	6	2
Haddock 0-gr.	1,245	457	0	0
Whiting 0-gr.	2,472	376	27	4

From THORSTEINSSON G., 1992.

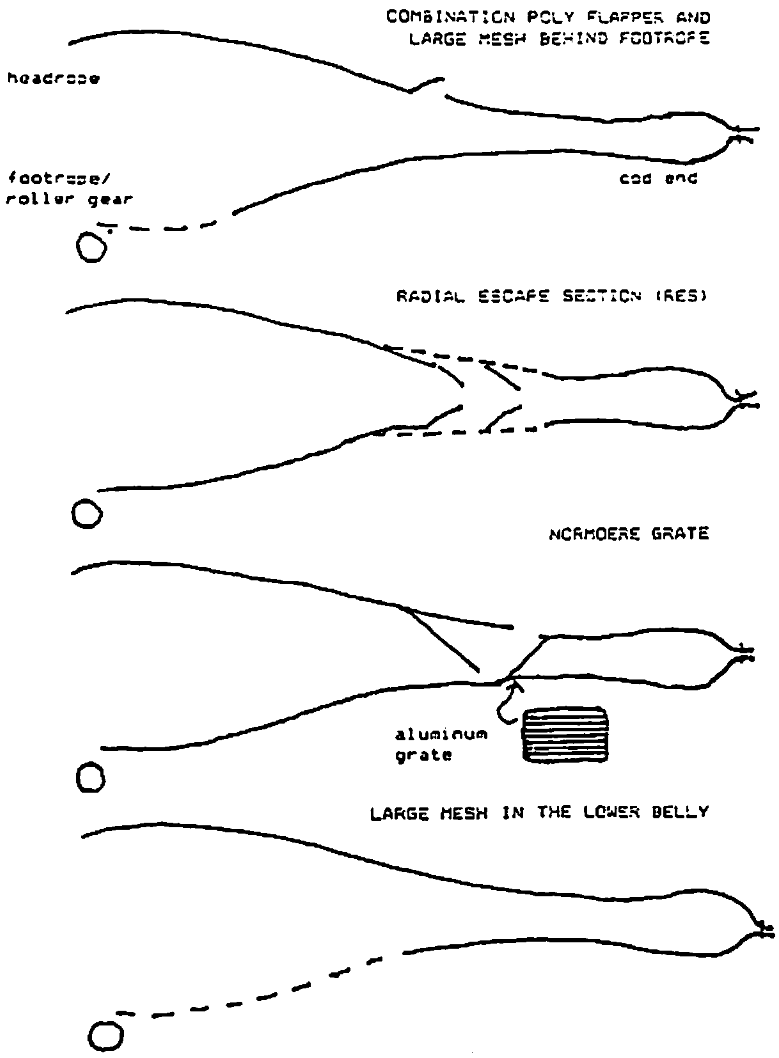


Figure 2. Conceptual Designs of Separator Trawls for Possible Use in the Gulf of Maine Northern Shrimp Fishery.

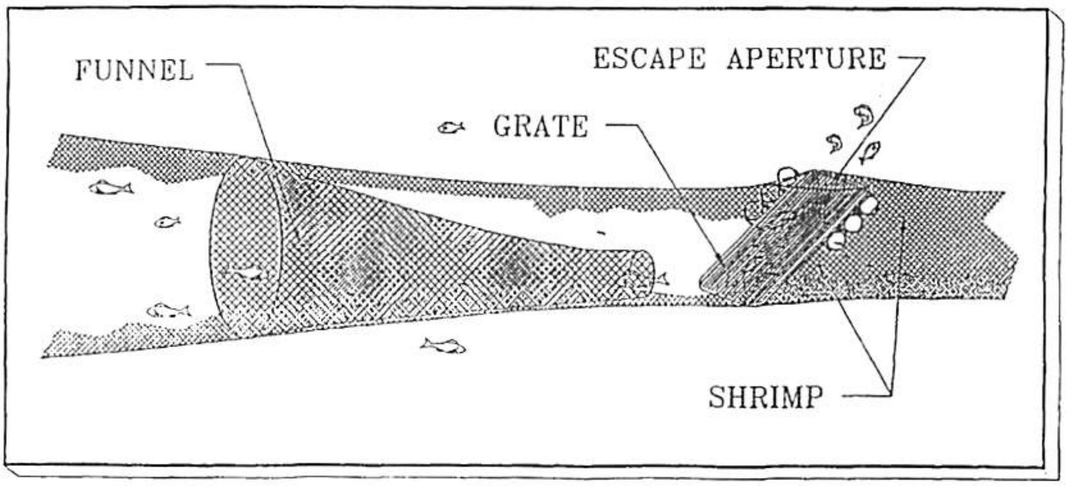
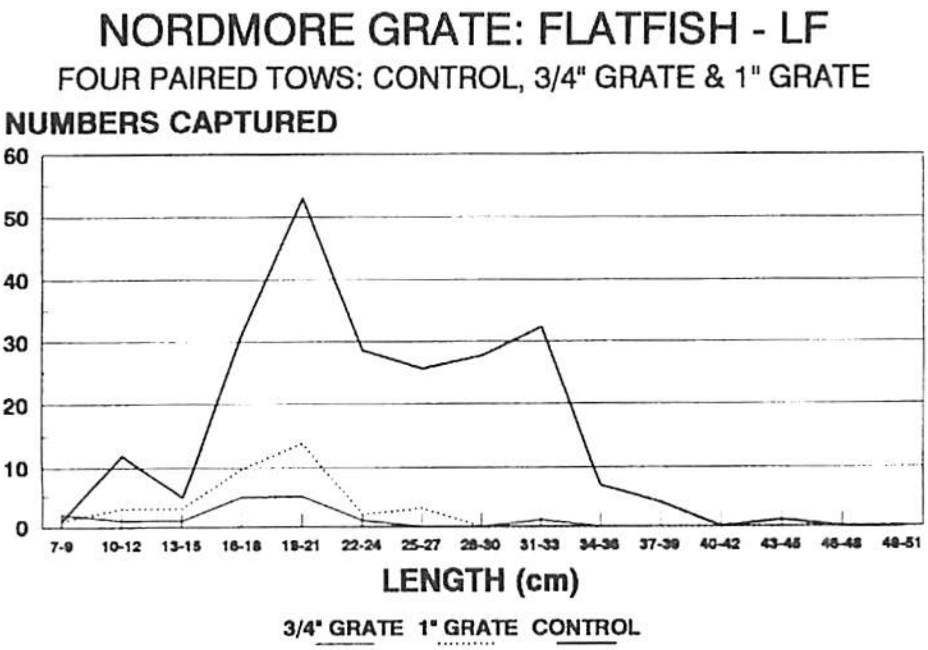


FIGURE 3. NORDMORE GRATE ASSEMBLY IN AN OTTER TRAWL
From: Kenny, et al., 1990. Nordmore Grate Study. NMFS-NER Fisheries Engineering Group. Narragansett, R.I.

Figure 4.



FLATFISH = BB, DAB, YT, GS

Figure 5.

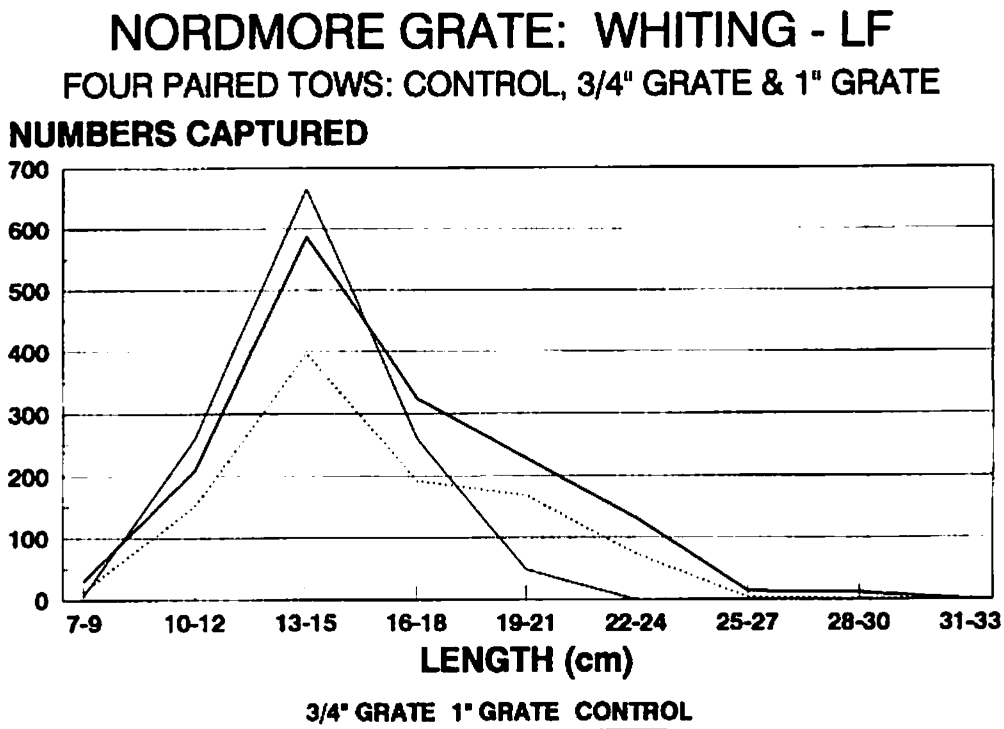


Figure 6.

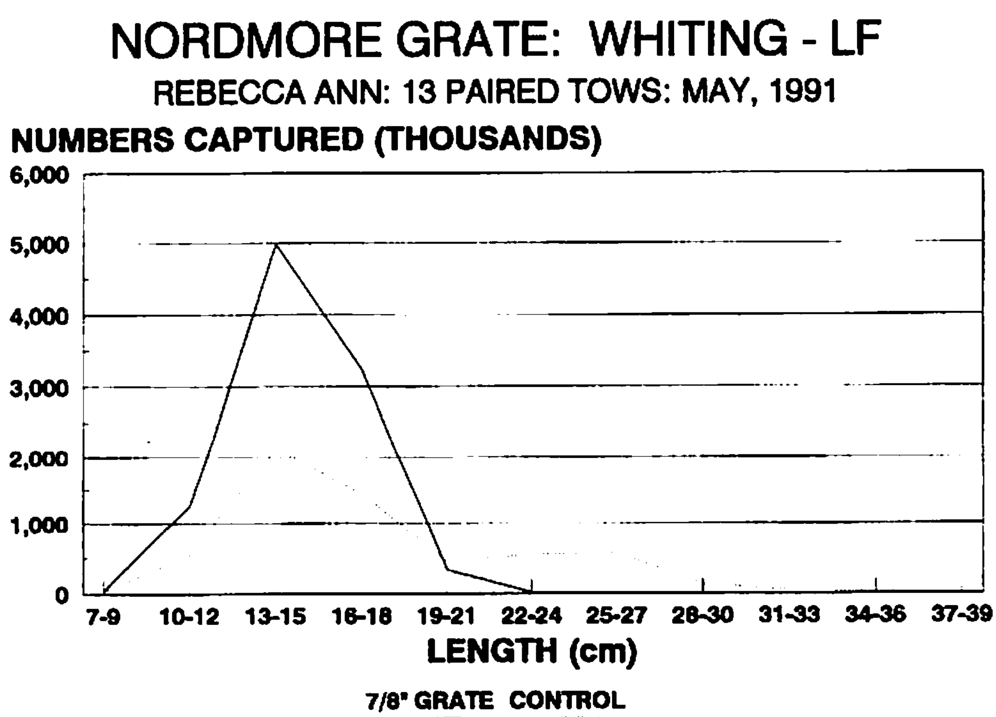


Figure 7.

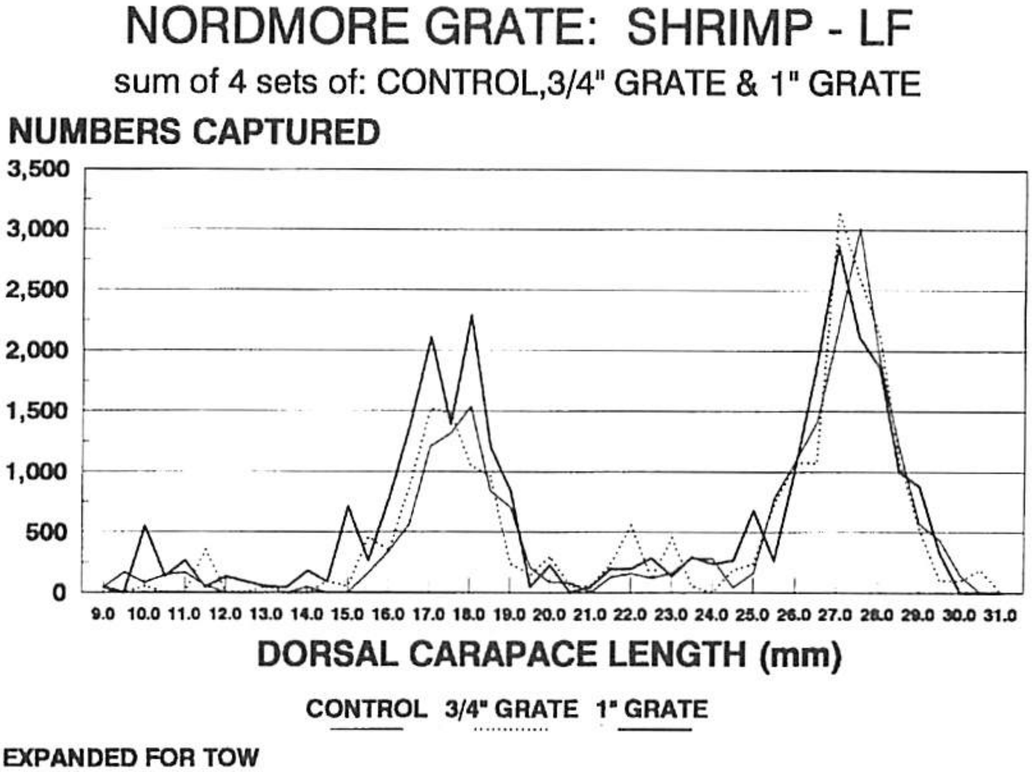


Figure 8.

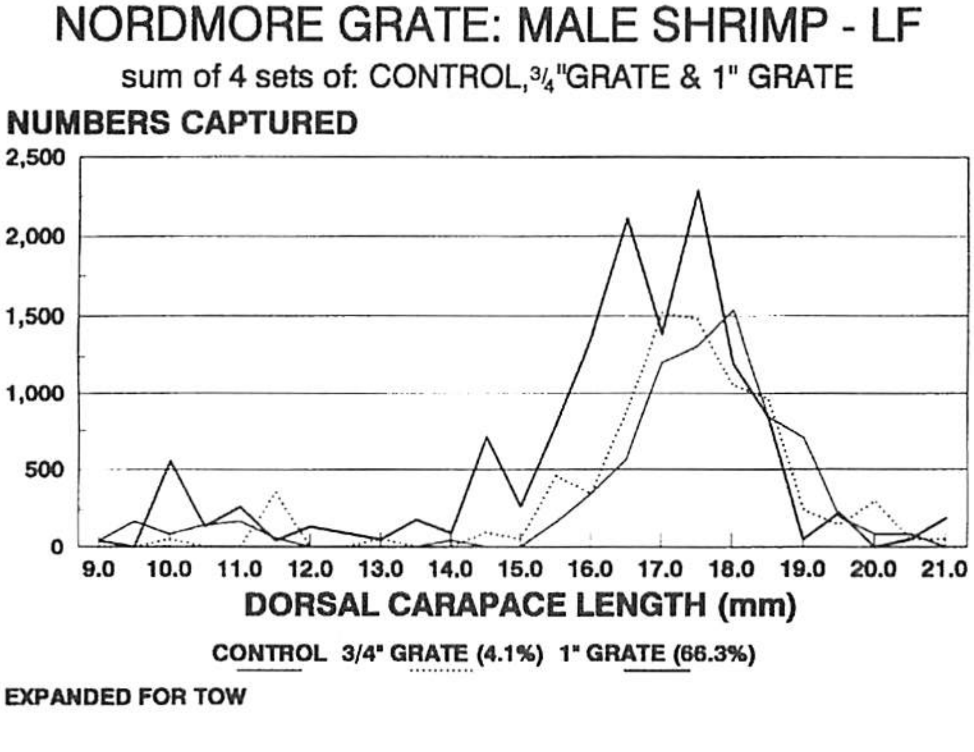
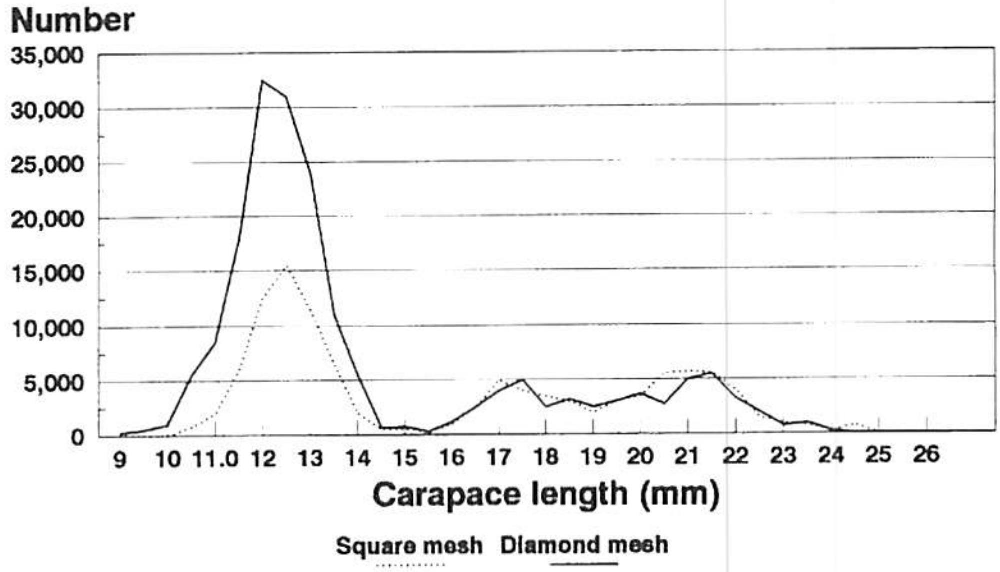


Figure 9.

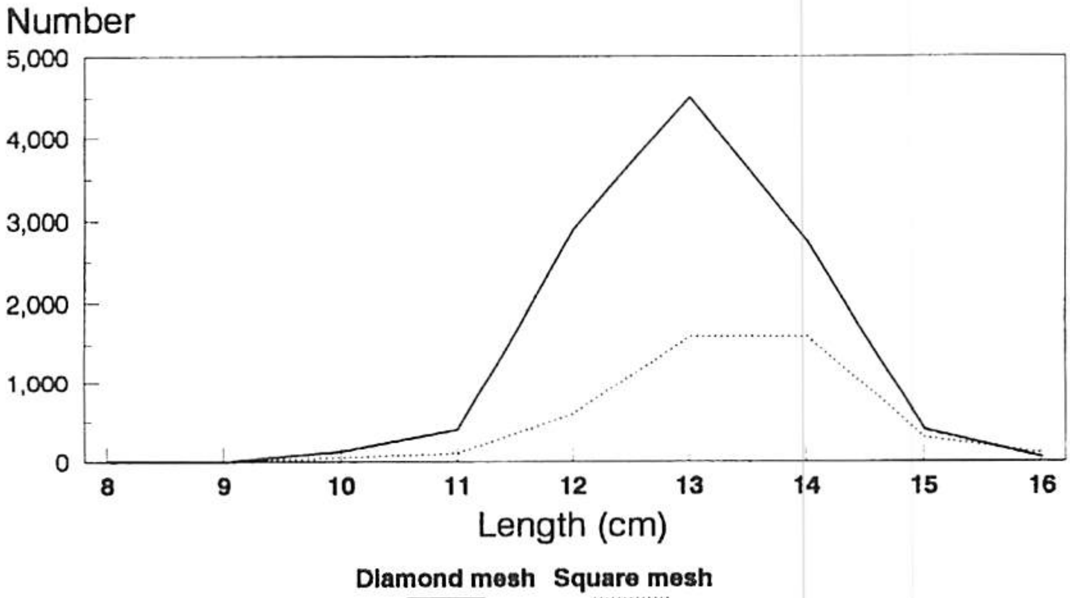
Length distributions of shrimp by number in square and diamond mesh codends in Isafjardardjup.



From THORSTEINSSON G., 1992.

Figure 10.

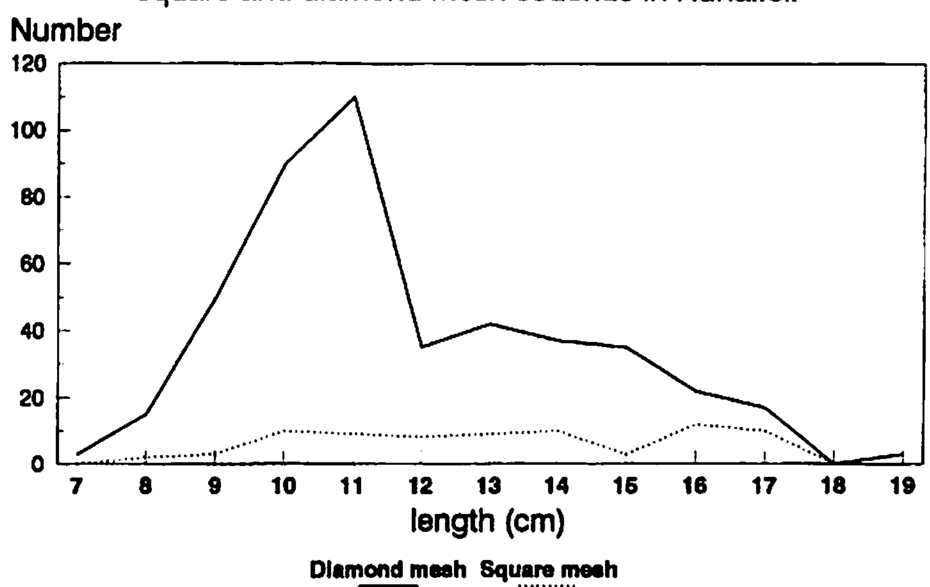
Length distribution of haddock by number in four pairs of tows in square and diamond mesh codends in Isafijardardjup.



From THORSTEINSSON G., 1992

Figure 11.

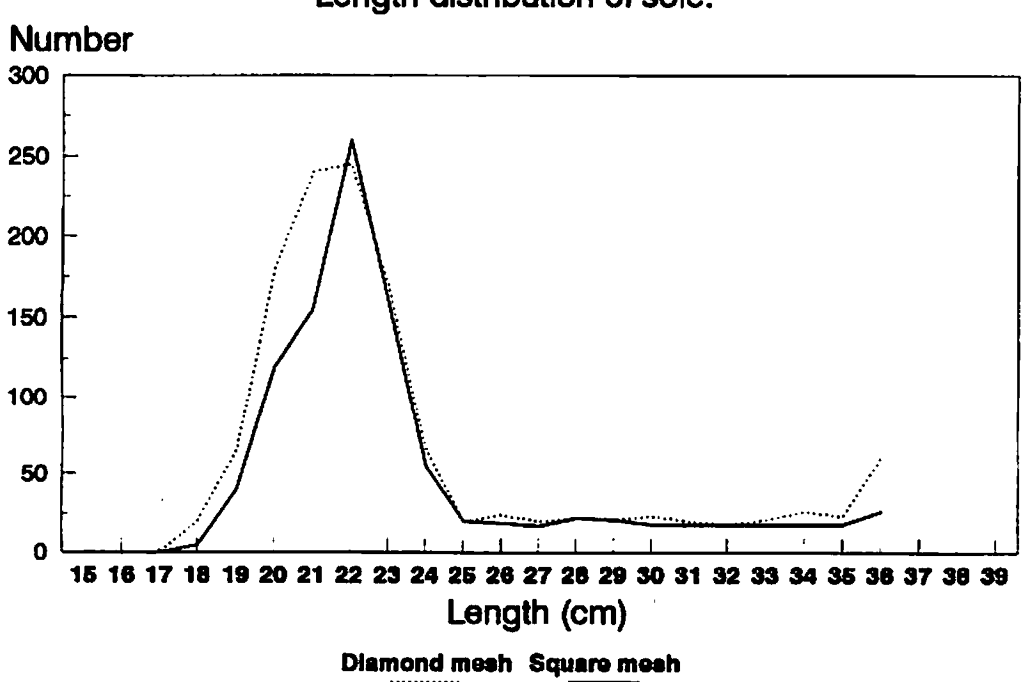
Length distribution of whiting by number in square and diamond mesh codends in Hunafloi.



From THORSTEINSSON G., 1992

Figure 12.

Length distribution of sole.



From FONTEYNE R., ET AL. 1992.

Southeast Shrimp Fishery

Finfish Excluder Devices in the South Atlantic Shrimp Fishery

David L. Harrington
University of Georgia Marine Extension Service

The rule of thumb that provides the efficiency of the Gulf shrimping operation is simplicity in gear, methods, and techniques. Small crews of two to three men can handle four large trawls, sort and ice the catch, cook, navigate, and maintain an engine room. No other fishery is as efficient. Complicated gear does not fit this type of operation.

Since the early days of commercial shrimp trawling, fishermen were creative in their gear development when it came to excluding cabbage-head jellyballs. This same creativity in the south Atlantic waters was the forerunner of the Turtle Excluder Device (TED), as a turtle jammed in the jellyball shooter caused a complete loss of production. Fishermen continue to develop devices that allow them to maintain production and quality of their shrimp. This is evident in the Bycatch Reduction Device (BRD), known in the industry as a "Fisheye," or the application of "hummer lines" to avoid fish capture.

If any lesson was learned during the TED saga, it should have been that devices put in trawls must be simple and are best designed by fishermen. The door to acceptance of TEDs by industry was opened when simple, shrimper-designed devices were certified. All TEDs in use today are based on the original jellyball excluders, not ones designed by nonfishermen. In this context, we foresee long-standing finfish reduction devices, such as the Cameron fisheye, as acceptable gear in the bycatch issue.

Since TEDs have been mandated in the shrimp fishery, there have been significant contributions to bycatch reduction. It is known that different TED types have exclusion rates between 4 and 32 percent, and individual TEDs exclude certain species at yet higher rates. Although it was never scientifically measured, shrimpers feel the Morrison TED excludes both menhaden and silver eels at rates greater than 80 percent.

It would be a great disservice to the fishing industry not to recognize 1) the exclusion rates of TEDs, 2) how each can be modified to increase or decrease such rates, and 3) an exclusion credit for TEDs. It would be an even greater disservice not to let the general public know of this contribution.

If a BRD existed that significantly reduced bycatch from shrimp trawls without economic injury to fishermen, then we wouldn't have to consider a credit for TEDs. But no such BRD exists, and the more complicated the BRDs get to reduce more or certain fishes, then the more incompatible to the shrimping operation they become.

Depending on fish species and TED types, finfish exclusion can be either sensory or physical. Menhaden and silver eels, for example, exclude nicely from the top-shooting Morrison soft TED, but not from the bottom-exiting hard TEDs. Conversely, whiting, flounder, spot, and croaker have good exclusion rates from Georgia Jumper-style TEDs.

Any single hard TED can have different exclusion rates depending on such features as bar spacing, bar diameter, flap arrangement and the use or non-use of an accelerator funnel. Similarly, the stretched mesh size of the Morrison TED can be reduced from 8 inches, so increasing the exclusion rate. University of Georgia data, as well as Australian fisheries research, indicate 31 to 32 percent bycatch reduction for the 8-inch Morrison. Matagorda Bay fishermen commonly install 6-inch Morrisons when small jellyballs occur. The exclusion rate for the 6-inch Morrison is unknown but certainly higher than 32 percent.

The exclusion rates for certain TEDs are shown in Figure 1. Table 1 is an accumulation of TED bycatch reduction research from several organizations.

Different exclusion rates for the same Georgia hard TED are shown in Figure 2. As compared to 11 percent, the 24 percent reduction rate exhibits the effects of bar spacing and lack of a funnel on bycatch reduction. Since these data have been collected, modifications to the flap arrangement of Super Shooter hard TEDs has reduced the bycatch exclusion rate for that device to around 4 percent. However, not all fishermen adhere to this evolved Super Shooter style flap. Indeed, many in Georgia use a flap which does not extend beyond the bottom of the TED and find such a flap arrangement excludes certain fish species at high rates.

Soft TEDs have significantly higher exclusion rates than hard TEDs. As mentioned earlier, the Morrison had an exclusion rate of 31 percent at the Cape Canaveral trials, while Australian researchers reported a 32 percent reduction. Bottom-shooting soft TEDs have significantly higher exclusion rates than top shooters (43–60 percent vs. 31–33 percent). The noncertified Golden TED, which is essentially a bottom-shooting Morrison but made from 6-inch mesh, had a 49 percent reduction rate against a Super Shooter control, which at that time had an 11 percent rate. Consequently, a 60 percent reduction value can be attributed to the Golden TED. Also, the Golden had a 2.2 percent increase in shrimp over the Super Shooter. (These data were collected on a commercial trawler during nighttime fishing off Apalachicola, Florida, with a NMFS observer on board).

There is a definite need for bottom-shooting soft TEDs, especially in "shell-ball" and sponge areas. These devices have exhibited extremely high finfish exclusion rates (greater than 50 percent). This fact, plus their acceptance by commercial fishermen, makes these devices near-ideal TED/BRDs. A 5-inch Andrew is approved, but this mesh size is unacceptable to parts of the industry because of a loss of bulldozer lobsters. However, it is gaining in popularity amongst fishermen in the western Gulf of Mexico. Larger mesh bottom-shooting soft TEDs have been tested for certification but failed the small turtle protocol. Since NMFS has improved the conditioning and trawl injection methods for these small turtles, many researchers feel the same devices that originally failed would now pass. The necessity of getting such a device certified has prompted them to consider a smaller mesh along the excluder panel edges—a subject they didn't wish to address earlier. Individual fish species reduction for these devices is not known.

The reduction rate of juvenile red snapper from bottom-excluding soft TEDs is a high priority research item of Texas A&M and University of Georgia gear specialists and the Gulf and South Atlantic Fisheries Development Foundation. The exclusion rates of standard certified TEDs on red snapper has not been well documented, and research on these devices is needed.

NMFS has good video evidence demonstrating the difficulty in getting small red snapper out of a trawl. They do not, however, know what percent, if any, of the small red snapper that enter the trawl exit the TED hole. The 5-inch Andrew may well be the ideal TED/BRD to solve the red snapper problem. The fact that the Golden 6-inch and Andrew 8-inch had overall exclusion rates in excess of 50 percent demands testing of the 5-inch Andrew on red snapper.

TEDs can also become more efficient BRDs with changes in trawl configuration. Standard bags or codends are usually 120 meshes in length. Small boats generally use shorter bags of 80 or 60 meshes. Using the same TEDs as larger boats, the short-bag/TED configuration commonly found on small boats will exclude a greater percentage of fish out the TED hole. The short bag does not collapse as easily as the long one, so fish are not trapped during the panic stage of haulback. Research conducted on the R/V *Georgia Bulldog* showed a 29 percent increase in bycatch reduction using an 80-mesh length bag versus a 120-mesh bag. Small boats should be credited for this greater reduction.

The bycatch problem should be clearly defined as to whether it is a biological, political, recreational, allocation, or nonutilization (waste) issue. Blaming the decline of any fish species on shrimp trawl bycatch mortality may not have the merit some claim. In the early days, shrimp trawl bycatch was defined as waste or nonutilization, and many efforts were undertaken to utilize it. However, it never was economically feasible to ice down fish for 1.5 to 2.0 cents per pound, and if the boats did, no dock could afford to handle them.

It's quite possible Gulf red snapper can be defined as a biological problem; however, we on the East Coast hear different views from credible sources. We have a recreational problem when sport fishermen perceive they would have better catches if trawl bycatch was reduced. As many biologists feel there is no genetic connection between south Atlantic weakfish and the impacted Chesapeake stock, we define the weakfish as a political problem. There is a definite danger in assuming the opposite is true. Should a mandatory 50 per-

The bycatch problem should be clearly defined as to whether it is a biological, political, recreational, allocation, or nonutilization (waste) issue.

cent reduction of weakfish from shrimp trawls not result in a stock recovery by a prescribed year, there then would be pressure to increase the reduction rate. This would involve more complicated gear put into the trawls.

If bycatch can honestly be defined as a waste problem for certain species, then address it as such. *Instead of magical recovery formulas, go by the dictum of reducing bycatch as much as possible without economic injury to the industry.*

In brief, there is a need to establish 1) the bycatch reduction rates of the various TEDs, 2) the species-specific reduction rates of various TEDs, and 3) the reduction rates of similar TED/trawl feature combinations.

The bycatch issue is being partially addressed with TEDs. We realize this will not be the answer, but TEDs and TED/BRD combinations, such as shorter bags, can significantly address the problem. Fishery managers would be both socially and scientifically wise to give credit for these contributions. Our hats are off to the Georgia DNR, South Carolina DNR, and the Atlantic States Marine Fisheries Commission for doing just such.

The key elements in the solution of the bycatch problem are finfish reduction, shrimp retention, simple gear, and industry involvement. How better would the fisherman's attitude be if we gave him credit for what he knows he's contributing with TEDs?

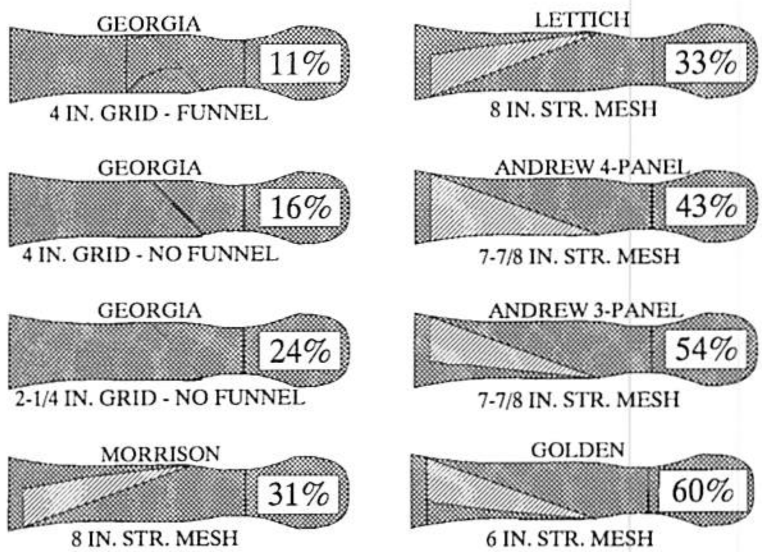


Figure 1. Bycatch reduction of various TEDs

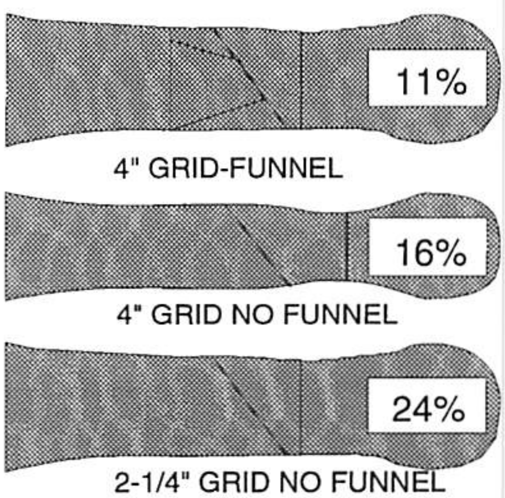


Figure 2. Bycatch reduction rates of Georgia-type TEDs with different structural features.

Table 1. TED exclusion rates for finfish and/or biomass against an identical net with no TED (Unless otherwise noted)

TED TYPE	WHO	WHEN	WHERE	SPACING	TOWS	%F	%B
TX-Matagorda	UGA-BULLDOG	Aug 86	Cape Can., FL	1.75 in	20	47	45
NMFS-collaps. w/funnel	UGA-BULLDOG	Aug 86	Cape Can., FL	4.5 in	7	NA	35
NMFS-collaps. w/o funnel	UGA-BULLDOG	Aug 86	Cape Can., FL	4.5 in	13	NA	57
LA-Cameron TED	UGA-BULLDOG	Aug 86	Cape Can., FL	2.0 in	20	18	34
GA-Jumper	UGA-BULLDOG	Aug 86	Cape Can., FL	2.37 in	20	13	24
NMFS-collaps.	SC-DNR	Jul-Aug 86	Charleston, SC	4.5 in	30	55	NA
GA-Jumper	SC-DNR	Jul-Aug 86	Charleston, SC	2.37 in	30	37	NA
NMFS-collaps.	SC-DNR	Oct-Nov 86	St. Helena Sound, SC	4.5 in	10	55	NA
GA-Jumper	SC-DNR	Oct-Nov 86	St. Helena Sound, SC	2.37 in	10	37	NA
Morrison Soft	UGA-BULLDOG	Jul 87-Jan 88	St. Simons Is., GA	8 in str.	48	NA	24
Morrison Soft	UGA-BULLDOG	June 87	Cape Can., FL	8 in str.	15	NA	31
Parrish TED	UGA-BULLDOG	Oct 87	Cape Can., FL	8 in str.	10	NA	73
Morrison Soft	Fisheries Research Inst., Australia	Oct 91	New South Wales, Australia	7.75 in str.	24	NA	32
GA TED, no funnel	NMFS	Mar 88-Jul 89	Gulf & S. Atl. Areas	4 in	256	16	NA
GA TED, w/funnel	NMFS	Mar 88-Jul 89	Gulf & S. Atl. Areas	4 in	450	11	NA
GA TED, w/funnel	NMFS	Sep 89-Aug 90	Gulf & S. Atl. Areas	4 in	188	9	NA
Super Shooter, w/funnel	NMFS	Sep 89-Aug 90	Gulf & S. Atl Areas	4 in	237	4	NA
Golden Soft TED (against Super Shooter TED)	NMFS- Observer	July 91	Apalachicola, FL	6 in str.	11	49	NA
Andrews 3 Panel	UGA-BULLDOG	July 91	Cape Can., FL	7 7/8 in str.	5	NA	54
Andrews 4 Panel	UGA-BULLDOG	July 91	Cape Can., FL	7 7/8 in str.	21	NA	43
Lettich Soft TED (old style)	UGA-BULLDOG	June 87	Cape Can., FL	8 in str.	10	NA	35
Lettich Soft TED (new style)	UGA-BULLDOG	Oct 87	Cape Can., FL	8 in str.	5	NA	18
GA-Jumper	NC-DMF	Sept 88	off Beaufort Inlet, NC	4 in	14	17	NA
GA-Jumper	NC-DMF	Sept 88	off Beaufort Inlet, NC	2.37 in	6	20	NA
Parrish TED	NC-DMF	Sept 88	off Beaufort Inlet, NC	8 in str.	18	75	NA
Morrison Soft	NC-DMF	Oct 88	off Beaufort Inlet, NC	8 in str.	16	24	NA

%F = Percent finfish reduction
%B = Percent biomass reduction
SC-DNR = South Carolina Department of Natural Resources
NC-DMF = North Carolina Department of Marine Fisheries

Southeast Shrimp Fishery

Cooperative Shrimp Trawl Bycatch Research in the Southeast

Walter Shaffer
Gulf & South Atlantic Fisheries Development Foundation
Bycatch Steering Committee

Work on the reduction of bycatch has been ongoing for 12 years, starting with the development of Turtle Excluder Devices (TEDs). Today there is a 97 percent exclusion of turtles from shrimp trawls. Presently there is a problem that is more of a public perception problem than one based on scientific information, the perception being a 9:1 finfish-to-shrimp ratio in Southeast and Gulf of Mexico shrimp trawls. The Atlantic States Marine Fisheries Commission has decreed that there will be a 60 percent reduction of finfish bycatch—namely, red snapper, croaker, and weakfish—in shrimp trawls. However, South Carolina sees no detriment to fish stock sizes caused by shrimp trawls.

In 1992 a three-year, $7.4 million bycatch program was started to assess the impacts of shrimp trawls on finfish populations. The program is an exclusive cooperative effort, with strong participation by the shrimp industry, state universities, sportfishing interests, and the conservation community. Funding has come from available sources, which has reduced the need for "new" funding. The purpose of the program is to: (1) determine bycatch-induced mortality on the affected stocks; (2) identify other mortality sources; (3) assess the status of the stocks; (4) evaluate management options; and (5) design effective gear and non-gear options. Field studies were conducted from February 1992 to August 1994.

Preliminary results indicate a finfish-to-shrimp ratio of 2.3 :1 pounds and 1.6 :1 total numbers in the Southeast, and 4.3 :1 pounds and 2.8 :1 total numbers in the Gulf of Mexico.

Southeast Shrimp Fishery

A Cooperative Research Program Addressing Finfish Bycatch in the Gulf of Mexico and South Atlantic Shrimp Fishery

John W. Watson
National Marine Fisheries Service Southeast Fisheries Center

Abstract: *Research to develop bycatch reduction devices (BRDs) for use by the shrimp trawl fishery in the southeast United States has been conducted under a regional cooperative program involving industry, state and federal research agencies and state universities. This research was initiated in response to the need to reduce fish mortality in shrimp trawls in order to recover stocks of depleted fish, in particular the red snapper* (Lutjanus campechanus). *A total of 82 gear designs have been evaluated since this project was initiated in 1990. Evaluations have included observations of fish behavior, video documentation of operational characteristics, water flow measurements, and delineation of water flow patterns.*

Prototype designs have been developed by commercial fishermen, net shops, gear technicians, and fishery biologists. Proof-of-concept evaluations have been conducted on commercial shrimping grounds for 24 designs, and three designs are being evaluated by commercial fishermen. The designs with the best performance were the top-position fisheye and the extended funnel design. The data indicate that use of these devices can reduce fishing mortality for red snapper in the shrimp trawl industry by 50 to 60 percent. The devices may also allow for recovery of the snapper stocks to 20 percent spawning stock potential by 2009 if the total allowable take by directed fisheries is limited to 6 million pounds.

In response to mandates of the Magnuson Fishery Conservation and Management Act amendments passed by Congress in 1990, the National Marine Fisheries Service Southeast Region has developed a program in cooperation with the Gulf and South Atlantic Fisheries Development Foundation to address shrimp trawl bycatch. One of the objectives of this program is to identify, develop, and evaluate gear options for reducing bycatch in the Gulf and South Atlantic shrimp fisheries. The research plan calls for gear modification studies to be conducted in inshore, nearshore, and offshore waters, focusing on key FMP-managed species—Gulf red snapper, Atlantic weakfish, king mackerel and Spanish mackerel—and coordinated through a technical review panel. The technical review panel is responsible for selecting the best prototype gear modifications for commercial evaluation, for monitoring testing in different shrimping areas, and for prioritizing gear modification options for management consideration.

The goal of the gear development project is to develop shrimp-trawl gear modifications and/or fishing tactics that are capable of reducing the bycatch of finfish with minimum loss of shrimp production. Specific objectives of the program were to evaluate existing bycatch reduction techniques, to collect data on behavior of fish and shrimp in trawls, and to develop and evaluate new bycatch reduction techniques. The key species targeted for reduction are red snapper, weakfish, king mackerel, and Spanish mackerel.

The research plan developed in 1992 by the Gulf and South Atlantic Fisheries Development Foundation (GSAFDF) identified a four-phase gear development program that included:

1. *Initial design and prototype development*—The full technical range of trawl design and modification approaches was identified. Industry techniques, ideas solicited from fishermen, net shops designs, and research studies conducted by various research groups were evaluated. Fish behavior, gear instrumentation, and gear performance studies were conducted on each design using SCUBA, remote video cameras, and other techniques. This work evaluated fish behavior and feasibility of prototype concepts. The results of this phase were subjectively evaluated based on the experience and expertise of the gear designer and research team. Operational data was taken on the modified net, and preliminary catch performance data obtained during comparative gear trials. The second phase of development was initiated once a design

was determined to offer bycatch reduction potential and was integrated into the construction of a net.

2. *Proof of concept*— Objectives during this phase were evaluation of prototype devices on key species, determination of total finfish reduction rates, and establishment of shrimp catch rates. Proof-of-concept testing evaluated adequacy of design for safety and for problems with operational use. Proof-of-concept testing was conducted under a specific scientific protocol developed under the NMFS Shrimp Trawl Bycatch Research Requirements (NMFS, 1991). The most successful designs were prioritized based on proportional bycatch reduction and shrimp retention; these were reviewed by a technical review panel for inclusion in operational evaluation by the commercial shrimping industry throughout the Southeast.

3. *Operational evaluation*— The objective in this phase was to test the Bycatch Reduction Device/Turtle Excluder Device gear combination against a standard TED net under conditions encountered during commercial shrimping operations. Trained observers were placed aboard cooperating commercial vessels to collect data on both shrimp and finfish catch rates as well as species composition. BRD/TED combinations were tested on trawlers using the same TED employed in both the test and control gear. Testing was conducted over a wide range of geographic areas, seasons, and conditions.

4. *Industry evaluation* — The commercial shrimping industry will be responsible for fleet testing of candidate BRDs.

Evaluation results

A total of 82 BRD designs have been evaluated by the National Marine Fisheries Service Harvesting Systems Division between 1990 and 1994. Of these designs, 24 were recommended for proof-of-concept testing. These designs included modified trawl designs, modified TED designs, fisheye designs, funnel designs, and fish stimulator designs. Three of these designs were approved by the gear review panel for operational evaluation, based on their performance in the proof-of-concept phase. These designs include the top position fisheye design (Figure 1), the expanded mesh design (Figure 2), and the extended funnel design (Figure 3).

Operational testing of these designs was conducted on commercial shrimp vessels in the Gulf of Mexico by the National Marine Fisheries Service (NMFS) Galveston Laboratory and the Gulf and South Atlantic Fisheries Development Foundation (GSAFDF), and in the South Atlantic by GSAFDF and the North Carolina Department of Marine Fisheries (NCDMF).

Shrimp loss rates from operational testing in the Gulf of Mexico are shown in Figure 4. The top position fisheye was tested in two positions, 30 meshes and 45 meshes back from the front of the codend on 120-mesh codends. Shrimp loss rates for the fisheye BRD were 3 percent for the 30-mesh position and 7 percent for the 45-mesh position (GSAFDF). There was no shrimp loss for the expanded mesh BRD (NMFS) or the extended funnel BRD (GSAFDF).

Reduction rates for key species are shown in Figure 5. Reduction rates for red snapper were 41 percent for the top-position fisheye (30m), 24 percent for the top-position fisheye (45m), 26 percent for the extended funnel, and 0 percent for the expanded-mesh BRD. Snapper mortality rate reduction based on reduction by size class was 40 to 52 percent (Figure 6) for the fisheye (45m) and 50 to 60 percent for the extended funnel (Figure 7). Reduction rates for trout *(Cynosion spp)* were 19 percent for the fisheye (30m), 38 percent for the fisheye (45m), 34 percent for the expanded mesh, and 15 percent for the extended funnel (Figure 5). Reduction rates for king mackerel were 0 percent for the fisheye (30m), 79 percent for the fisheye (45m), 25 percent for the expanded-mesh BRD, and 25 percent for the extended-funnel BRD (Figure 5). Spanish mackerel reduction rates were 0 percent for the fisheye BRDs, 56 percent for the expanded-mesh BRD, and 54 percent for the extended-funnel BRD. Reduction rates for king and Spanish mackerel are not statistically significant, and values may change with more data. Reduction rates for abundant species in the Gulf of Mexico are shown in Figure 8. Good reduction rates were achieved by all three BRD designs for abundant species.

Results of operational evaluations in the South Atlantic by the Gulf and South Atlantic Fisheries Development Foundation were analyzed for the top-position fisheye in the 30-mesh and 45-mesh positions and with different TED types. The analysis was conducted for shrimp, croaker, spot, and weakfish. Only statistically significant reduction rates are presented. Reduction rates by weight for the top-position fisheye in the front (30m) and middle (45m) positions are presented in Figure 9. There was no statistically significant difference in shrimp catch rates between the fisheye-equipped trawl and the control trawl. The front-position fisheye had reduction rates of 41 percent for croaker, 38 percent for spot, and no significant difference for weakfish by weight. The middle-position fisheye had reduction rates of 32 percent for spot and 68 percent for weakfish by weight. Reduction rates for these species by number is presented in Figure 10.

There was no difference in shrimp catch rates by number for the front- and middle-position fisheye BRDs. Significant reductions of 32 percent for croaker, 26 percent for spot, and 30 percent for weakfish were obtained for the front-position fisheye BRD. Reduction rates for the top-middle–position fisheye installed in nets with three different TEDs are shown in Figure 11. There was no significant difference in shrimp catch rates. Significant reductions for croaker, spot, and weakfish were obtained with the fisheye installed in Super Shooter TEDs, and significant reductions of spot and weakfish were obtained with the fisheye installed in a Georgia TED. Significant reductions by number were obtained for croaker, spot, and weakfish with the fisheye installed in the Super Shooter design TED (Figure 12).

Regulatory follow-up

Extensive evaluation of the three BRDs recommended for commercial evaluation by the gear review panel under the cooperative research program indicates that these devices effectively reduce fish bycatch with minimum reduction in shrimp production. A complete statistical analysis of the total BRD evaluation database will be conducted in June 1995, in order to allow the gear review panel to prioritize gear modification options for management consideration.

Regulatory language will be written within technical guidelines set forth by the gear review panel in order to allow flexibility within the commercial industry to improve performance. This flexibility will operate within specifications that ensure effectiveness of the gear to achieve management goals.

Reduction rates vary for the recommended BRDs by species and in combination with different TED designs, which also have variable reduction rates. Regulations should take into account this variability. In the Gulf of Mexico, for example, red snapper is under a management plan that may include mandatory use of BRDs. The extended-funnel and top-position fisheye provide significant reduction in fishing mortality for red snapper, but the expanded-mesh BRD does not. In the South Atlantic, weakfish is under a similar management plan, and in this case all three of the recommended BRDs effectively reduce weakfish within specific parameters of BRD size and placement. These parameters must be defined.

Specific gear recommendations will be made after detailed analysis of BRD evaluation data has been conducted to analyze effects of size, placement, and other factors that must be defined in recommendations in preparation for drafting regulatory language.

Figure 1.

Fisheye Positions

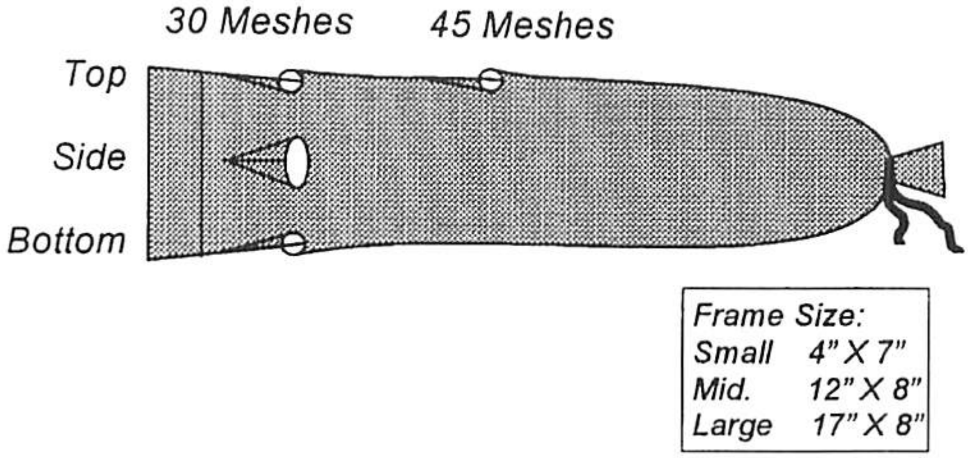


Figure 2.

Expanded Mesh
(Two Positions)

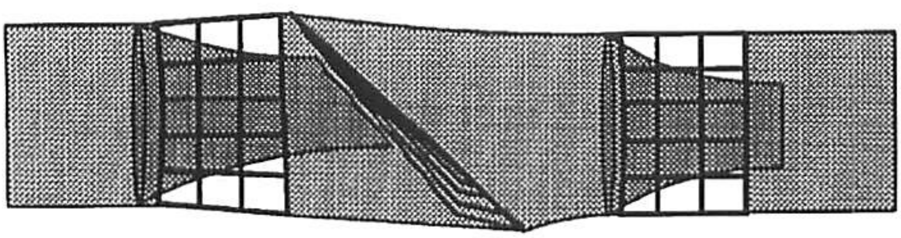
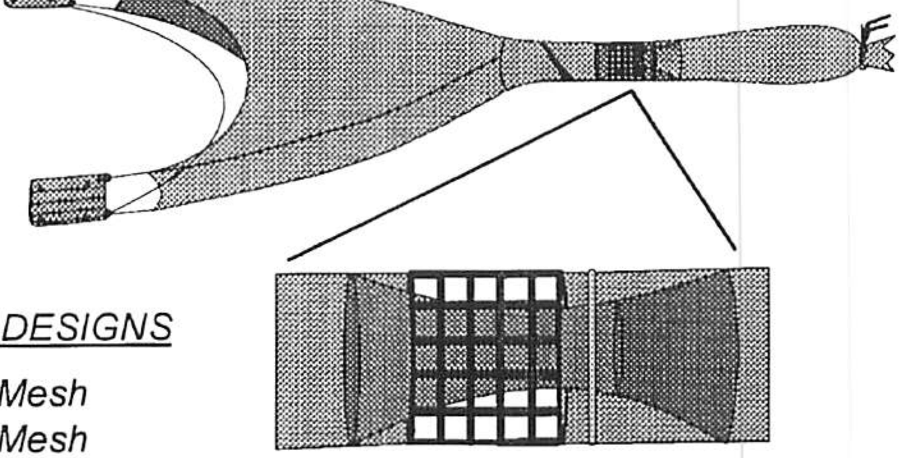


Figure 3.

Extended Funnel



TWO DESIGNS

5 Mesh
3 Mesh

Figure 4.

Reduction Rates For Shrimp (Gulf of Mexico)

	Fisheye (30m)	Fisheye (45m)	Extended Funnel	Expanded Mesh
n	119	150	162	120
SHRIMP	3%	7%	+3%	0%

Figure 5.

Reduction Rates for Key Species

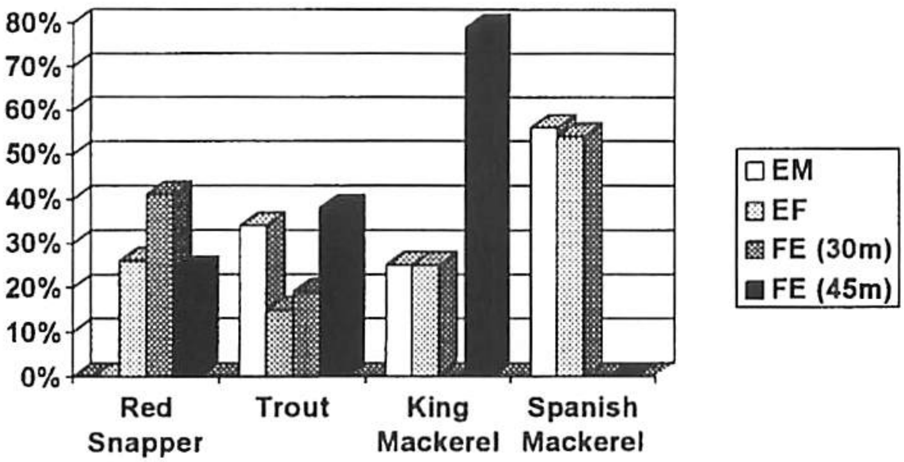


Figure 6.

Red Snapper Reduction by Size

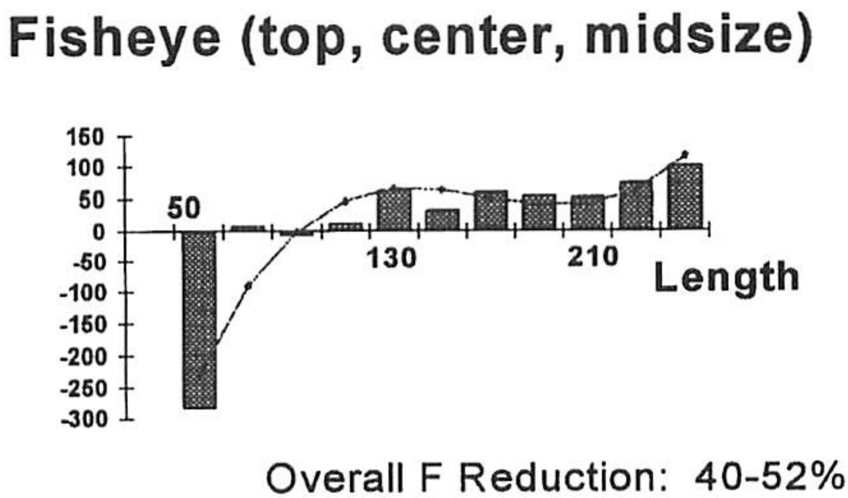


Figure 7.

Red Snapper Reduction by Size

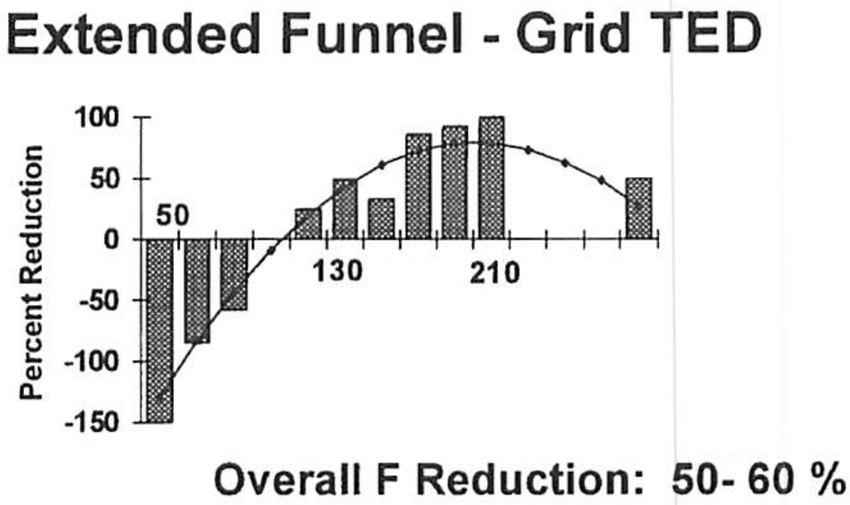


Figure 8.

Reduction Rates for Abundant Species (Gulf of Mexico)

	Fisheye	Extended Funnel	Expanded Mesh
n	341	162	120
Croaker	19	48	56
Spot	15	72	66
Porgy	25	16	43
Butterfish	82	34	40
Bumper	47	59	59
Catfish	74	95	73
Whiting	67	54	66

Figure 9.

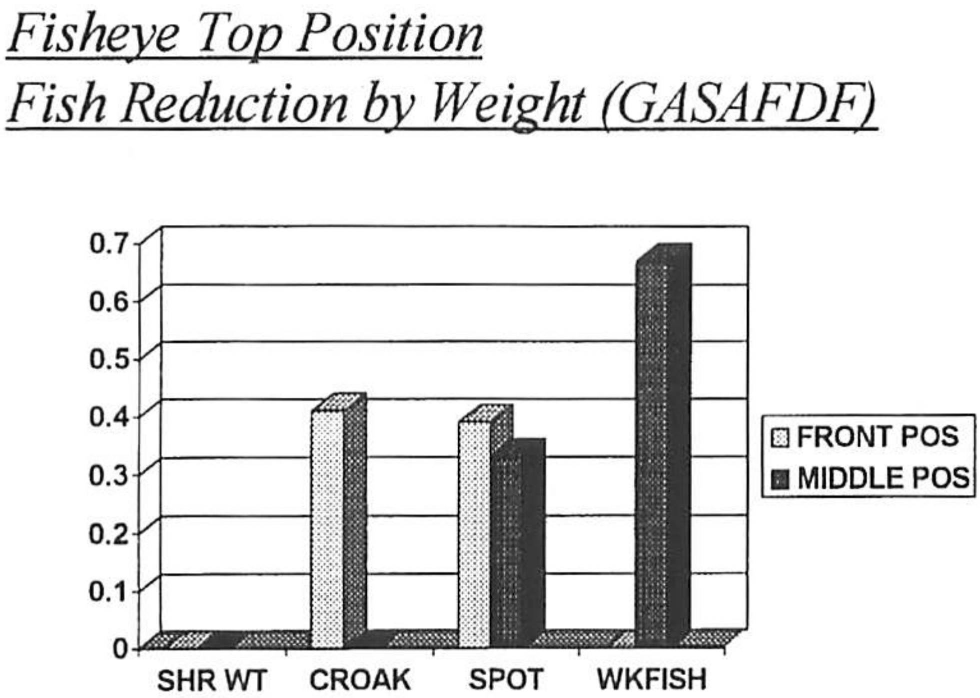


Figure 10.

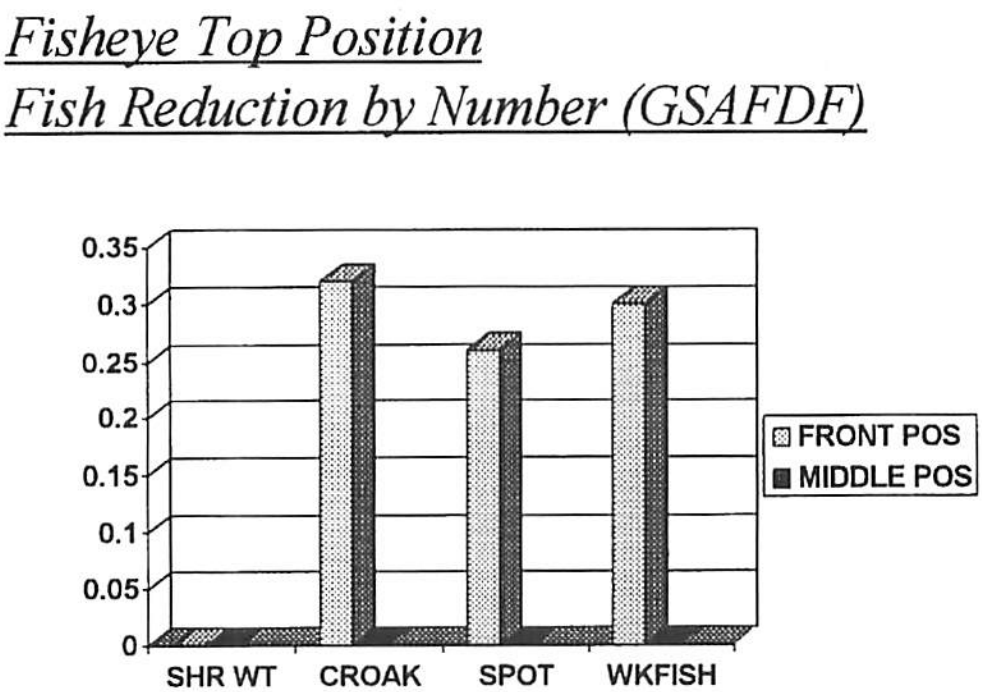


Figure 11.

Fisheye Top Middle Position
Reduction by weight (GSAFDF)

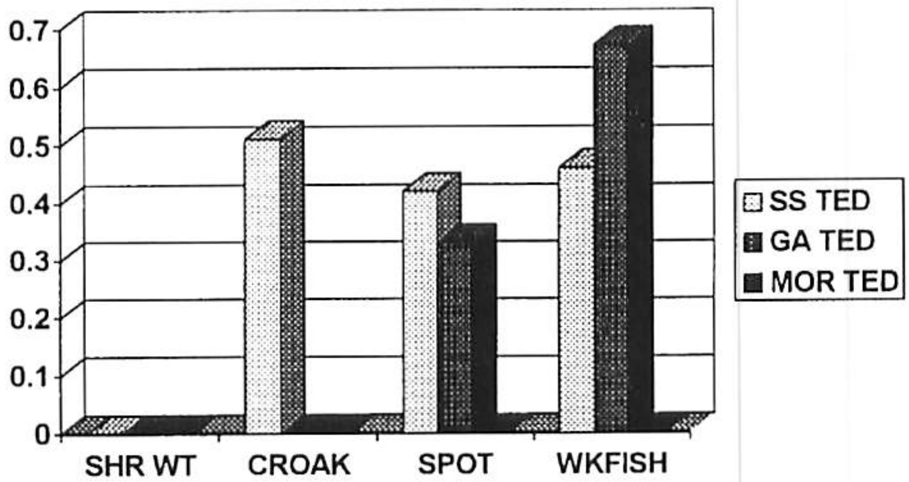
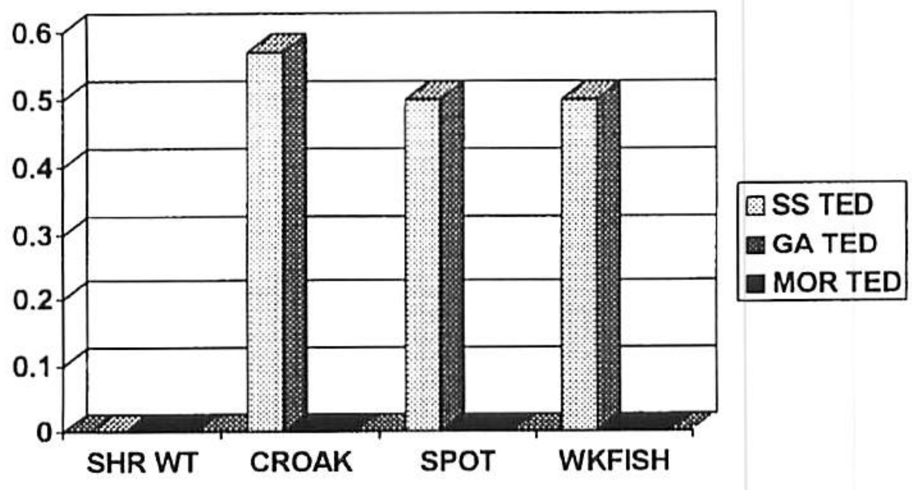


Figure 12.

Fisheye Top Middle Position
Fish Reduction by Number (GSAFDF)



Southeast Shrimp Fishery

Effectiveness of Excluder Devices on Bycatch Reduction and Shrimp Retention

Sean McKenna
North Carolina Department of Environment, Health & Natural Resources, Division of Marine Fisheries

The North Carolina coastal fishing industry contributes over $500 million to the state's economy each year. The shrimp fishery represents one of North Carolina's most important fisheries, with an average dockside value of $15.6 million [North Carolina Division of Marine Fisheries (NCDMF) landing data 1985-1990]. This fishery is dependent upon three species of shrimp, brown (*Penaeus aztecus*), pink (*P. duorarum*) and white (*P. setiferus*). Over 95 percent of the shrimp landed in North Carolina are captured by otter trawls. Due to the nonselective nature of this gear, concerns have been raised about the incidental capture of finfish and sea turtles in conjunction with this fishery.

During the 1980s the NCDMF and NMFS conducted studies on shrimp retention rates for various TEDs (1985-1986 DMF unpublished data, and 1988-1989 NMFS unpublished data), and started work on identifying means to reduce finfish bycatch in the shrimp trawl fishery (Pearce et al. 1988, and Holland 1988). In response to mandates of the Magnuson Fishery Conservation and Management Act amendments passed by Congress in 1990, the NCDMF initiated a gear development program to reduce bycatch in the inshore shrimp and ocean flynet fisheries (McKenna and Monaghan 1993). In 1991 Amendment 1 to the Weakfish Fishery Management Plan (FMP) was adopted. This amendment recommended that South Atlantic states implement programs to reduce bycatch mortality of weakfish in their shrimp trawl fisheries by 50 percent by January 1, 1994. Based on results obtained during development work in 1990 and 1991 on NCDMF research vessels and operational testing conducted aboard a commercial trawler in 1992, the NCDMF required all shrimp trawlers working in state waters to equip their nets with functional fish excluders in October 1992. However, North Carolina is currently the only state on the Atlantic and Gulf coasts that requires finfish excluders in all shrimp trawls. On October 20, 1994, Amendment 2 of the weakfish FMP was passed. This amendment requires that all South Atlantic states (NC-FL) implement management measures to achieve the 50 percent reduction in bycatch of weakfish in the shrimp trawl fisheries for the 1996 shrimping season.

The shrimp fishery in North Carolina is very diverse in terms of participation, vessel and gear characteristics, and physical characteristics of the areas fished. There are between 1,500 and 1,800 full-time commercial shrimpers, approximately 2,000 part-time commercial, and 3,500 to 3,800 recreational shrimpers in the state. Actual fishing strategies and equipment vary with geographical location, bottom type, target species, and other factors. To realize the optimum benefits of a given BRD or TED/BRD design, it is of the utmost importance to have specific data on shrimp retention and bycatch exclusion rates for various designs in different areas.

In 1994 the NCDMF conducted a study to: 1) develop effective bycatch reduction devices that minimize shrimp losses; 2) identify and evaluate appropriate BRD and TED/BRD designs for various geographic areas in North Carolina, and to integrate these gears into the shrimp fishery.

The following results are from work conducted aboard commercial trawlers. Two of the three BRD designs that underwent commercial evaluation in 1992 and 1994 meet the requirements of Amendments 1 and 2 of the weakfish FMP—50 percent reduction of weakfish by numbers (Table 1). FFEs are currently being utilized by over 80 percent of the shrimp trawlers in the state (close to 100 percent for recreational shrimpers). Reduction rates for selected species and total finfish and biomass for this gear are given in Table 2.

The effectiveness of this gear in reducing weakfish and other fish species is a function of the size of the FFE opening and the placement of the gear in the tailbag of the trawl. A minimum opening of 5.5" x 6.5" is required for the reduction of weakfish at the mandated level (Table 3). Placement in the tailbag is a function of the distance the gear is placed from the tailbag tie-off and general location in the net (top, side, or bottom). The distance from the tailbag tie-off is expressed as a ratio: BRD length/ tailbag length, where BRD length is equal to the distance from the tailbag tie-off to the opening of the FFE, and tailbag length is the length of the tailbag from the tie-off rings to the beginning of the tailbag (excluding any extension). To obtain a 50 percent value in weakfish reduction, this ratio cannot exceed 0.70 (Table 4). Data collected during the development of FFEs indicated that maximum reduction of weakfish was obtained when the FFE was placed 15 meshes to the side of the tailbag (Table 5). For commercial evaluation only two positions (15 meshes and 30 meshes) can be examined that also meet the aforementioned criteria (FFE at least 5.5" x 6.5", and BRD/ tailbag ratio less than 0.70). These data support NCDMF data in terms of optimum gear placement, which is 15 meshes to the side (Table 6).

The large mesh extended funnel (LMEF) showed very good potential in its ability to retain shrimp and exclude weakfish and other fish species (Table 7). 1994 was the first year that this device was used in North Carolina waters, and it is gaining popularity with the shrimping industry. Modifications to this gear (Figure 5) are currently being evaluated by the industry and the NCDMF.

Snake-eyes are a popular device in the southern part of the state. While this design showed good shrimp retention, weakfish exclusion rates fall well below the mandated level (Table 8).

Evaluation of three basic BRD designs indicates that specific FFE and LMEF designs effectively reduce weakfish bycatch to the mandated levels, with minimum reduction in shrimp production. The effectiveness of FFEs, however, depends on size and placement in the net.

Based on the results of this study, the NCDMF director will require, by proclamation, the use of either:

1) a Florida fish excluder (fish-eye) measuring at least 5.5" x 6.5" positioned 1/8th of the distance away from the top center of the tailbag and located no more than 65 percent up from the tailbag tie-off (tailbag length not to exceed 105 meshes) (see Figure 1)

or

2) a large mesh extended funnel (LMEF) (see Figure 2).

References

Holland, B. F., Jr. 1988. Evaluation of certified trawl efficiency devices (TEDS) in North Carolina's nearshore ocean. N. C. Dept. of Nat. Res. and Comm. Dev., Div. Mar Fish., Comp. Rpt, Project 2-439-R, 38 pp.

McKenna, S. A., and J. P. Monaghan Jr. 1993. Gear development to reduce bycatch in the North Carolina trawl fisheries. N. C. Dept. of Env. Health and Nat. Res., Div. Mar. Fish., Com. Rep. Project NA90AA-H- SK052, 75 pp.

Pearce, K.B., D.W. Moye, and S.K. Strasser. 1988. Evaluation of trawl excluder devices in the Pamlico Sound shrimp fishery. Albemarle-Pamlico Estuarine Study Rep. No. 88-07. 46 pp.

Table 1. Operational evaluation reduction rates for the three basic BRD designs tested in 1992 and 1994, aboard commercial trawlers in North Carolina

	GEAR		
	FFE	LMEF	SE
Year	92 + 94	94	94
n	213	36	49
Shrimp	-7.81	-2.06	-1.45
Weakfish (weight)	-53.37	-50.30	-22.90
Weakfish (numbers)	-57.63	-55.56	6.16
Total finfish	-48.27	-54.72	-8.69

Table 2. FFE reduction rates (kgs) for selected species and groups

	Total weight (kgs)		Percent
n=213	Control	FFE	reduction
Atlantic croaker	2,909.96	1,369.09	-52.95
Spot	1,500.52	739.92	-50.69
Weakfish	448.68	209.21	-53.37
Spanish mackerel	34.66	22.95	-33.79
King mackerel	0.38	0.21	-44.74
Total finfish	15,792.74	8,170.07	-48.27
Total biomass	24,051.29	17,276.45	-28.17

Table 3. Reduction rates (kgs) for selected species and groups for various sizes of FFEs

	FFE size		
	9"x9"	5½"x6½"	6½"x3½"
n	97	38	48
Atlantic croaker	-61.11	-40.76	-25.61
Spot	-55.18	-48.97	-23.21
Weakfish (weight)	-64.79	-71.31	37.41
Weakfish (numbers)	-58.62	-71.31*	37.41*
Spanish mackerel	-42.66	nc	-38.29
Shrimp	-8.52	-5.99	-5.76
Total finfish	-47.15	-32.61	-19.01
Total biomass	-36.17	-21.46	-1.21

nc = no catch
*=weakfish numbers estimated (#s=wgt/0.192), from Vaughan 1994

Table 4. Reduction rates (kgs) for selected species and groups for various BRD/tailbag ratios (FFEs GE 5½"x6½")

	BRD/tailbag ratio		
	0.4 - 0.5	0.5 - 0.6	0.6 - 0.7
n	64	31	60
Atlantic croaker	-59.46	-67.86	-31.77
Spot	-61.42	-57.83	-25.54
Weakfish (weight)	-73.91	-56.44	-49.75
Weakfish (numbers)	-64.46	-56.44*	-49.75*
Spanish mackerel	-73.04	0.00	-4.16
Shrimp	-8.08	-11.61	-4.82
Total finfish	-47.95	-55.50	-50.29
Total biomass	-37.60	-38.34	-11.52

*=weakfish numbers estimated (#s=wgt/0.192), from Vaughan 1994

Table 5. Reduction rates (kgs) for NCDMF gear placement tests. A 9"x9" FFE with a BRD/tailbag ratio of .57 was used

	FFE position		
	Top of tailbag	15 meshes to the side	Bottom of the tailbag
n	20	20	20
Atlantic croaker	-14.46	-17.97	-25.45
Spot	-5.75	-22.15	-52.01
Weakfish	0.00	-27.00	0.00
Shrimp	0.00	-3.00	-11.10
Total finfish	-3.59	-17.18	-40.26

Table 6. Reduction rates (kgs) for commercial gear placement

	FFE position	
	15 meshes to the side	30 meshes to the side
n	138	17
Atlantic croaker	-53.72	-84.16
Spot	-53.66	-66.16
Weakfish	-67.09	-39.67
Spanish mackerel	-33.55	nc
Shrimp	-7.95	-6.30
Total finfish	-49.03	-56.96
Total biomass	-28.73	-36.09

nc = no catch

Table 7. LMEF reduction rates (kgs) for selected species and groups

n = 36	Total weight (kgs) Control	LMEF	Percent reduction
Atlantic croaker	1,612.28	595.06	-63.09
Spot	668.11	191.04	-71.40
Weakfish	366.03	181.89	-50.30
Spanish mackerel	2.51	0.42	-83.26
Total finfish	3,442.78	1,558.75	-54.72
Total biomass	4,434.38	2,708.05	-38.93

Table 8. Snake-eye reduction rates (kgs) for selected species and groups

n = 50	Total weight (kgs) Control	Snake-eyes	Percent reduction
Atlantic croaker	557.97	534.79	-4.15
Spot	276.90	235.52	-14.94
Weakfish	74.96	55.93	-25.38
Spanish mackerel	2.91	3.69	0.00
Total finfish	1,186.65	1,091.60	-8.00
Total biomass	2,290.97	2,177.45	-4.95

Figure 1. Florida Fish Excluder

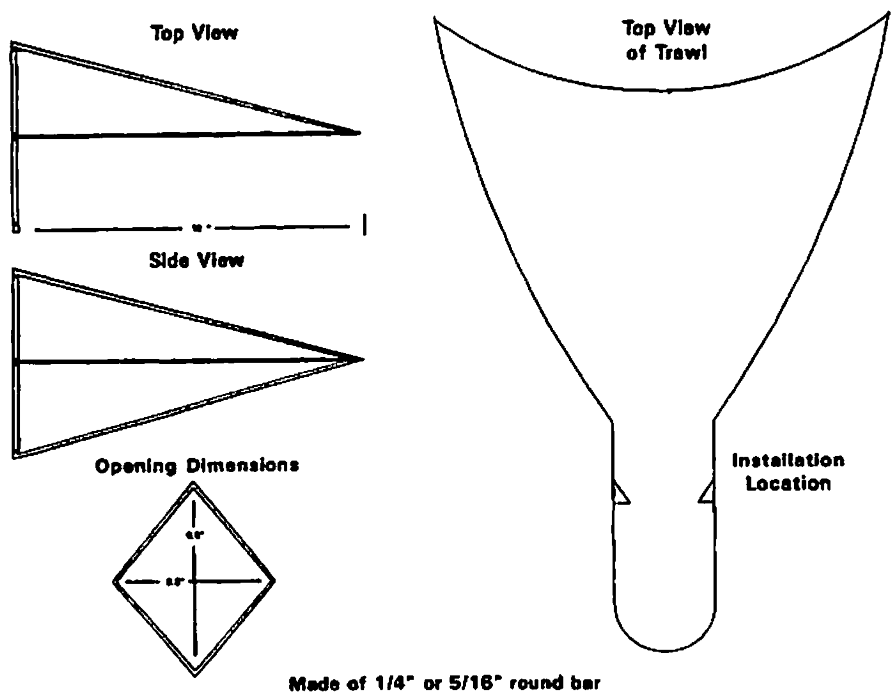
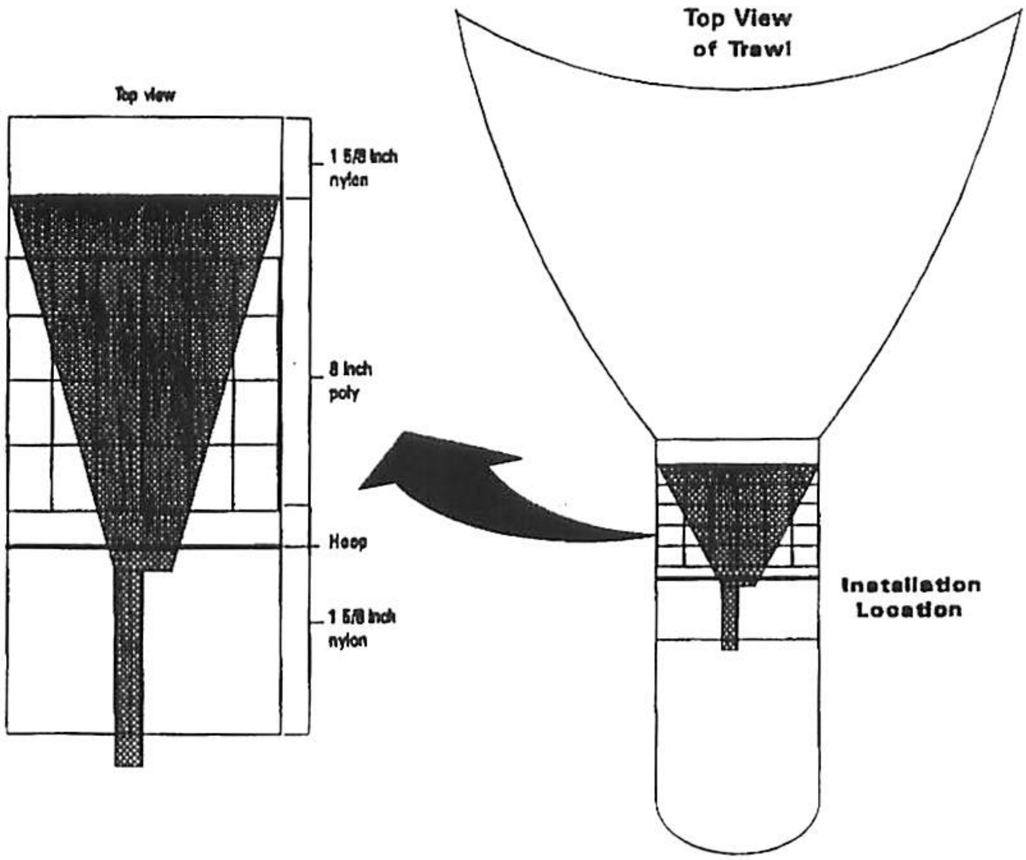


Figure 2. Large mesh extended funnel BRD (NMFS design).



Gulf of Maine Sink Gill Net Fishery

Heading Off Net Bans in Sink Gill Net Fishery

Bob MacKinnon
Massachusetts Gillnetters Association

We'll talk a little today about what's going on in the sink gill net fishery. One of the first questions is, why fish gill nets? Fishermen have found this to be a very selective fishery, both in size and species. It is habitat-friendly; it doesn't destroy the natural habitat. It is a passive fishery; with large mesh, juveniles are allowed to escape. It is also a fuel-efficient fishery. And it can be the most easily managed fishery, something the managers fail to understand.

Around 1990, harbor porpoise bycatch became a hot issue. Some fishermen were concerned because all we were hearing was that gillnetting would be banned because nothing was being done to stop the bycatch of harbor porpoise. Then, at a meeting concerning outfall pipes in Massachusetts Bay, some people involved with the harbor porpoise issue were talking about that problem. It hadn't seemed like such a big deal; different fishermen had only caught a few in the last few years. This discussion led to the idea for a meeting to discuss the harbor porpoise problem, and from that meeting, essentially, the Harbor Porpoise Working Group was formed. This was an ad hoc group made up of people from the National Marine Fisheries Service, New England Aquarium, Woods Hole, the Manomet Observatory program, the Center for Coastal Studies, New Hampshire Sea Grant, and various representatives from the gill net industry. Over time, people from Canada became involved, too.

The main interest of this group was addressing the problem of harbor porpoise bycatch and looking for solutions. It took time, but the group got together and got results. A gear workshop in Falmouth, Massachusetts, was one of the results. People from all over the world were in attendance. And now we have industry awareness, time-area closures, and, recently, a one-of-a-kind pinger experiment carried out on Jeffreys Ledge last fall. Things happened because some people looked at the problem head-on and became committed to doing something about it. We found that these pingers work. And what we learned here can be used worldwide.

The National Bycatch Conference in Oregon last February was also an eye-opener. Jim Martin, Chief of Fisheries for Oregon's Department of Fish and Wildlife, gave a great talk. He made the statement, "We must know the truth, and we must very effectively tell the truth." If the truth hurts, then we must address it head-on, much like the Harbor Porpoise Working Group has done.

Another speaker at that conference talked about the various groups in Florida that were trying to ban nets. He didn't think the ban would go through in 1992, but he said that if the fishermen didn't address the problems, nets would be banned. And we all know what happened.

Image problem

The public's perception of gillnetting is bad. There is a very serious image problem. The Sportfishing Association writes articles weekly about banning gill nets. Examples of early articles written in Florida in 1991, 1992, lead up to 1994, and we all know what happened—nets were banned this July. All kinds of articles in all kinds of magazines—they talk about violating the public trust.

If we have a problem, it's got to be addressed and addressed right away. We did it with harbor porpoise, we can do it with other species, other situations.

Gillnetters also have a communication problem. Recently in North Carolina laws were filed to ban nets in state waters. Right now, due to the success in Florida, there are efforts under way to ban nets along the entire East Coast. And Massachusetts is a prime target. If nets are banned in Massachusetts, a multimillion-dollar dogfish fishery will be lost. Keep in mind that the best producers of dogfish with the least amount of bycatch are the gillnetters, and that gillnetters are directing their efforts away from multispecies. This kind of information, unfortunately, does not reach the public, and it has to. All the public hears is the slanted view.

When we have a problem with bycatch, we must address the problem head-on, let the public know we are doing something about it. We need public recognition and credibility. We cannot hide anymore. No one can. Right now, those fishermen who are not involved are their own worst enemies. If you are not part of the solution, then you are part of the problem. We've all heard that before. Fishermen must unite, not against the people, but instead to understand the problems that exist and to correct them.

Robin Alden (editor and publisher of *Commercial Fisheries News* and now Maine Commissioner of Marine Resources) sort of defined the meaning of conservation at the 1992 bycatch workshop: "Operating within and understanding the limits of the natural system that we live in." The catch words are sustainability and protection of the ecosystem. We must not violate the public trust. We must understand biodiversity. Right now, what is needed is more involvement of individual fishermen so that we understand the big picture. We need to know how to address problems and seek solutions. It can be done, and it must be done. It is a fishery well worth saving. We need to move our fishery to keep sustainability and to protect the ecosystem. If we do not do this and do it now, then we will lose.

Gulf of Maine Sink Gill Net Fishery

Harbor Porpoise Working Group

Roland Barnaby
Maine-New Hampshire Sea Grant

Abstract: *The gill net fishery is an important commercial fishery in the Gulf of Maine region. The fleet is made up of small inshore "day boats" spread throughout the region. Gill nets have some characteristics that make them an appealing method of fishing: They can be fished from a small vessel (25 feet to 45 feet); they are size-selective, with very little fish bycatch; and they do little damage to the habitat. They do, however, cause entanglements with marine mammals.*

In 1990 gill net fishermen were told at the Maine Fishermen's Forum that several conservation groups were going to file a petition asking that harbor porpoise be placed on a threatened or endangered list. These groups felt there was a decline in the harbor porpoise population due to large numbers of animals being killed in gill net interactions. After this meeting, Bob MacKinnon, a gill net fisherman, and David Willey, senior scientist for the International Wildlife Coalition, invited a group of people together to talk about the problem. Included in this group were fishermen, scientists, conservationists, fishery managers, fishery engineers, and educators.

The group called itself the Harbor Porpoise Working Group. Its goal was to reduce the take of harbor porpoise with as little impact as possible on fishermen. Any decisions the group made were by consensus. This process was new to most members and caused a great deal of frustration and anxiety, but the results have been extremely positive.

One of the most important accomplishments of the Harbor Porpoise Working Group was its "pinger" research. Experiments with pingers on gill net vessels in 1992, 1993, and 1994 showed a difference in entanglements between nets with pingers and nets without pingers. The 1994 experiment was conducted according to a more structured and rigid scientific protocol, with results more statistically significant than those of the earlier years.

A few words on the Harbor Porpoise Working Group: This was a new, interesting, exciting, and at times frustrating, approach to solving a problem. It provided a model that fisheries managers, fishermen, scientists, and conservationists should look at. And it demonstrated that getting all the stakeholders at the table is the best way to solve problems. Bureaucrats have to realize that solving problems behind closed doors and then bringing the solutions out to public hearings doesn't work.

In four years the members of this group never voted on anything; everything was done by consensus. We learned that the only way to get anything done was to find a common ground and go from there. It was a waste of time to deal with the things that people disagreed on. It took months to agree on a goal, but once that was done we had a place to start from.

Jon Lien's work with whales led to contact between Jon and the University of New Hampshire Sea Grant. Jon had developed an alarm, or pinger, that was designed to alert whales to the presence of fish traps. His alarms did not scare whales away; in fact, when the alarms were placed in open ocean, Jon observed that whales were actually attracted to them. They appeared to be very curious.

The most important difference between his work with acoustical devices and most of the other experiments that have been done around the world was that Jon's alarms did not drive the animals away. He had observed whales feeding in and around fish traps for days in good and bad weather, night and day, without any problems. Then all of a sudden, for no apparent reason, a whale would swim into the trap. Jon felt that it was an accident, that the whale was not paying attention, or was distracted. His alarms were there to remind the whales that there was something close by, not to scare them away. The alarms won't work to keep an animal out of a place he wants to go; they will only work if the interaction is an accident.

Jon agreed to bring his alarms to New Hampshire if fishermen would use them. He drove down from Newfoundland with his pickup loaded so heavily it was dragging on the ground.

Four vessels were outfitted with these alarms, even though the devices were certainly not designed to be used on gill nets. We lost maybe 20 alarms the first day. There were some problems with this experiment, but the bottom line is:

Fishing Condition	Total Days of Fishing Effort	N Catch				
		Pollock	Cod	Seals	Porpoise	Birds
Control Nets (N nets = 275)	5,562	6,505	2,290	3	10	127
Experimental Nets (N nets = 94)	2,468	1,108	693	1	0	18

Table 1: Effort and catches in groundfish gill nets with alarms, and in control nets, fished in 1992.

The sample size was obviously too small, and there was too much variation on strings where the alarms were placed. And the critics said that fishermen probably placed their nets with alarms in areas were there weren't any porpoises, and the control nets where porpoises were. Fishermen knew that was not only not true, but not possible.

Dr. Lien agreed to come to New Hampshire the next year with a new alarm and a different experimental design. The fishermen, with Jon's help, built their own alarms. The alarms were placed on half of the fishermen's string of gear, as shown here:

```
Experimental strings:

          +      +      +      +      +      +      +      +      +      +
-------  ------ ------ ------ ------ ------ ------ ------ ------ ------ ------
          o      o      o      o      o      o

               Alarmed                6 th                Control
                Nets                  Net                  Ne t

Control Strings:
          +      +      +      +      +      +      +      +      +      +
-------  ------ ------ ------ ------ ------ ------ ------ ------ ------ ------
```

Figure 1: Diagram of the planned deployment of alarms in experimental and control strings in the 1993 experiment (o = alarm; + = bridle).

Category	N	Harbor Porpoise Catches
Total trips	133	-
Total strings	565	-
Alarmed Strings	230	12
Nonalarmed strings	335	21
Mean # nets/string	14	-
Mean soak time	34.4 hr.	-
Total net days	10,998.9	33
Total alarmed net days	1,580.7	1
Total nonalarmed net days	9,095.4	32
-In nonalarmed nets in control strings	6,492.8	21
-In nonalarmed nets in alarmed strings	2,602.6	8
Total # half-alarmed net days (6th net)	322.8	3

One harbor porpoise was caught in nets with alarms on each end. Thirty-two were caught in control nets.

Six porpoises were caught in this net with one alarm. When the National Marine Fisheries Service looked at the results they said the sixth net should be called an alarmed net, so the count was seven porpoises in alarmed nets and 26 in control nets. This interpretation was not received well by the fishermen, the observers, Jon Lien, or anyone working on the project. Fishermen believed that the animals turned when they heard the alarm or when they got near it. From their point of view, 43 harbor porpoises had been caught in control nets and one in alarmed nets over a two-year period, and no one seemed to believe them.

Fishermen were frustrated, discouraged, and confused at this point. They told their story to anyone who would listen, and in the spring of 1994 the U.S. Fish and Wildlife Foundation agreed to fund an experiment that would, they hoped, be designed to answer the question in such a way that the results would have to be accepted.

Scott Kraus from the New England Aquarium agreed to be the principal investigator, and New Hampshire fishermen agreed to participate once again. In this experiment 15 vessels were going to be used instead of four.

It was a "double blind" experiment. Two sets of alarms were built; one set was live alarms with saltwater switches, and one set, exactly like the live ones in appearance, was actually dummies. These did not ping. The fishermen and the observers did not know which alarms they were using when the nets were deployed. When the nets were hauled back they knew, because the live alarms were beeping. The alarms had to be changed every day to keep everyone honest. To do this required a tremendous amount of work and coordination by project manager John Williamson, the observers, and the fishermen.

The final report should be out in a few weeks. Some of the data is shown on the following page.

14 February 1995

PINGER EXPERIMENTAL DATA

Data calculated from pinger trips **ONLY** ("Obs/Trip ID No." ending with P or *):

HP = Harbor Porpoise (*Phocoena phocoena*)
HS = Harbor Seal (*Phoca vitulina*)

Net Type	No. Hauls[1]	No. HP Caught	No. HS Caught[2]	Avg. Hours Net Soaked[3]	Avg. No. Nets[4]
1	421	2	2	41.25	12.00
2	423	25	1	40.86	12.00
3	65	1	0	34.14	11.98
4	362	14	20	55.48	12.81
N/A	7	0	0	31.37	10.29
TOTAL	1,278	42	23	---	---

[1] No. hauls for Net Type 1 and 2 calculated for 12-string nets only

[2] No. HS caught does not include 1 unknown "seal" species caught in Net Type 4

[3] Soak time values are missing for 7 hauls

[4] String size values are missing for 1 haul

Net Type Codes: 1 = Active pingers

2 = Dummy pingers

3 = Standard string, no pingers

4 = Nonstandard strings, mostly monkfish gear

Conclusion

The problem is not solved, because the results of these experiments still have to be accepted by the National Marine Fisheries Service, New England Fisheries Management Council, environmental groups, scientists, the public, etc. Then the use of alarms has to be folded into a management plan, and the alarms have to be built with a price that allows fishermen to use them.

The goal of the Harbor Porpoise Working Group is to reduce the incidental take of harbor porpoise in gill nets while minimizing impacts on the fishery. The tool is here to solve the problem. The rest will be accomplished quickly and without controversy.

Large Pelagic Fisheries—Longline Fishery

Gear and Operational Differences Affecting Bycatch in the Longline Fishery

John Hoey
National Fisheries Institute

Abstract: *Through research funded by a Saltonstall-Kennedy grant, observer data collected on pelagic longline sets in the western North Atlantic is being analyzed for differences in species composition or catch rates that are attributable to gear and/or operational differences. These differences might provide guidance for gear and operational changes that would alter the species composition of the catch. In general, preliminary data from Japanese longline sets off the northeast United States coast indicates that overall species survival increased as rig depth increased from shallow to deep configurations. Similar patterns will be examined with further analysis of recent observer data. This information will be shared with the fleet to help fishing vessel captains respond to bycatch issues.*

Presented here is preliminary information being developed through a Saltonstall-Kennedy grant to the National Fisheries Institute and the Blue Water Fishermen's Association. This grant supports research to analyze observer data on pelagic longline sets in the western North Atlantic. The effort of the observers and data managers—especially Dennis Lee of the National Marine Fisheries Service, Southeast Fisheries Science Center, and Dennis Hansford, NMFS, Northeast Fisheries Science Center—and all those involved, including willing captains and owners, should be recognized and applauded. Their effort will pay dividends as these valuable data sets are used to improve management advice. The detail and complexity of these data sets is daunting, and a great deal of work is required to keep this information current and usable. Although the gear looks rather simple, scientists have managed to identify more than 150 variables for observers to code on each set before they identify the catch—by individual animal—and its status and disposition.

The U.S. pelagic longline fishery is wide-ranging, and both small and large vessels operate in the fishery. Initially the U.S. longline fishery targeted swordfish; however, in recent years the fishery has increasingly focused on tuna (Figure 1, Species composition of landings, 1979-1993). The tuna fisheries are generally more geographically restricted than the swordfish fishery. Yellowfin tuna is the primary target in the Gulf of Mexico. Off the Northeast coast, bigeye tuna is the primary target, yet it is caught in association with yellowfin tuna and swordfish. It is not as distinguishable a fishery as the Gulf yellowfin fishery is from the Gulf swordfish fishery. Pelagic longline fishing effort is primarily associated with the edge of the continental shelf, sea mounts and oceanographic canyons, and thermal frontal zones. These areas are subject to dramatic seasonal change in sea surface temperature and thermal stratification.

Several observer data sets that will be examined as part of the Saltonstall-Kennedy–funded research are as follows:

a) Observer records accounting for approximately 5,475 longline sets aboard Japanese vessels operating inside the U.S. Exclusive Economic Zone (EEZ) from 1978 to 1992

b) Louisiana State University observer data accounting for 320 sets by U.S. vessels in the Gulf of Mexico between 1987 and 1992

c) Current NMFS (NEFSC and SEFSC) observer programs accounting for 1,523 sets (at this time) between 1991 and 1994.

The grant emphasizes examining trip and set records for differences in species composition and catch rates that are attributable to gear and/or operational differences among sets or trips. These differences might provide guidance for gear and operational changes that would alter the species composition of the catch. Currently, the species composition data has been summarized and the associated gear- and set-specific data are being audited.

The following figures will describe an analysis of Japanese observer records that illustrates the approach that will be used to differentiate among operational styles within regions, particularly in the Gulf of Mexico and off the northeast coast of the United States.

GULF OF MEXICO

Figure 2 documents the Japanese longline catch in the Gulf of Mexico. That fishery relied on shallow-rigged gear to target bluefin and yellowfin. Between 1978 and 1981, 765 sets were observed, and they accounted for a total catch of 22,347 animals. Forty percent of the catch was recorded alive at retrieval. Tuna and swordfish account for 66 percent of the total catch in number of individual animals. Adding marketable marlin and mako sharks to the swordfish and tuna would bring this up to 75 percent of the total catch. U.S. regulations required that the Japanese vessels discard all swordfish, marlin, and sharks. Pelagic sharks, coastal sharks, and rays reported alive were 73 percent, 80 percent, and 85 percent, respectively.

Figure 3 summarizes data collected by observers from Louisiana State University. This figure reflects the use of live bait to target yellowfin tuna. The figure displays both the species composition (pie diagram) and the disposition of components of the catch (stacked bar), summarized to reflect current management categories for the species caught. For sets characterized by live bait, 68 percent of the catch is retained, 9 percent is released alive, and 23 percent is discarded dead. The last reflects very limited or no market demand for very small tuna and several inedible fish; shark- and whale-damaged carcasses—approximately 5 percent of the swordfish and yellowfin catch—which are usually unmarketable; and the effect of regulations that require discarding of bluefin, marlin, and small swordfish.

Figure 4 reflects a different Gulf fishing operation, which uses dead bait and chemical light sticks to target swordfish. Sixty five percent of the total catch (in numbers) is retained, 13 percent is released alive, and 22 percent is discarded dead. The reasons for discarding are the same as those previously described.

Figure 5 provides a preliminary summary of the most recent observer data for the Gulf of Mexico. The general proportions of the total catch are similar to the previously summarized data sets. Additional analyses will focus on this sample once the gear-related data has been audited.

NORTHEAST U.S.

For comparative purposes the following figures reflect observed sets off the northeast coast from Cape Hatteras to the U.S. Canadian border (Hague Line).

Figure 6 summarizes observed Japanese longline sets off the northeast coast of the United States (within the EEZ). Between 1978 and 1988, 4,634 sets were observed, and these accounted for a total catch of approximately 356,700 animals. The mean and median proportion of the total catch (all species) that arrived at the boat alive was 60 percent. Tuna and swordfish accounted for 60 percent of the total catch. For pelagic sharks, 88 percent was alive. For coastal sharks, 80 percent was alive, and for skates and rays, 94 percent was alive.

Figure 7 provides a preliminary summary of more recent observer data from the same northeast U.S. region. This figure includes catch composition and disposition as in figure 5. Fifty percent of the total catch (all species) was kept for sale, 36 percent was released alive, and 14 percent was discarded dead. The last included 7 percent dead discards of swordfish and tuna. As previously mentioned, discarding of these otherwise marketable species reflects minimum-size regulations for swordfish; trip limits for bluefin tuna; inadequate market opportunities for small tuna, including skipjack and bonito; and damaged, unmarketable animals. The remaining 7 percent includes a variety of unmarketable fish, several species that are marketable only outside U.S. markets—for example, marlin and oilfish—and other marine creatures.

In terms of perspective, these figures indicate that dead discards are generally on the order of 20 to 30 percent of the total catch. It must be emphasized that these dead discard rates are based on numbers of individuals. Because dead discards are generally smaller individuals than the retained and released catch, a discard proportion expressed in terms of weight, as in the recent FAO assessment of bycatch and discards, would probably be less than 15 percent for these longline fisheries. This means that approximately 85 percent of the weight harvested each day is either kept or released alive. In comparison to other world fisheries, this would probably rate as very selective.

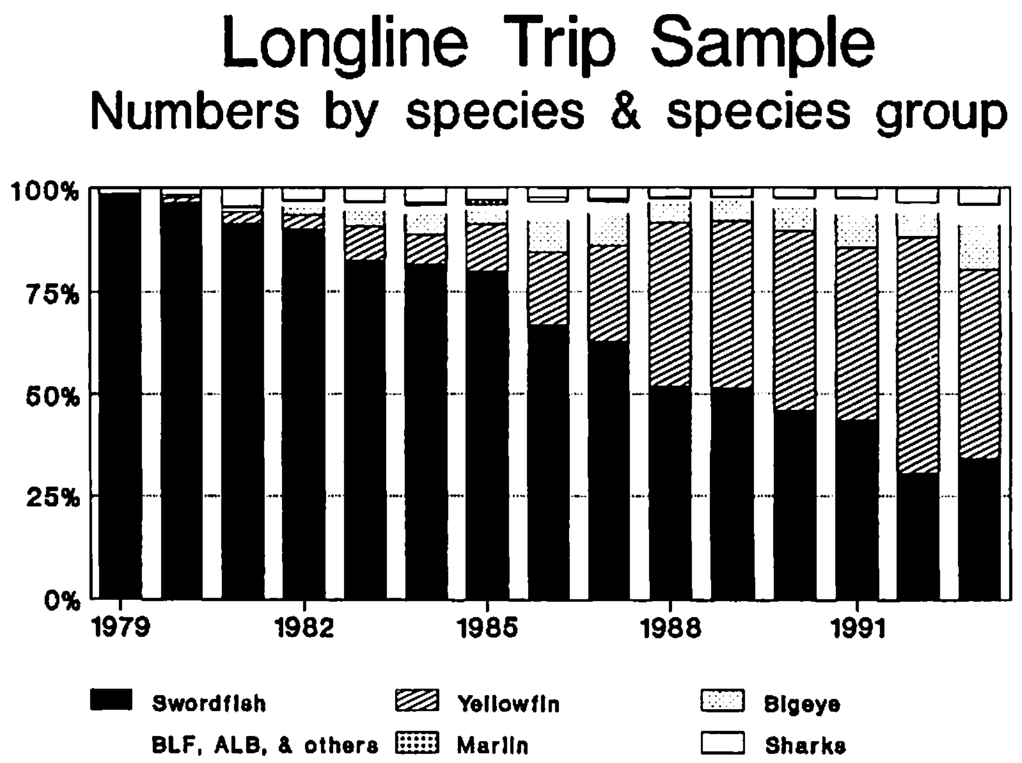
Figures 8 and 9 illustrate changes in catch composition attributable to gear changes. These figures reflect observed Japanese longline sets off the northeast coast within the U.S. EEZ. Figure 8 illustrates a shallow-rigged longline set with seven or fewer hooks between floats. Figure 9, on the other hand, reflects a deeper-rigged configuration, with more than 11 hooks between floats. The change in the proportion of bigeye tuna is the most significant difference between these operation styles.

As rig depth increased from shallow to deep configurations, the overall species survival increased, while the total numbers of animals, marketable and unmarketable, declined from about 95 fish caught per set to about 65 fish per set. However, the proportion of bigeye increased by a factor of 3, from 9.4 bigeye per set to 28.4 bigeye per set. In addition, swordfish survival increased from about 34 percent to about 40 percent; the catch per set of coastal shark species declined by 62 percent; and the catch per set of marlin declined by 48 percent.

It appears the gear was set through the community of surface dwellers and more selectively harvested the deeper-dwelling bigeye. The bigeye is one of the most valuable components of the catch, and this increased bigeye efficiency provides a significant economic incentive to fish deeper. This deeper fishing operational style will have a beneficial effect on other components of the ecosystem as fishing mortality declines for the bycatch species.

As the recent U.S. observer data is analyzed, similar patterns will be examined. The goal of the S-K grant is to share this information with the fleet so that responsible captains will be able to help address these bycatch issues.

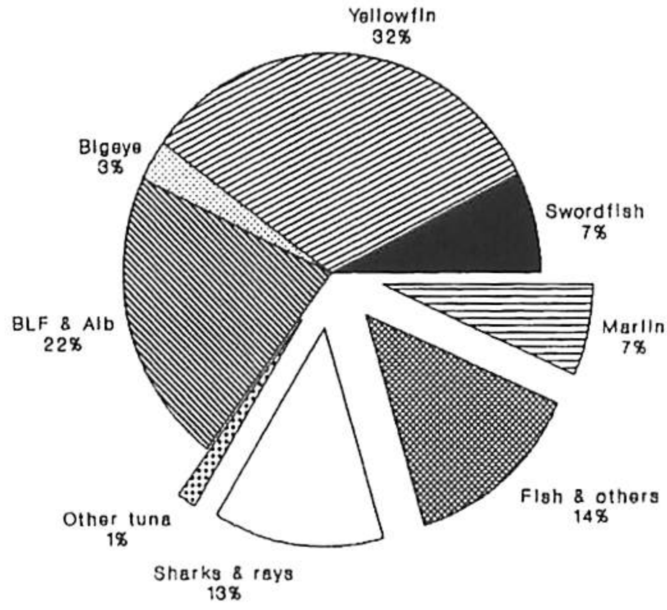
Figure 1.



Data from unloading reports

Figure 2.

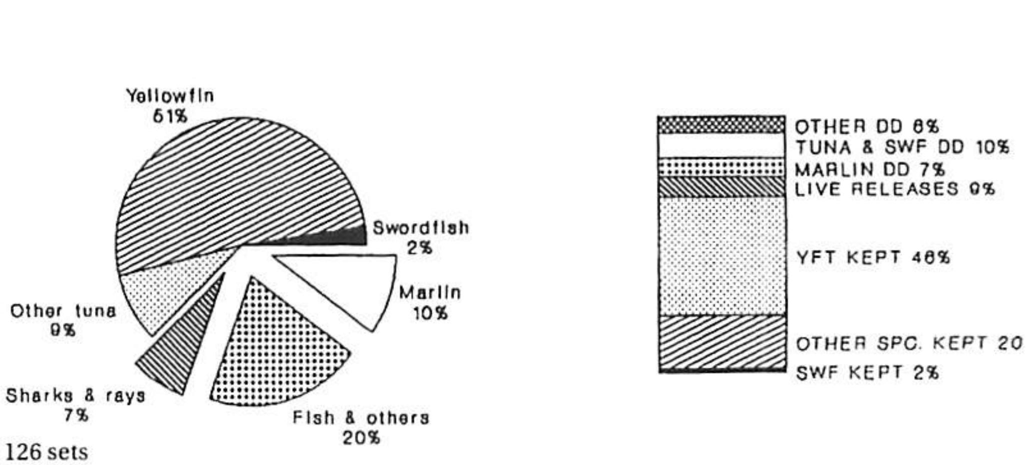
Japanese Longline - GOM
Species Comp. 765 Sets Catch 22,347



78-81 Shallow sets
Mean & alive 40%

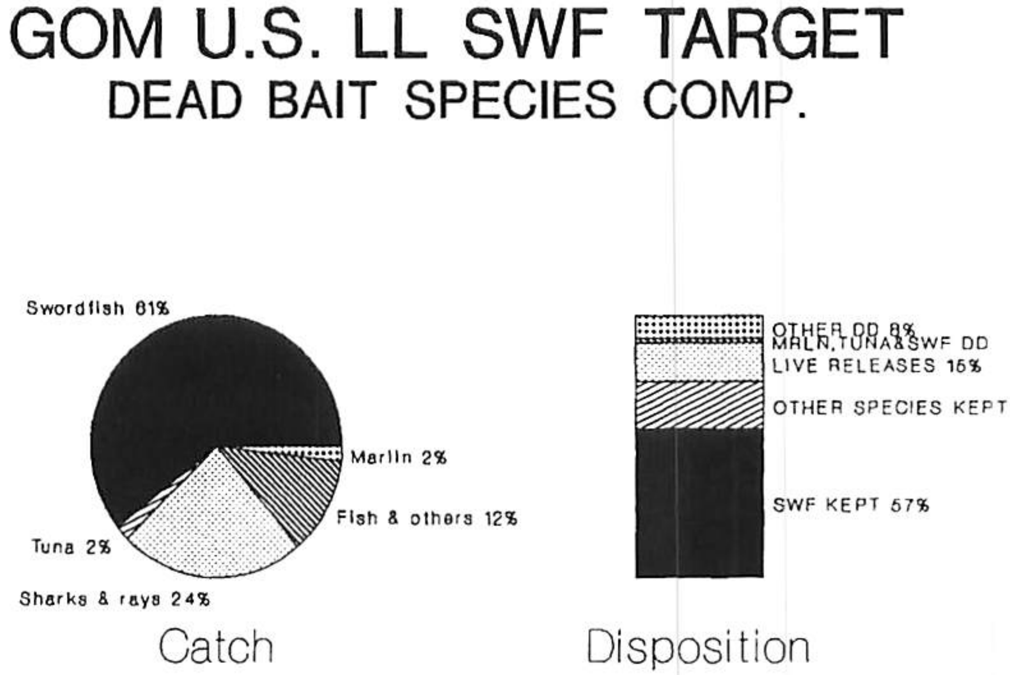
Figure 3.

GOM U.S. LL TUNA TARGET
LIVE BAIT CATCH & DISCARD



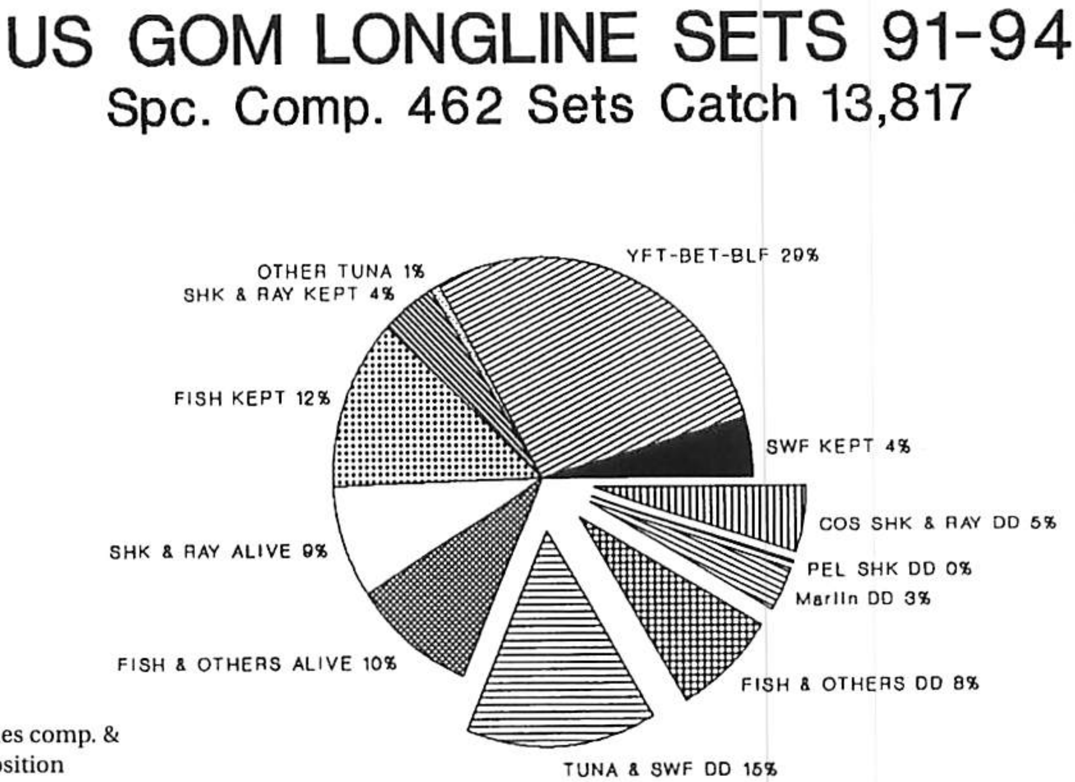
LSU (89-92) 126 sets
catch 3,773

Figure 4.



LSU limited sample 12 sets

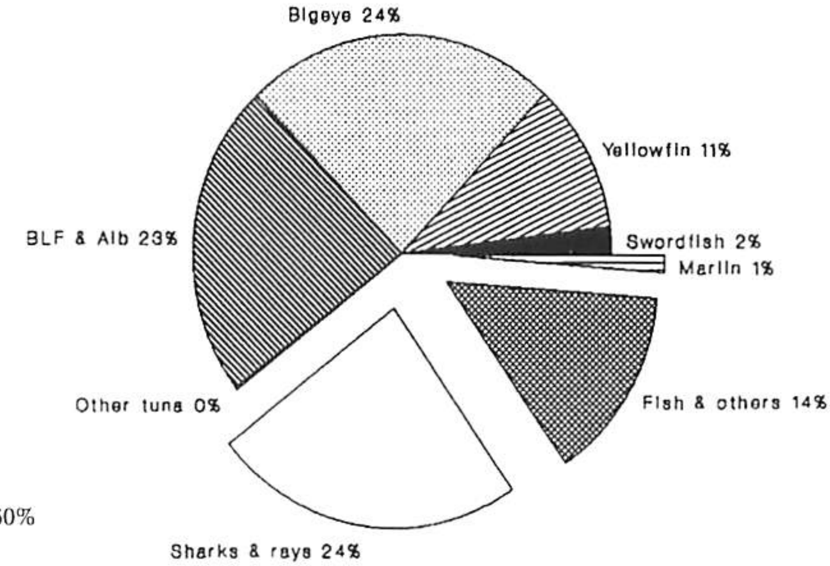
Figure 5.



Species comp. & disposition

Figure 6.

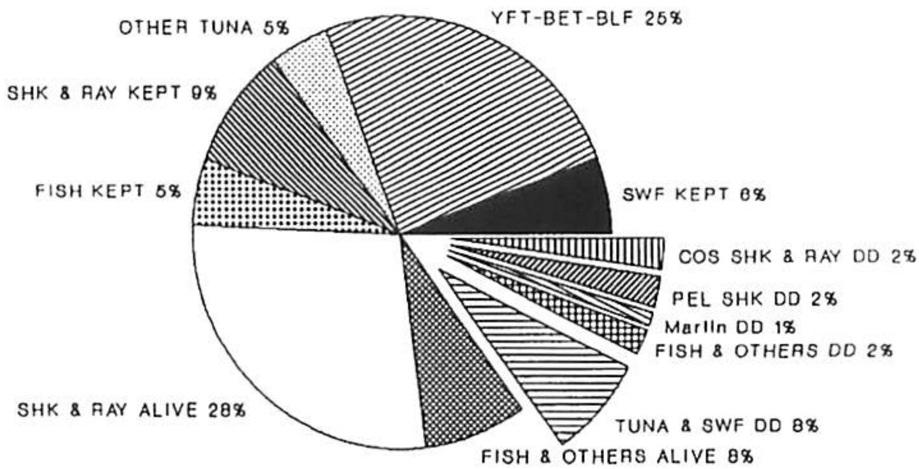
Japanese Longline - NE US
Spc. Comp. 4,634 Sets Catch @ 356,742



78-88 Mean & alive 60%

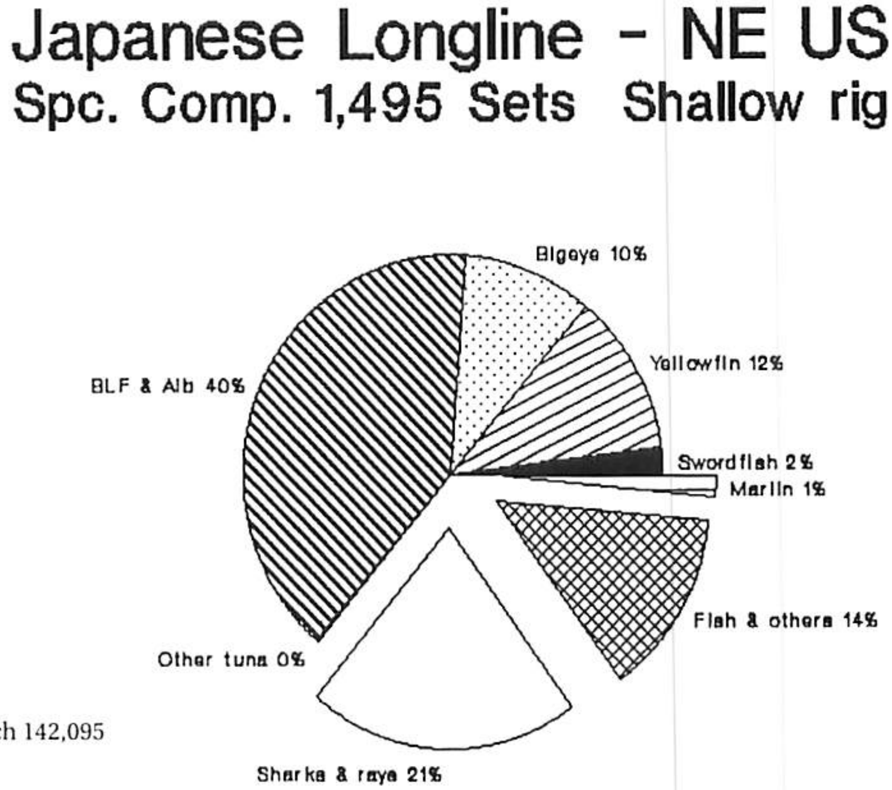
Figure 7.

NEUS (MAB-NEC) LONGLINE SET
Spc. Comp. 388 Sets Catch 14,355



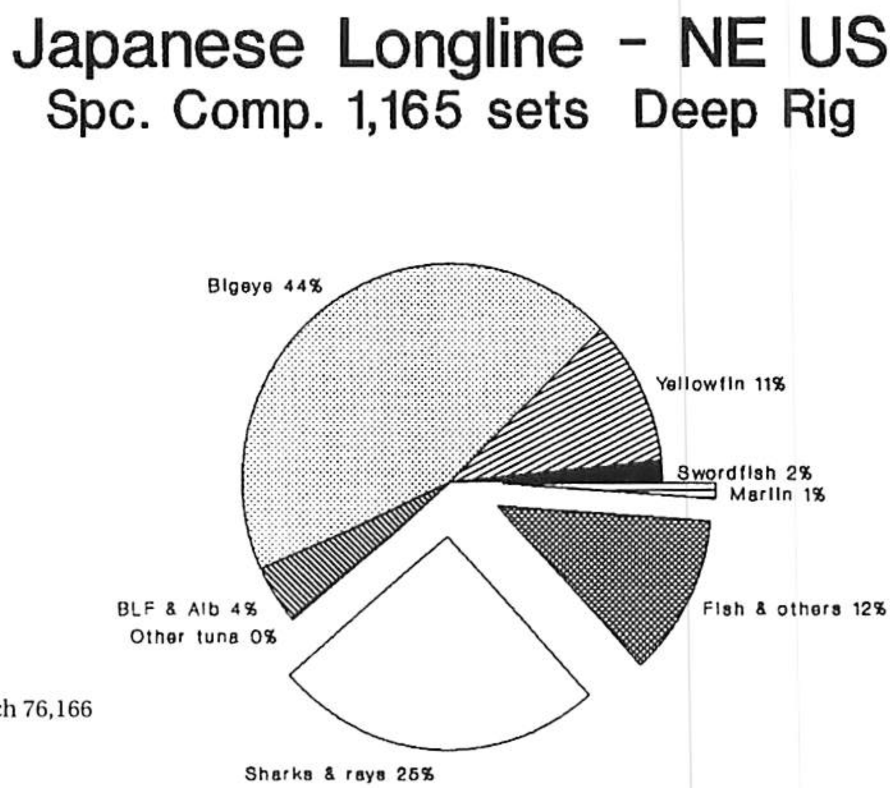
Species comp & dispostion

Figure 8.



HBF <=7 Catch 142,095
55% alive

Figure 9.



HBF >11 Catch 76,166
64% alive

Large Pelagic Fisheries—Longline Fishery

Controlling Bycatch in a Shared Fishery

Larry Thompson
New York longline fisherman

In this fishery, we call ourselves pelagic multispecies longliners, because of the multispecies catch. Rather than telling you what longliners are trying to do, this report will just offer some highlights about the fishery. The type of gear used has changed since about 1979 from a hook every 60 feet to what we're fishing with now, which is monofilament-type gear with hooks 200 to 300 feet apart. The longline fishery is a year-round fishery, and occurs in various areas, from the Grand Banks off Newfoundland to the Gulf of Mexico and down in the Caribbean.

Look at some of the percentages of what the American fisherman catches of the total catch by recreational and American commercial fishermen working in the Atlantic Ocean: swordfish, 10 percent; bluefin tuna, 6 percent; yellowfin, 4 percent; bigeye, less than 1 percent; albacore, less than 1 percent; blue marlin, 8 percent; white marlin, 3 percent; sailfish, 2 percent. These numbers are also reflected in the bycatch on our vessels.

Everyone needs to be aware that this is a multinational fishery. We're sharing this fishery among at least 10 other nations, and it's growing every year. And one thing the United States does, that all fishermen who fish in this country realize, is put us under a microscope. There is observer coverage here that goes way beyond what other nations have. There is enforcement. And there are laws that some of the other nations don't have. U.S. longliners are not allowed to keep bluefin. This is the only nation in the shared Atlantic fishery that has this prohibition. As far as small swordfish go, there is a percentage that U.S. fishermen can keep. It seems from the results and tallies we're seeing from other nations that the United States is ahead in this regard and is the only country going by the guidelines specified by the International Commission for the Conservation of Atlantic Tunas (ICCAT).

Longliners, like other fishermen, realize that we need to minimize the catch of fish that we can't utilize and the mortality of those that we can—which means releasing them alive. And we need to maximize the utilization of those fish that we do catch that can be utilized but, because of government regulation, we're not allowed to keep.

The longline fleet is working on different methods of releasing fish that do come up alive. The main problem with most of the fish is that the hook you're fishing with costs a dollar. That doesn't sound like much, but if you get into blue sharks—which is the main species we catch besides our target species—the problem is that they all have hooks in their mouths. It's not easy to get the hook out and let them swim away without a slice in their mouths. So, we're working on hook extractors.

That will go along with the turtle problem longliners are dealing with. The problem with turtles is that the United States has a regulation that they're endangered, so we're not supposed to touch them or even bring them on the boat. That makes it difficult to do anything with them except cut the line off.

These are a few of the highlights of the pelagic longline fishery. If there's one thing to keep in mind, it's that the United States shares this fishery with quite a few nations. And whatever we do here, we're the leaders in what is being done. It's not happening everywhere.

> ***We need to maximize the utilization of those fish that... can be utilized but, because of government regulation, we're not allowed to keep.***

Large Pelagic Fisheries—Swordfish Drift Net Fishery

Unofficial Pinger Experiment Shows Promise

Rodney Avila
Massachusetts fisherman

One of the reasons for a fisherman to continue fishing the swordfish drift net fishery is that this fishery harvests larger fish: The average dressed weight is 110 pounds. At this size, the fish has completed one to two spawning cycles before being harvested. This is in keeping with other management plans to harvest larger fish—there are minimum sizes for cod, haddock, yellowtails, etc.

As in other fisheries, there is also bycatch in the swordfish drift net fishery. Since 1991, the Northeast Atlantic Swordfish Netters Association has asked the National Marine Fisheries Service for an experimental swordfish drift net fishery. The request has been denied. The reason for asking for this experimental fishery was to try to reduce the bycatch of marine mammals. Because the mammal bycatch is so erratic, our science model had to consist of a large number of sets—approximately 300 repetitions—to scientifically prove that anything we tried was working. The swordfish drift net fishery's quota of approximately 138,000 pounds is divided into semiannual quotas: this leaves approximately 69,000 pounds for the summer season, which is the traditional swordfish drift net season. In the past two years, the summer quota has been caught in eight to 10 days, which is not long enough to conduct any valid experiments.

In 1994, after once more being denied an experimental swordfish drift net fishery, the Northeast Atlantic Swordfish Netters Association went ahead on its own and conducted an experiment with underwater acoustic "pingers" similar to the pingers used to deter harbor porpoise in the Gulf of Maine sink gill net fishery. The fishermen constructed 150 pingers to be used by four boats in two-boat teams. Each team used 75 pingers on one experimental net while its team partner set a similar net without pingers to act as a control. The two nets were placed as close in proximity to each other as possible. The pingers were then switched between boats for the next night's set. This would eliminate any bias between nets.

The experiment was observed and documented by both the National Marine Fisheries Service and University of Rhode Island observers. Unfortunately, during the experiment approximately 70 of the pingers failed due to water leakage. In spite of the fact that about half the pingers failed, we still reduced the mammal bycatch by approximately 50 percent from the bycatch caught in the control net.

Although this experiment didn't have enough sets to prove anything scientifically, it definitely shows promise for reducing marine mammal bycatch in the swordfish drift net fishery.

Large Pelagic Fisheries—Drift Net Fishery

Results of an Experiment Using Acoustic Devices to Reduce the Incidental Take of Marine Mammals in the Swordfish Drift Gill Net Fishery in the Northwest Atlantic Ocean

Joseph DeAlteris, Erik Williams, Kathy Castro
University of Rhode Island

Introduction

From June 30 to July 9, 1994, four vessels in the swordfish drift gill net fishery volunteered to test the effectiveness of an acoustic device, or "pinger," in deterring marine mammal interactions with the fishing gear. The acoustic devices were based on a design developed by Jon Lien at the University of Newfoundland: They consisted of 2.5-inch PVC tubing sealed at both ends, with four standard 9-volt batteries attached to a piezo inside. The acoustic device was activated when seawater completed the circuit across two brass screws drilled into the side of the PVC cylinder.

The acoustic devices were placed in small bait bags and clipped to the drop lines of the net about 15 feet from the head rope. The nets used by each of the vessels participating in the experiment differed slightly in mesh depth, net length, and number of escape panels. The typical drift gill net consisted of about 7,500 to 9,000 feet of 22-inch mesh webbing, 60 to 70 meshes deep, with 1 or 2 escape panels.

Four fishing vessels participated in the experiment: the F/V *Xiphias*, operated by Capt. Bill Gell of New Bedford, Massachusetts (vessel A); the F/V *Ventura*, operated by Capt. Pete Dupuy of Green Cove Springs, Florida (vessel B); the F/V *Travis and Natalie*, operated by Capt. Fred Mattera of Point Judith, Rhode Island (vessel C); and the F/V *Trident*, operated by Capt. Rodney Avila of New Bedford, Massachusetts (vessel D).

The experiment was designed as an alternate, paired comparison in which two vessels would fish side by side, one control vessel and one experimental vessel. The vessels would alternate use of the pingers each day. The four vessels initially attempted to work as two matched pairs. However, by July 4 many of the acoustic devices used by one of the pairs were nonfunctional due to a seawater leak. The seawater leak was a result of the rapid corrosion of the screws on the side of the pingers. On July 6, one of the vessels from the dissolved pair joined the other vessels with one set of functioning pingers. Table 1 is a list of the net sets by the vessels that were involved in the experiment.

Some of the net sets could not be used in the analysis (see comments in Table 1). Subsequently, the final data set used for analysis contained only 10 matched pairs. The last four experimental net sets were accompanied by two other vessels, either of which could serve as control net sets for the final analysis.

The nonexperimental net sets of five other vessels in the fleet were compared to the control vessels in the experiment. There were more than nine total vessels in the fishery; however, only nine vessels carried observers on board (four in the experiment, five not in the experiment).

Statistical Analyses

The experiment was originally designed to compare the incidental take of marine mammals in experimental and control net sets. The null hypothesis is that the marine mammal takes in the control sets were less than or equal to the takes in the experimental sets. This leaves the alternate hypothesis that marine mammal takes in the control sets are greater than the takes in the experimental sets.

Since the sample size for this data set is less than 30, a t-test may be appropriate. However, given the limited data, it is unclear whether it is normally distributed or not. If it is normally distributed, then the t-test applies, but if the data are not normally distributed, then nonparametric tests apply. Another factor determining which test is appropriate is whether the experiment was truly a matched, paired comparison or not.

In Table 2, a nonpaired t-test was used to test the null and alternate hypotheses, but before this could be performed, an F-test for equal variance was performed, as this would determine which t-test is appropriate. As is shown in Table 2, the F-test indicated that the variances were equal, and the appropriate t-test was then used to analyze the data set. The nonpaired t-test for equal variance in Table 2 revealed no significant difference between the control and experimental sets at the 95 percent confidence level.

The nonpaired t-test in Table 2 was used based on the assumption that the data is normally distributed. Given the small size of the data set it is unlikely that the state of normality can truly be determined. Therefore, in Table 3 a nonpaired, nonparametric test was also used to analyze the data set assuming the data are not normally distributed. The test revealed no difference between the control and experimental sets at the 95 percent confidence level.

The tests in Table 2 and 3 were based on nonpaired comparisons. However, this experiment was designed as a paired comparison, and the net sets appear to have been fished in a paired comparison. Therefore, paired t-tests and paired nonparametric tests were also performed on the data set. The results of the paired t-test using two different combinations of control vessels for the last four net sets are listed in Table 4. Only the test using vessel C as the control for the last four net sets was significant at the 95 percent confidence level. The results of the paired nonparametric test are listed in Table 5. Both tests indicated a significant difference at the 95 percent confidence level, and the test with vessel C as the control vessel for the last four net sets was significant at the 97.5 percent confidence level.

In Tables 6 and 7, a nonpaired t-test and nonpaired, nonparametric test, respectively, were applied to compare the control net sets to the nonexperimental net sets. The t-test showed no significant difference at the 95 percent confidence level, while the nonparametric test revealed a highly significant difference at the 99 percent confidence level. Just looking at the average marine mammal takes of 1.15 for the nonexperimental vessels and 2.0 for the control vessels indicates there is some difference.

Discussion

The goal of this experiment was to test the effectiveness of acoustic devices for deterring marine mammal interactions with the fishing gear. The experiment was designed and implemented as an alternate, paired method. Given this fact, the paired statistical tests in Tables 4 and 5 are most appropriate. Whether the t-test or nonparametric test is appropriate depends on the level of adherence to the normality assumption for the t-test. In any case, of the four tests which were performed in Table 4 and 5, the majority of the tests indicated significant difference between the control and experimental net sets at the 95 percent confidence level.

There appears to be a strong indication that the acoustic devices tested in this experiment can significantly reduce the incidental take of marine mammals. The difference is valid only if the experiment was a true paired comparison. Both of the nonpaired tests detected no difference between the control and experimental net sets. The validity of the paired comparison could be questioned on the basis of the differing net designs used by the four vessels operating in the experiment. The differences in net designs probably did not significantly affect the outcome of this experiment, based on the fact that the acoustic devices were alternated between vessels.

The significantly higher marine mammal takes in the control vessels compared to the nonexperimental vessels could cause some criticisms of the experiment. However, further analysis of the spatial and temporal distribution of the incidental takes may reveal that there exist areas with a higher likelihood of marine mammal interactions.

The acoustic devices should be further investigated before another experiment is performed. The frequency and signal strength must be tested. This could indicate whether more devices per net might be needed in a future study. Given the promising results that Jon Lien is having in Newfoundland and the results from this study, further investigation of the ability of these acoustic devices to reduce the incidental take of marine mammals is warranted.

Table 1. A list of the net sets from the vessels that were involved in the experiment showing which sets were used in the statistical analyses.

Date	Vessel	Pingers set/working	Control Marine Mammals	Exp. Marine Mammals	Used in Analysis	Comments
6/30/94	B	None	1		No	No experimental sets
7/1/94	All	None	2		No	No experimental sets
7/2/94	D,A	71/70	5	1	Yes	Valid comparison
7/2/94	B,C	70/?	2	2	Yes	Valid comparison
7/3/94	A,D	30/29	1	0	No	Experimental had only 1/2 a net
7/3/94	C,B	75/?	2	1	Yes	Valid comparison
7/4/94	D,A	66/62	1	0	Yes	Valid comparison
7/4/94	B,C	23/?	3	2	Yes	23 pingers on experimental?
7/5/94	A,D	66/66	0	0	Yes	Valid comparison
7/6/94	C,A	68/67	1	0	Yes	Valid comparison
7/6/94	B		1		Yes	Valid comparison
7/7/94	D,A	71/70	0	5	Yes	Valid comparison
7/7/94	C		3		Yes	Valid comparison
7/7/94	B		10		No	Not in experiment
7/8/94	D,A	70/70	5	0	Yes	Valid comparison
7/8/94	C		1		Yes	Valid comparison
7/8/94	B		1		No	Not in experiment
7/8/94	A	31		0	No	Day set, no control set
7/9/94	A,D	70/66	1	0	Yes	Valid comparison
7/9/94	C		3		Yes	Valid comparison
7/9/94	B		11		No	Not in experiment

Note: Vessel A - F/V *Xiphias*, Vessel B - F/V *Ventura*, Vessel C - F/V *Travis and Natalie*, Vessel D - F/V *Trident*

Table 2. Analysis of the swordfish drift gill net experiment data set using a nonpaired t-test.

Date	Vessel	Control set	Date	Vessel	Pinger set
7/2/94	D	5	7/2/95	A	1
7/2/94	B	2	7/2/94	C	2
7/3/94	C	2	7/3/94	B	1
7/4/94	D	1	7/4/94	A	0
7/4/94	B	3	7/4/94	C	2
7/5/94	A	0	7/5/94	D	0
7/6/94	C	1	7/6/94	A	0
7/6/94	B	1	7/7/94	A	5
7/7/94	D	0	7/8/94	A	0
7/7/94	C	3	7/9/94	D	0
7/8/94	D	5			
7/8/94	C	1			
7/9/94	A	1			
7/9/94	C	3			

$n_1 = 14$
avg. = 2.0
$S_1^2 = 2.62$

$n_2 = 10$
avg. = 1.1
$S_2^2 = 2.54$

test for equal variance

Ho: variances equal
Ha: variances not equal

$F = s_1^2 / s_2^2 = 1.03$

$F_{0.05, 10, 14} = 2.602$, $F_{0.05, 14, 10} = 2.865$

Do not reject Ho.

t-test (nonpaired), equal variances

Ho: Marine mammal takes in the control sets are less than or equal to the takes in the experimental sets.

Ha: Marine mammal takes in the control sets are greater than the takes in the experimental sets.

$s_p^2 = (n_1 - 1)s_1^2 + (n_2 - 1)s_2^2 / n_1 + n_2 - 2 = 2.59$

$t = (2.0 - 1.1) / (s_p^2 / n_1 + s_p^2 / n_2)^{0.5} = 1.35$

$t_{0.10, 22} = 1.321$

$0.05 < P < 0.10$

Do not reject Ho.

Table 3. Analysis of the swordfish drift gill net experiment data set using the Mann-Whitney test with tied ranks (nonparametric, nonpaired).

Ho: Marine mammal takes in the control sets are less than or equal to the takes in the experimental sets.

Ha: Marine mammal takes in the control sets are greater than the takes in the experimental sets.

Date	Vessel	Control set	Rank	Date	Vessel	Pinger set	Rank
7/2/94	D	5	23	7/2/94	A	1	11
7/2/94	B	2	16.5	7/2/94	C	2	16.5
7/3/94	C	2	16.5	7/3/94	B	1	11
7/4/94	D	1	11	7/4/94	A	0	4
7/4/94	B	3	20	7/4/94	C	2	16.5
7/5/94	A	0	4	7/5/94	D	0	4
7/6/94	C	1	11	7/6/94	A	0	4
7/6/94	B	1	11	7/7/94	A	5	23
7/7/94	D	0	4	7/8/94	A	0	4
7/7/94	C	3	20	7/9/94	D	0	4
7/8/94	D	5	23				
7/8/94	C	1	11				$n_2 = 10$
7/9/94	A	1	11				$R_2 = 98$
7/9/94	C	3	20				
			$n_1 = 14$				
			$R_1 = 202$				

$U^1 = n_2 n_1 + n_2(n_2 + 1)/2 - R_2 = 97$

$U_{0.05(1),10,14} = 99$

Since 97 < 99, do not reject Ho.

$0.05 < P < 0.10$

Table 4. Analysis of the swordfish drift gill net experiment data set using a t-test for matched pairs.

Ho: Marine mammal takes in the control sets are less than or equal to the takes in the experimental sets.

Ha: Marine mammal takes in the control sets are greater than the takes in the experimental sets.

Date	Vessel	Control	Pinger	Diff.	Diff.^{2}	Date	Vessel	Control	Pinger	Diff.	Diff.^{2}
7/2/94	B,C	2	2	0	0	7/2/94	B,C	2	2	0	0
7/2/94	D,A	5	1	4	16	7/2/94	D,A	5	1	4	16
7/3/94	C,B	2	1	1	1	7/3/94	C,B	2	1	1	1
7/4/94	B,C	3	2	1	1	7/4/94	B,C	3	2	1	1
7/4/94	D,A	1	0	1	1	7/4/94	D,A	1	0	1	1
7/5/94	A,D	0	0	0	0	7/5/94	A,D	0	0	0	0
7/6/94	B,A	1	0	1	1	7/6/94	C,A	1	0	1	1
7/7/94	D,A	0	5	-5	25	7/7/94	C,A	3	5	-2	4
7/8/94	D,A	5	0	5	25	7/8/94	C,A	1	0	1	1
7/9/94	A,D	1	0	1	1	7/9/94	C,D	3	0	3	9
			Total	9	71				Total	10	34

$S_d^2 = 6.99$

$t = 1.08$

$t_{0.10(1),9} = 1.383$

$0.10 < P < 0.25$

Do not reject Ho.

$S_d^2 = 2.67$

$t = 1.94$

$t_{0.05(1),9} = 1.833$

$0.025 < P < 0.05$

Reject Ho.

Table 5. Analysis of the swordfish drift gill net experiment data set using the Wilcoxon (nonparametric) paired-sample test.

Ho: Marine mammal takes in the control sets are less than or equal to the takes in the experimental sets.

Ha: Marine mammal takes in the control sets are greater than the takes in the experimental sets.

Date	Vessels	Control	Pinger	Difference	Rank
7/2/94	B,C	2	2	0	1.5
7/2/94	D,A	5	1	4	8
7/3/94	C,B	2	1	1	5
7/4/94	B,C	3	2	1	5
7/4/94	D,A	1	0	1	5
7/5/94	A,D	0	0	0	1.5
7/6/94	B,A	1	0	1	5
7/7/94	D,A	0	5	-5	-9.5
7/8/94	D,A	5	0	5	9.5
7/9/94	A,D	1	0	1	5

n = 10

T- = 9.5

$T_{.05(1),10} = 10$

Since $T- < T_{.05(1),10}$, Ho is rejected.

$0.025 < P < 0.05$

Date	Vessels	Control	Pinger	Difference	Rank
7/2/94	B,C	2	2	0	1.5
7/2/94	D,A	5	1	4	10
7/3/94	C,B	2	1	1	5
7/4/94	B,C	3	2	1	5
7/4/94	D,A	1	0	1	5
7/5/94	A,D	0	0	0	1.5
7/6/94	C,A	1	0	1	5
7/7/94	C,A	3	5	-2	-8
7/8/94	C,A	1	0	1	5
7/9/94	C,D	3	0	3	9

n = 10

T- = 8

$T_{.05(1),10} = 10$, $T_{.025(1),10} = 8$

Since $T- = T_{.025(1),10}$, Ho is rejected.

$0.01 < P < 0.025$

Table 6. Analysis of the swordfish drift gill net experiment data set using a nonpaired t-test to compare the control sets with the rest of the fleet.

Date	Vessels	Nonexperimental set takes	Date	Vessels	Control set takes
6/29/94	H	0	6/29/94		
6/30/94	B	1	6/30/94		
7/1/94	A,B,C,D,E,F,G	0,0,2,0,0,0,0	7/1/94		
7/2/94	E,F,G,H,I	0,0,1,1,1	7/2/94	D,B	5,2
7/3/94	E,F,G,H,I	0,0,0,0,0	7/3/94	C	2
7/4/94	E,F,G,H,I	0,1,0,7,3	7/4/94	D,B	1,3
7/5/94	B,C,E,F,G,H,I	0,1,0,0,0,0,0	7/5/94	A	0
7/6/94	D,E,F,G,H,I	1,0,0,0,0,0	7/6/94	C,B	1,1
7/7/94	B,E,F,G,H,I	10,1,0,5,3,0	7/7/94	D,C	0,3
7/8/94	B,E,F,G,H,I	1,0,0,0,10,0	7/8/94	D,C	5,1
7/9/94	B,F,G	11,0,0	7/9/94	A,C	1,3

$n_1 = 52$ — $n_2 = 14$

avg. = 1.15 — avg. = 2.0

$s_1^2 = 7.0$ — $s_2^2 = 2.62$

test for equal variance

Ho: variances equal

Ha: variances not equal

$F = s_1^2 / s_2^2 = 2.67$

$F_{0.05,50,14} = 2.24, F_{0.05,14,50} = 1.895$

Reject Ho.

t-test (nonpaired), unequal variances

Ho: Marine mammal takes in the control sets are less than or equal to the takes in the nonexperimental sets.

Ha: Marine mammal takes in the control sets are greater than the takes in the nonexperimental sets.

Adjusted degrees of freedom = $(s_1^2 / n_1 + s_2^2 / n_2)^2 / [(s_1^2 / n_1)^2 / n_1 - 1 + (s_2^2 / n_2)^2 / n_2 - 1] = 33.95$

$t = (1.15 - 2.0) / (s_1^2 / n_1 + s_2^2 / n_2)^{0.5} = 1.5$

$t_{0.05(1),34} = 1.691$

$0.05 < P < 0.10$

Do not reject Ho.

Table 7. Analysis of the swordfish drift gill net control and nonexperimental data sets using the Mann-Whitney test with tied ranks (nonparametric, nonpaired).

Ho: Marine mammal takes in the control sets are less than or equal to the takes in the nonexperimental sets.

Ha: Marine mammal takes in the control sets are greater than the takes in the nonexperimental sets.

Date	Vessels	Nonexperi-mental set takes	Ranks	Date	Vessels	Control set takes	Ranks
6/29/94	H	0	19	6/29/94			
6/30/94	B	1	44.5	6/30/94			
7/1/94	A,B,C, D,E,F,G	0,0,2,0,0,0,0	19,19,53,19, 19,19,19	7/1/94			
7/2/94	E,F,G, H,I	0,0,1,1,1	19,19,44.5, 44.5,44.5	7/2/94	D,B	5.2	61,53
7/3/94	E,F,G, H,I	0,0,0,0,0	19,19,19,19, 19	7/3/94	C	2	53
7/4/94	E,F,G, H,I	0,1,0,7,3	19,44.5,19,63,57	7/4/94	D,B	1.3	44.5,57
7/5/94	B,C,E,F,G, H,I	0,1,0,0,0,0,0	19,44.5,19, 19,19,19,19	7/5/94	A	0	19
7/6/94	D,E,F,G, H,I	1,0,0,0,0,0	44.5,19,19, 19,19,19	7/6/94	C,B	1,1	44.5,44.5
7/7/94	B,E,F,G, H,I	10,1,0,5,3,0	64.5,44.5,19,61, 57,19	7/7/94	D,C	0,3	19,57
7/8/94	B,E,F,G,H, I	1,0,0,0,10,0	44.5,19,19, 19,64.5,19	7/8/94	D,C	5,1	61,44.5
7/9/94	B,F,G	11,0,0	66,19,19	7/9/94	A,C	1,3	44.5,61

$n_1 = 52$ $n_2 = 14$

$R_1 = 1547.5$ $R_2 = 663.5$

$U = n_1 n_2 + n_1(n_1 + 1)/2 - R_1 = 558.5$

$U_{0.01(1),14,52}$

Reject Ho

$0.005 < P < 0.01$

Large Pelagic Fisheries—Tuna Pair Trawl Fishery

Experimental Tuna Pair Trawl Fishery

Clifford A. Goudey
Center for Fisheries Engineering Research, MIT Sea Grant

Abstract: *Ten vessels participated in an experimental tuna pair-trawl fishery in the northwest Atlantic during the 1994 season, making 28 paired trips between July 1 and October 31. Data covering environmental parameters, gear behavior, and gear handling practices and their effects on catch and bycatch were gathered during 369 tows. All trips but two carried NMFS observers. In general, there were two tows per night.*

This paper describes the gear and methods used in this fishery and summarizes the findings. During the experiment, participants monitored headrope depth and tow duration and established experimental protocols to minimize the potential for marine mammal and turtle interactions. In addition, bycatch performance criteria were in place, providing dramatic individual incentives for zero-bycatch fishing practices.

Only three trips recorded encounters with marine mammals or turtles. This low bycatch level indicates that midwater pair trawling may be the preferred method of exploiting these tuna species, from a bycatch perspective. Similarly, data on target species size distribution indicate that the method has advantages from a tuna resource-management perspective as well.

The technique of midwater pair trawling has been used in the northwest Atlantic since 1969, when it was first used in the Gulf of Maine on herring (Taber and McLeod, 1972). Since that time the method has come in and out of favor depending on the market for schooling pelagics. In 1991 the technique was first used on large pelagic fish when the F/V *Jason and Danielle* and the F/V *Luke and Sarah* successfully paired up and targeted swordfish.

Several other pairs joined the fishery, but concern over the strength of the swordfish resource soon shut the fishery down. During this first season, the participants learned that they could catch tuna effectively, and for the 1992 season 11 vessels engaged in a directed fishery on bigeye, albacore, and yellowfin tuna. All vessels operated out of southern New England, with a season starting in July and running to October.

Initially, the trawl nets used for this fishery were from the earlier fisheries for herring, butterfish, or *Illex* squid. By the 1992 season, all vessels were using nets designed specifically for the large pelagic fishery. Most pairs used nets designed and built by Shuman Trawl of Wood River Junction, Rhode Island. One pair used a French-built net developed for the Bay of Biscay tuna fishery.

In 1993, an experimental fishery was organized to gather information and better characterize this method of fishing. Eleven vessels participated; however, insufficient observer coverage and inadequate detail in reporting weakened the effort. In addition, the 1993 season was considered by some of the participants to be unusual with respect to catch levels. Uncertainties over whether the fishery was to be allowed resulted in participants being late in gearing up. In addition, some pairs quit the season early because of unprofitability.

The primary data for the 1993 experimental fishery comes from the reports submitted by the NMFS observers and assembled by the National Marine Fisheries Service observer program (Gerrior, 1994). The commercial catch and discards of these 18 trips is presented in Table 1. The incidental take associated with that commercial harvest is presented in Table 2.

1994 Experimental Fishery

A second experimental fishery was organized for the 1994 season. Again, the principal goal of this experiment was to determine the species- and size-selectivity of existing gear and methods. A second goal was to correlate catch and bycatch levels with fishing parameters. A final goal was to identify gear and methods to reduce the bycatch of marine mammals, turtles, and undersized tunas. Eleven vessels participated in this experiment; they are listed in Table 3.

Species	Caught (lbs)	Discards (lbs)	Percent Kept
Albacore	31,321	271	99.1
Yellowfin Tuna	15,744	303	98.1
Bigeye Tuna	21,354	20	99.9
Swordfish	10,166	4312	57.6

Table 1. Summary of catch in pounds from observed tows, 1993
(adapted from Gerrior)

Species	Mortality
Bottlenose dolphin	17
Saddleback dolphin	6
Pilot whale	5
Leatherback turtle	2

Table 2. Observed marine mammal and turtle mortality, 1993 (adapted from Gerrior)
* One turtle released alive, not injured

Captain	Vessel Name	Home port
John Riemer	*Jason & Danielle*	Pt. Judith
Jim Thayer	*Luke and Sarah*	Pt. Judith
Mark Phillips	*Illusion*	Greenport
Peter Wadelton	*Katie & Meg*	Greenport
Bob Soleau	*Primadona*	Shinnecock
Andrew Soleau	*Second Generation*	Shinnecock
Scott Bode	*Bulldog*	Pt. Judith
Paul Harvey	*Ing Toffer II*	Pt. Judith
Scott Trajillo	*Patriot*	Shinnecock
Gary Yerman	*Mystic Way*	New London
or Rick Saunders	*Lady Lynn*	New London

Table 3. Industry participants in 1994 experimental pair trawl fishery

Pair #	HP#1	HP#2	Fishing Circ.	Sounder
1	850	675	58 x 574 cm	Furuno CN 10B x 2
2	530	415	34 x 900	Furuno 110-A
3	1000	750	58 x 574	Furuno CN 10B
4	855	800	88 x 320	Scanmar
5	1500	1500	48 x 1596	Furring CN 10B x 2

Table 4. Engine and trawl gear specifications of the participating pairs

Gear and Methods

The participants in this experimental fishery were required to have trawl instrumentation to provide continuous indications of headrope depth. They were required to carry NMFS observers and to complete detailed data sheets documenting the performance of the trawl during the tow and accounting for all catch. In addition, they gathered other information on weather, water temperature, speed of tow, and course changes. The data sheet that was developed to facilitate the proper recording of this information is included at the end of this narrative.

All five vessel pairs used similar trawl gear. The nets have very large mesh in the front ends that graduates down to smaller mesh in the rear ends. Three of the trawls were made by Shuman Trawl of Wood River Junction, Rhode Island. Another net is of French design and construction and another is from Ireland. The codends of most of these nets are of special 12-inch square-mesh construction to ensure escapement opportunities for undersized fish.

In Table 4, the engineering parameters of the fishing systems of the five pairs are presented. The pair number in this table does not necessarily relate to the order in which the pairs are listed in the previous table.

These nets were towed by paired vessels at a speed of 3 to 4 knots. When the trawl is fully deployed, tow-wire lengths can vary from 200 to 300 meters, and vessel separation ranges from 150 to 200 meters. Flotation or headrope kites, in combination with wing end weights, provide the vertical gape. The typical design opening for these nets is 30 meters in height and 40 meters in width.

The towing depth varies and is controlled during the tow with a combination of tow-wire length and vessel speed. A net-mounted transducer is essential to the proper positioning of the net in the water column. These units are mounted on the footrope, looking up, providing indications of vertical gape of the net and headrope depth below the surface. Water temperature at the footrope is also displayed. In addition, most captains claim some ability to interpret the displays with respect to number and types of fish passing into the net.

Pair trawling for these tuna is a nighttime fishery. Some of the vessels remain idle or steam during the day, while others that are suitably rigged engage in bottom fishing. The 1994 experimental fishery was authorized to begin on August 1 and run until December 31 (Anonymous, 1994). The first trip started on August 9, and the twenty-eighth trip concluded on October 29.

Experimental guidelines with respect to trawling depth and duration were established. Captains were required to get the net to depth as quickly as possible during the setting process. In addition, a 5-fathom headrope ceiling was imposed. If headrope readings were shallower than 5 fathoms for longer than 15 minutes, the net was hauled back immediately. A 6-hour tow limit was imposed to improve the survivability of discards. Immediate fax transmittal of the data sheets to MIT allowed us to be responsive to bycatch trends and ensure that each pair was fishing responsibly.

Results

Trip data taken during the experiment is summarized in Table 5. The trip number, number of tows, average tow duration, average depth, number of takes, and presence of an NMFS observer are noted. The average trip was 6.5 days, or 13 tows, long. The average duration of a tow was 4.45 hours. The average depth of the headrope was 9.7 fathoms. All but two trips had an NMFS observer aboard one of the boats. There was a total of 28 pair trips and a total of 369 tows in the experiment. This represents approximately 480 vessel-days at sea.

Marine mammals or turtles were encountered by two different vessel pairs in three of the trips. In the first tow of trip two, one pilot whale was caught; the whale died. During this tow, the net was near the surface for 30 minutes before the headrope descended to a nominal 6 fathoms. During tow 8 of the same trip, one bottlenose dolphin was caught and released alive. This tow was of normal character, with an average headrope depth of 10 fathoms. During trip number six, a leatherback turtle was caught in each of two tows. Both animals were released alive. These tows were otherwise unremarkable. During trip number 17, the third tow yielded two dead bottlenose dolphin. Again, there was nothing unusual about the tow conditions to explain these takes.

The five encounters and three mortalities seen during the 28 trips provided little data to correlate bycatch data with tow parameters. The four marine mammal encounters were associated with one pair that uses a net that is of different design than the others. However, considering the low number of encounters, and without information on the mechanisms by which the marine mammals are being caught, we can only attribute the dolphin results to bad luck.

Trip No.	Start date	End date	No. of tows	Avg. Dur. (min)	Avg. depth (fm)	Takes? Y/N	Observed? Y/N
1	8/9/94	8/19/94	17	250	8.95	N	Y
2	8/13/94	8/21/94	14	230	10.17	Y	Y
3	8/26/94	9/2/94	14	242	8.57	N	Y
4	8/28/94	9/4/94	17	250	8.95	N	Y
5	9/1/94	9/8/94	10	240	10.22	N	Y
6	9/7/94	9/13/94	11	245	12.04	Y*	Y
7	9/8/94	9/14/94	14	272	8.13	N	Y
8	9/6/94	9/15/94	14	242	8.57	N	Y
9	9/12/94	9/18/94	12	265	10.33	N	N
10	9/12/94	9/19/94	17	236	8.26	N	Y
11	9/19/94	9/22/94	6	298	9.66	N	N
12	9/25/94	9/29/94	10	261	8.03	N	Y
13	9/24/94	10/3/94	19	269	12.11	N	Y
14	9/24/94	10/3/94	19	262	10.58	N	Y
15	10/3/94	10/9/94	15	219	8.24	N	Y
16	10/8/94	10/15/94	14	250	11.68	N	Y
17	10/8/94	10/15/94	13	282	11.35	Y	Y
18	10/14/94	10/19/94	10	290	7.88	N	Y
19	10/12/94	10/14/94	3	185	10.27	N	Y
20	10/24/94	10/27/94	8	225	7.69	N	Y
21	9/25/94	10/5/94	21	294	8.4	N	Y
22	10/11/94	10/17/94	13	324	9.62	N	Y
23	10/24/94	11/1/94	16	337	9.81	N	Y
24	10/31/94	11/6/94	13	301	8.08	N	Y
25	10/28/94	11/7/94	15	321	12.67	N	Y
26	11/4/94	11/7/94	5	304	11.49	N	Y
27	11/11/94	11/17/94	12	310	8.19	N	Y
28	10/21/94	10/29/94	17	281	11.98	N	Y
		Sum	369				
		Average	13.18	267.32	9.71		

Table 5. Summary of trip data

Marine mammal mortalities were seen in two of the 369 tows, or 0.54 percent. The rate of marine mammal mortalities for the duration of the season was one per 123 vessel-days at sea, or one per 548 hours of towing.

Table 6 summarizes the tuna catch per trip for each of the three significant species. Albacore tuna (*Thunnus alalunga*) dominated the landings with respect to number of fish. Albacore was consistently caught throughout the season, averaging 20.3 fish per tow. Fewer bigeye tuna (*T. obesus*) were caught, but their higher average weight yielded similar poundage to the albacore. Yellowtail tuna (*T. albacores*) were also caught, but not in significant quantities until trip number seven.

Since trip length was variable, a more revealing presentation of the data is presented in the right-hand columns of Table 6 where the trip catch has been divided by the number of tows. These data can be used as a measure of the fishing power of this method.

This catch-per-tow data is presented graphically in Figures 1 to 3. Figure 1 *(see page 148)* shows the average number of fish per tow for the five trawler pairs. Figure 2 presents the average weight per tow of these fish. Figure 3 shows the average size of the retained fish. The last figure reveals the size consistency of the fish caught by this method. The only anomaly was the yellowfin catch of pair four, in which the total catch of eight exceptionally large fish skewed the average.

The average size of the retained fish caught during this experiment is presented in Table 7. In this table, the average, high, and low weights in pounds are presented along with the sample size. The discarded fish are similarly presented. No bigeye were discarded, 0.56 percent of the albacore were discarded, and 3.35 percent of the yellowfin were discarded.

Table 6.

Summary of catch per trip and average catch per tow for the tuna species.

Catch per trip						
Trip	Bigeye		Yellowfin		Albacore	
	Fish	(pounds)	Fish	(pounds)	Fish	(pounds)
1	36	5,685	1	70	27	811
2	90	14,615	2	275	68	2,040
3	54	7,470	4	120	189	7,190
4	65	8,175	1	25	97	2,865
5	17	3,005	1	35	51	1,530
6	9	1,240	5	625	66	2,305
7	92	11,885	115	3,325	325	10,395
8	75	11,025	50	1,500	516	16,545
9	63	10,000	12	1,085	98	2,970
10	70	10,120	43	1,440	331	7,895
11	10	1,500	12	930	143	4,830
12	20	2,400	58	2,350	91	2,275
13	62	8,770	107	4,285	369	11,320
14	88	14,070	84	2,775	303	10,025
15	153	19,950	131	4,650	527	15,745
16	40	5,071	53	1,550	187	5,665
17	64	9,880	61	2,064	223	7,420
18	82	10,955	69	3,758	400	12,880
19	1	200	3	330	1	30
20	209	27,998	212	7,210	778	28,326
21	97	13,590	76	3,095	350	12,020
22	57	7,715	65	1,910	296	10,480
23	59	6,735	55	1,640	288	11,265
24	116	14,025	149	4,240	456	17,162
25	56	7,520	25	770	246	7,380
26	2	110	2	60	51	1,560
27	22	2,250	24	680	234	8,174
28	50	6,330	101	3,155	779	28,130
Totals	1,759	242,289	1,521	53,952	7,490	249,233
Avg. (lbs)		138		35		33

Average catch per tow						
# Tows	Bigeye		Yellowfin		Albacore	
	Fish	(pounds)	Fish	(pounds)	Fish	(pounds)
17	2	334	0	4	2	48
14	6	1,044	0	20	5	146
14	4	534	0	9	14	514
17	4	481	0	1	6	169
10	2	301	0	4	5	153
11	1	113	0	57	6	210
14	7	849	8	238	23	743
14	5	788	4	107	37	1,182
12	5	833	1	90	8	248
17	4	595	3	85	19	464
6	2	250	2	155	24	805
10	2	240	6	235	9	228
19	3	462	6	226	19	596
19	5	741	4	146	16	528
15	10	1,330	9	310	35	1,050
14	3	362	4	111	13	405
13	5	760	5	159	17	571
10	8	1,096	7	376	40	1,288
3	0	67	1	110	0	10
8	26	3,500	27	901	97	3,541
21	5	647	4	147	17	572
13	4	593	5	147	23	806
16	4	421	3	103	18	704
13	9	1,079	11	326	35	1,320
15	4	501	2	51	16	492
5	0	22	0	12	10	312
12	2	188	2	57	20	681
17	3	372	6	186	46	1,655
369						

Retained Tuna Size Distribution

Species	Average	Low	High	Number of Fish
Albacore	33.5	25	45	7,487
Bigeye	137.7	50	230	1,761
Yellowfin	35.2	10	150	1,521

Discarded Tuna Size Distribution

Species	Average	Low	High	Number of Fish
Albacore	27.4	20	30	42
Bigeye	-	-	-	0
Yellowfin	15.6	5	40	51

Table 7. Size of retained and discarded tuna

A total of 298 swordfish were caught during the experiment. Of these, 88 were retained at an average weight of 143 pounds, and 210 were discarded at an average weight of 64 pounds. The trip-by-trip swordfish catch is presented in Figures 4 and 5. Figure 4 shows the number of kept and discarded fish for each trip; Figure 5 shows the average weight of the two categories of swordfish in pounds. Due to variations in trip length, the catch rates per tow are more revealing than catch rates per trip. Figure 6 presents the average number of swordfish caught per tow for each trip. Swordfish were found in 171 of the 369 tows, or 46 percent. This yielded an average of 0.81 fish per tow, with a high of eight fish in one unusual tow.

The average ratio of swordfish to tuna for the 28 trips was 2.8 percent. Only one trip had no swordfish, while another trip caught 12.7 percent swordfish compared to tuna. Approximately half of the swordfish that were not kept were discarded undersized, while the remainder were discarded due to the two-fish-per-boat trip limit. Most discarded swordfish were released alive, and many were tagged.

Discussion

The data on the marine mammal and endangered species bycatch indicate that this midwater pair trawling for tuna has a low mortality rate compared to some other methods of fishing. The three mortalities seen during the experiment indicate an occurrence in less than 1 percent of the tows. Twenty-five of the 28 trips had no encounters. Twenty-six trips had no mortalities.

Based on number of tuna landed, the data indicate a marine mammal mortality rate of 0.0003 per tuna. Alternatively, the data imply that 182,172 pounds of tuna can be landed per mortality.

As stated in the results section, there were insufficient numbers of marine mammal and endangered species takes to establish correlations with any particular fishing parameter. The 5-fathom ceiling seems to be an effective measure in reducing the chances for encounters.

However, the importance of individual accountability cannot be overstated in the achievement of this low bycatch rate. The participants were highly motivated by the realization that their individual bycatch rates were going to be scrutinized. It was clear to all vessel owners that the continuation of the experiment was more important than the participation of any particular pair. If any pair experienced high bycatch rates, then their involvement in the experiment would be terminated. Without involvement in the experiment, NMFS would not allow them to continue pair trawling for tuna.

The average tow duration during the experiment was 267 minutes (less that 4.5 hours), and this may have contributed to the survivability of the bycatch. However, another explanation could be that those fish that survived were caught during the haulback and those that died were caught in the setting of the trawl. The captains believe it is at the beginning and the end of the tow, when the gear is at the surface, that the air-breathing bycatch is most likely to be encountered.

Since the vessels would typically make two tows per night, the tuna catch rate for midwater pair trawling, as outlined in Table 3, can be multiplied by two to get catch per day for the pair, or can be used directly as catch per boat per day.

The catch rates of the tuna species varied with the vessel pair. This was due to differences in the size of net used, the horsepower of the vessels, and the ability of the captains to locate fish. However, since a determination of fishing power is useful in comparing fisheries and in determining changes in a fishery, the catch data for tuna was analyzed based on pair-trawl circumference and horsepower. The latter approach, in which the catch per tow in pounds for each species was divided by horsepower, yielded similar values of fishing power for all of the four pairs that took three or more trips this season.

The 1994 season-averaged catch per tow in pounds divided by twice the horsepower of the lower-powered vessel is 0.47 for bigeye, 0.09 for yellowfin, and 0.44 for albacore. Assuming similar availability of fish and other factors, these values could be used in predicting the catching ability of a known pair of vessels intent on the exploitation of these tuna species.

The size-selectivity of pair trawling may be advantageous from a tuna management standpoint. Comparisons should be made with similar data on other methods used to exploit these same tuna stocks. The low discard rate suggests pair trawling is a responsible technique for harvesting this resource.

The low but consistent catch of swordfish indicates that these fish are neither being targeted nor are they avoidable in a pair trawl fishery for tuna. The waste of marketable fish caused by the two-swordfish-per-boat limit is unfortunate.

A fixed per-trip limitation on swordfish is troublesome due to the variable length of the trips. As shown in Figure 7, there is a correlation between trip length and number of discarded swordfish. If restrictions are required, they should allow for variable-length trips or should be based on a percentage of tuna landed.

The size distribution of the swordfish caught by pair trawling should be compared with similar data for other methods of fishing. The size-selectivity of this gear may indicate that this is a preferred method of harvesting swordfish, from a stock management standpoint.

Conclusions

1. The 1994 bycatch data from 369 pair-trawl tows show a marine mammal mortality rate of one per 123 tows.

2. Including live releases, the marine mammal and endangered species encounter rate for this fishery is one per 61.5 tows.

3. The average size of the retained tuna during this experiment was 33.5 pounds for albacore, 137.7 for bigeye, and 35.2 for yellowtail.

4. Of the 10,862 tuna caught, the overall retention rate was 99.14 percent.

5. During the experiment 298 swordfish were caught, of which 88, or 29.5 percent, were retained .

6. Swordfish are neither targeted in this fishery nor avoidable. The average ratio of swordfish per tuna was 2.8 percent. Longer trips resulted in more discards of swordfish due to the two-fish-per-boat trip limit.

Recommendations

1. Data from this report should be compared with similar data collected from other methods of exploiting these stocks to determine the relative appropriateness of each method based on marine mammal and endangered species bycatch. In addition, the size-selectivity of the various methods should be compared with respect to both tuna and swordfish.

2. Based on such comparisons, the status of pair trawling with respect to tuna and swordfish exploitation should be examined.

3. In order to retain the low bycatch and sharp selectivity characteristics of this method, the guidelines developed in this experimental fishery should be imposed on future experiments or authorized fisheries. These include:

a) A netsounder for continuous monitoring of trawl position

b) A 5-fathom headrope ceiling and clear rules for haulback if that ceiling is violated

c) Maximum tow duration of 360 minutes

d) Full observer coverage

e) Adequately trained participants to ensure efficient setting and hauling of the trawl and its controlled behavior during the tow.

Acknowledgments

This data analysis and reporting associated with this experimental fishery was supported by the MIT Sea Grant College Program through NOAA grant NA46RG0434 and by financial contributions from each of the participating pairs. The observer coverage was provided by NMFS. The thorough cooperation of the participating fishermen during the experiment was appreciated.

References

1. Taber, R.E. and J.W. McLeod. 1972. Pair trawling for herring in New England. URI Marine Bulletin No. 9.

2. Gerrior, P. 1994. Preliminary data presented at tuna pair trawl meeting in Riverhead N.Y., 25 February.

3. NMFS, 1994. Highly migratory species pair trawl authorization. 5 Aug.

Figure 1: Average number of tuna per tow

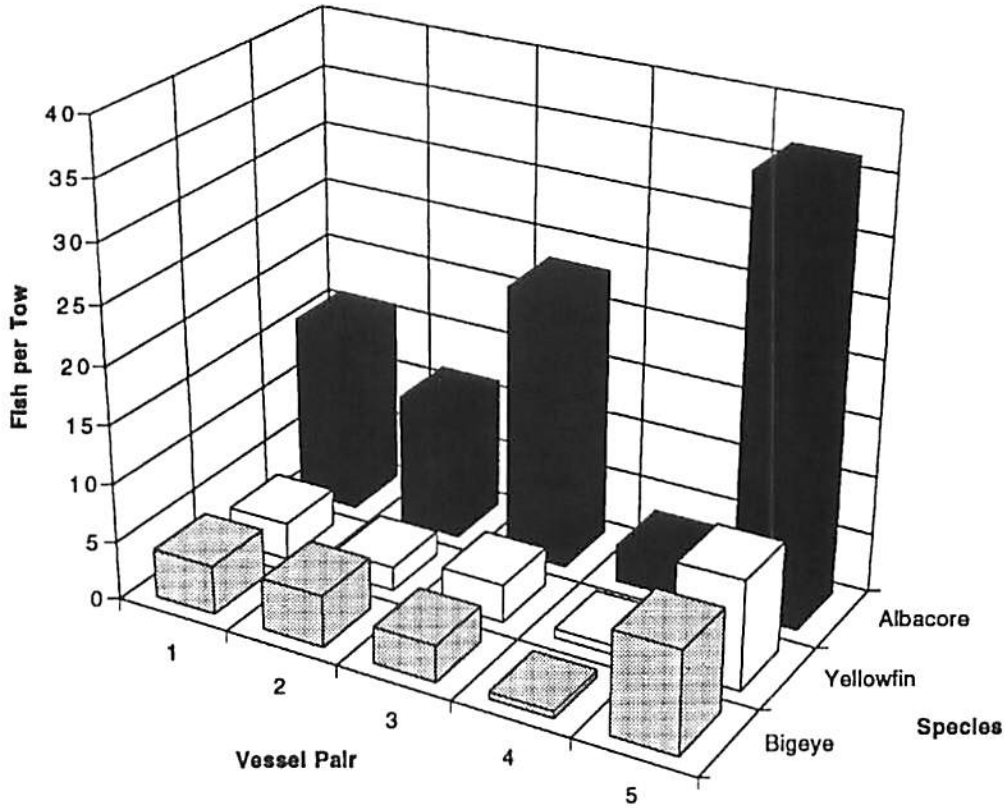


Figure 2: Average weight of tuna per tow

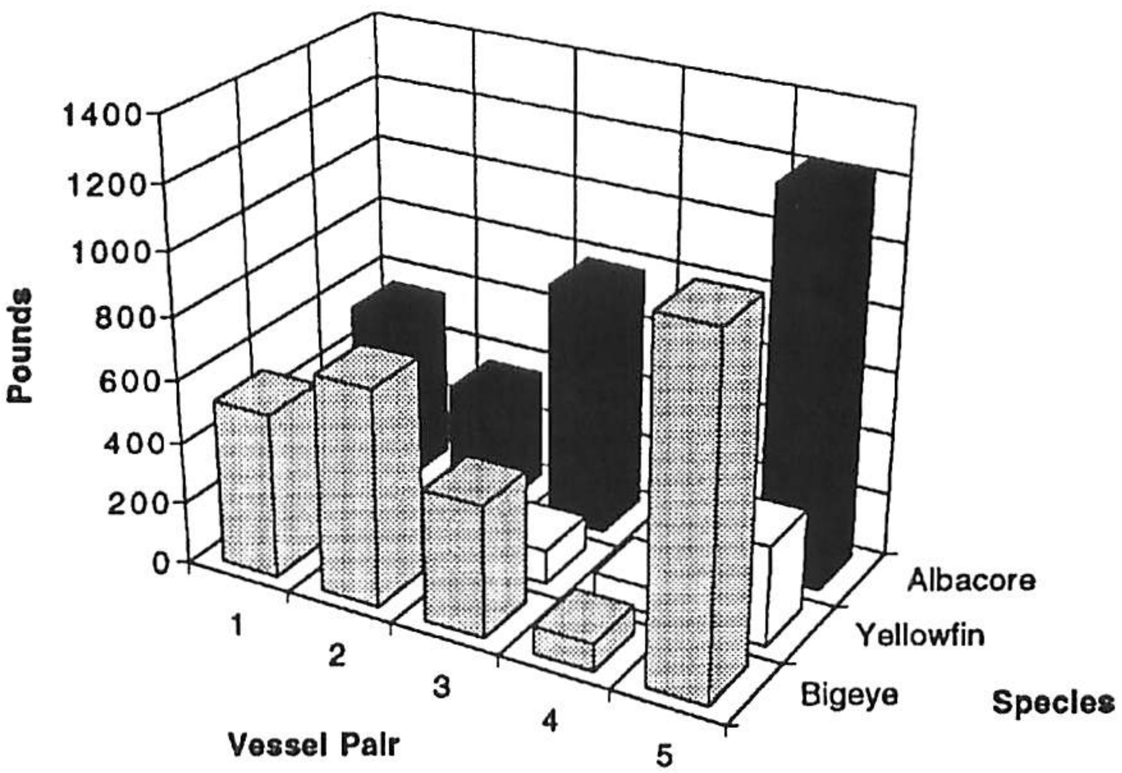


Figure 3: Average fish size

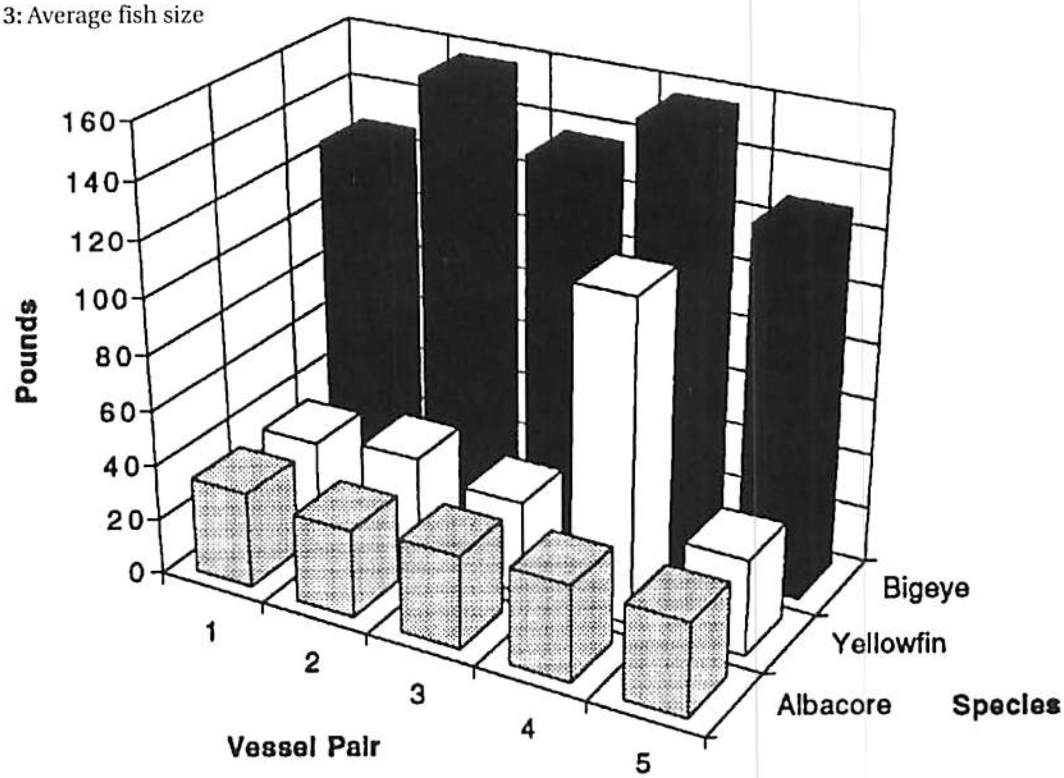


Figure 4: Swordfish per trip

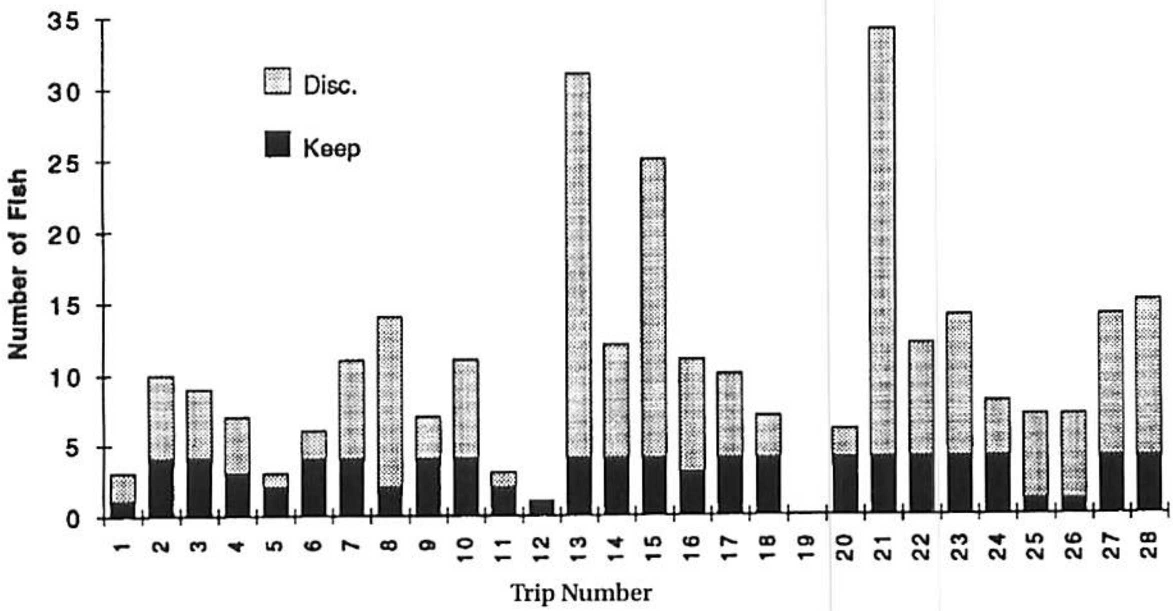


Figure 5: Swordfish average weight per trip

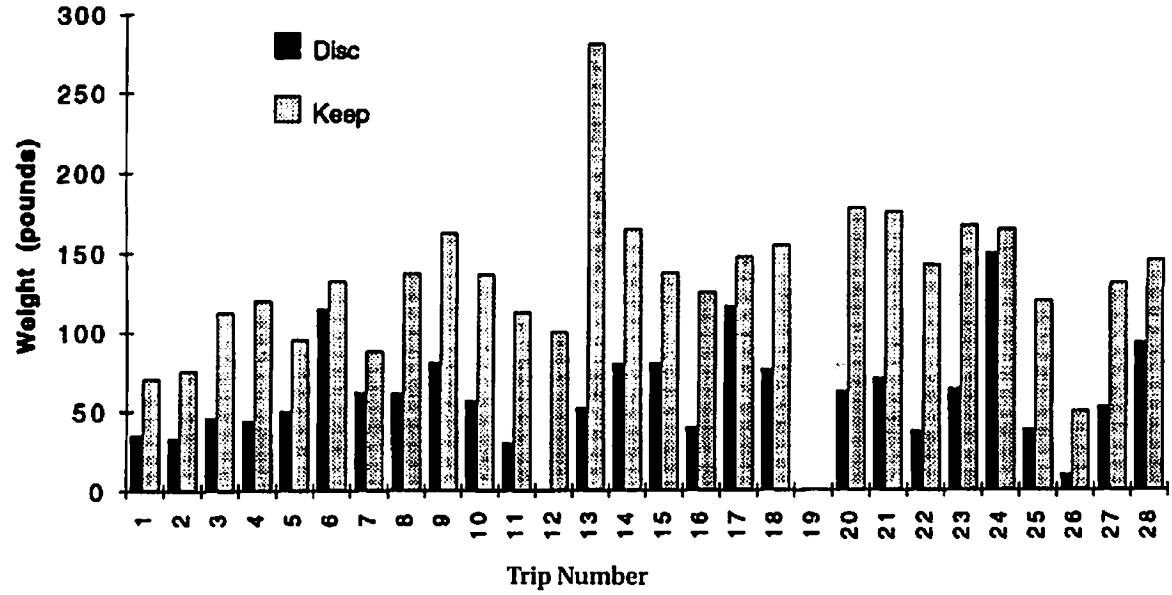


Figure 6: Swordfish per tow

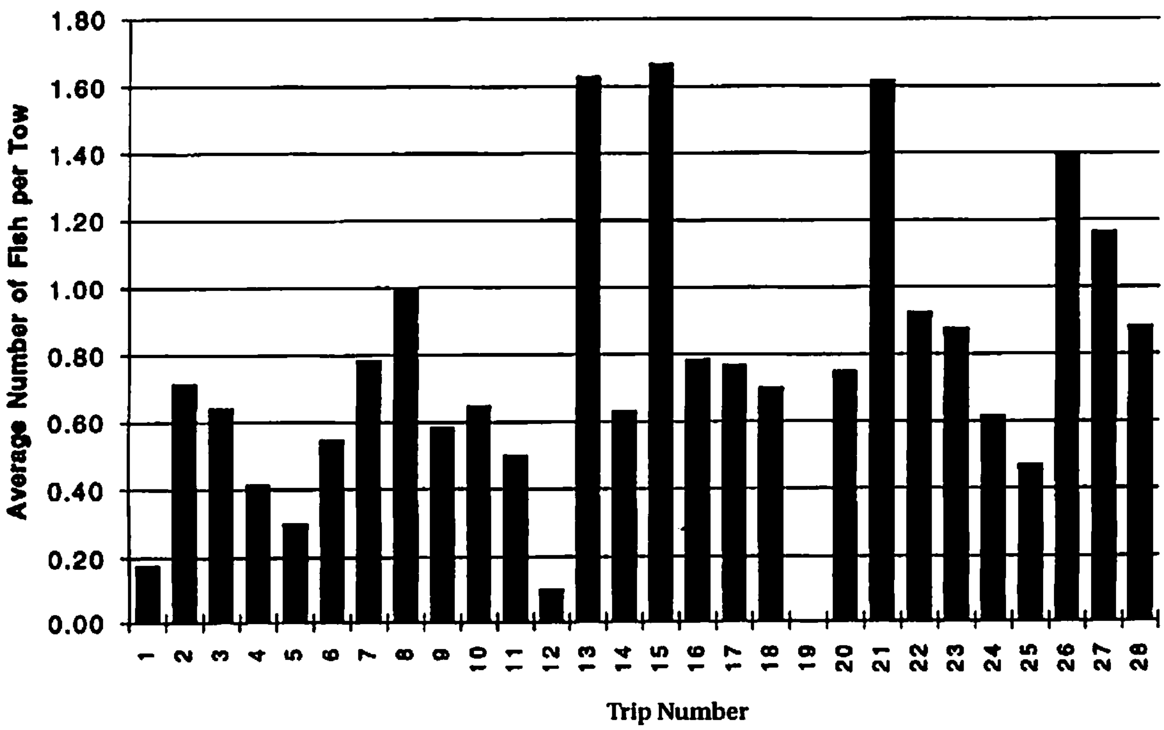
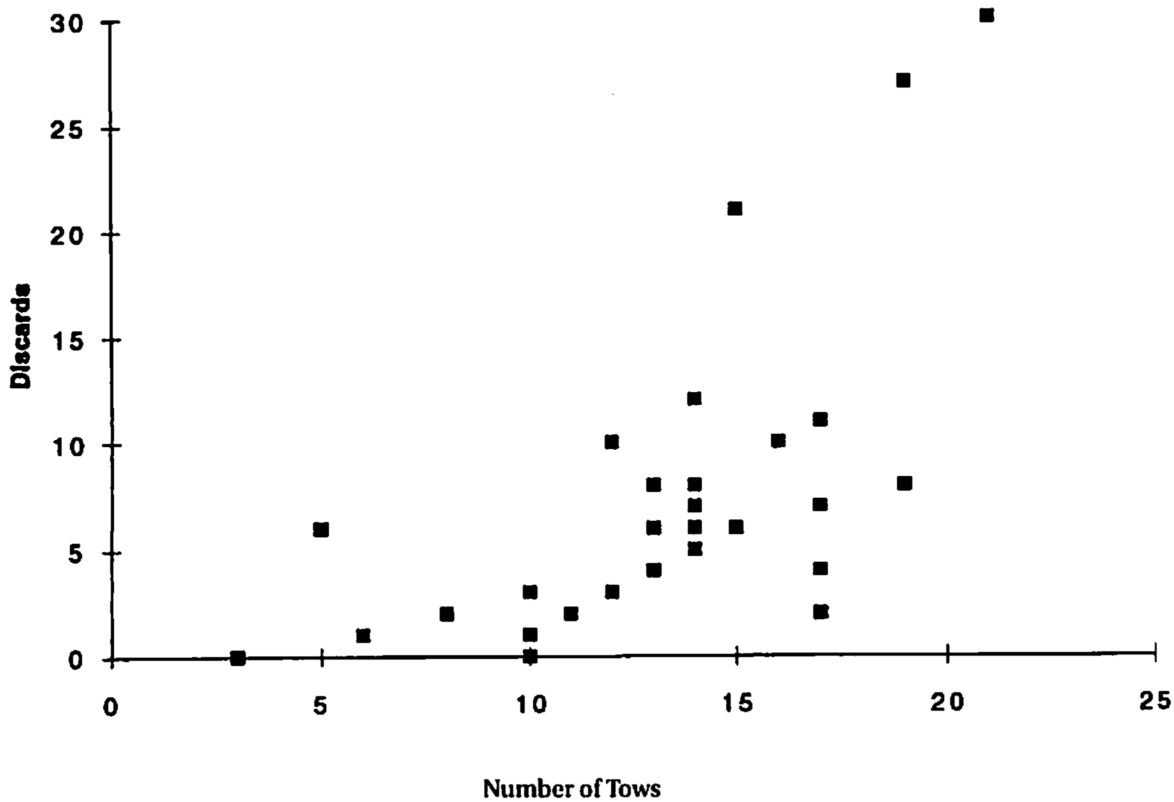


Figure 7: Swordfish discards vs. trip length



MIT Pelagic Pair Trawl Data Sheet

Center for Fisheries Engineering Research — MIT Sea Grant College Program

Boat name	1994 trip No.	Tow No.	Standard Config? Y / N	If no, describe:	
Date tow began	Time tow began	Time haul back	Water temp. Deg. F.	Location (Lat-Long.)	Weather

Set out	speed	boat separation	Time on surface	Comments on tide, wind, gear foul-ups, etc.
	kts	ft	min	

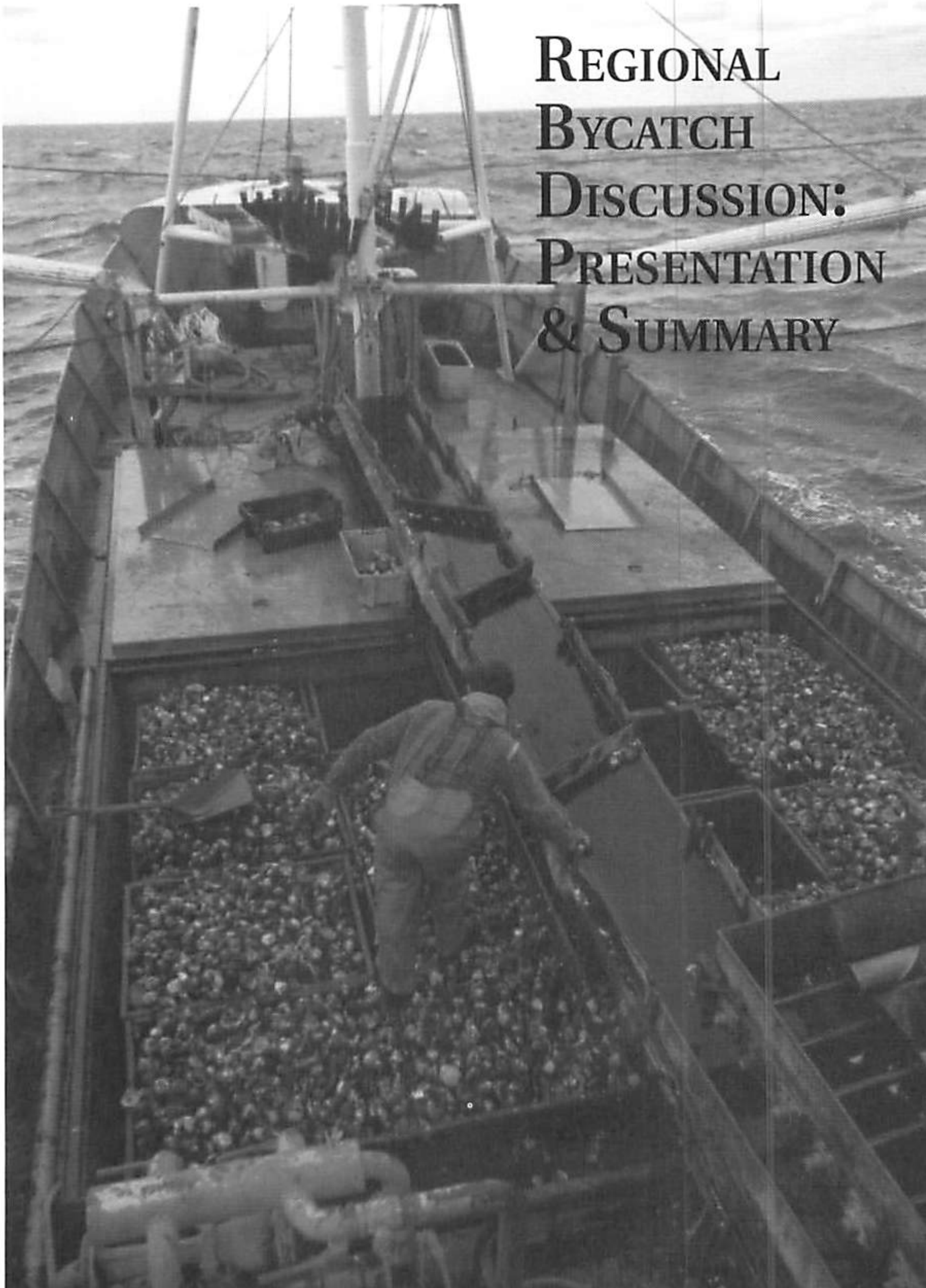
Tow	speed	boat separation	Top warp length	Time	H.R. depth	Comments on speed, separation, warp, turns, temp., etc.
First hour	kts	mi.	fm	00 Min.	fm	
				15 Min.	fm	
				30 Min.	fm	
				45 Min.	fm	
Second hour	kts	mi.	fm	00 Min.	fm	Comments
				15 Min.	fm	
				30 Min.	fm	
				45 Min.	fm	
Third hour	kts	mi.	fm	00 Min.	fm	Comments
				15 Min.	fm	
				30 Min.	fm	
				45 Min.	fm	
Fourth hour	kts	mi.	fm	00 Min.	fm	Comments
				15 Min.	fm	
				30 Min.	fm	
				45 Min.	fm	
Fifth hour	kts	mi.	fm	00 Min.	fm	Comments
				15 Min.	fm	
				30 Min.	fm	
				45 Min.	fm	
Sixth hour	kts	mi.	fm	00 Min.	fm	Comments
				15 Min.	fm	
				30 Min.	fm	
				45 Min.	fm	

Haul back	speed	boat separation	Time on surface	Comments on tide, wind, gear foul-ups, etc.
	kts	ft	min	

Catch	No. kept	Average weight	No. discarded	Average weight	Comments on unusual catch results:
Bigeye		lbs		lbs	
Yellowfin		lbs		lbs	
Albacore		lbs		lbs	
Skipjack		lbs		lbs	
Other tuna:		lbs		lbs	
Swordfish		lbs		lbs	
Other:		lbs		lbs	

Bycatch	No.	Average size	Condition	Comments on reasons for bycatch:
Bottlenose dolphin		lbs		
Saddleback dolphin		lbs		
Pilot whale		lbs		
Leatherback turtle		lbs		
Other:		lbs		

Regional Bycatch Discussion: Presentation & Summary



Working Groups: A Collaborative Approach to Solving Bycatch Issues

The purpose of the three break-out sessions was to discuss regional fisheries bycatch situations in order to identify new avenues of research for bycatch identification and reduction efforts. Participants in the sessions included fishermen, managers, environmentalists, researchers, and the general public. Each known fishery was examined as to bycatch priority for each group represented, magnitude of the real or perceived problem, and potential solutions. The following is a summary of these discussions. It should be noted that these are the opinions of the participants and do not constitute a thorough approach to identifying the problem areas, but rather present a starting point for future research.

NORTHEAST REGION

There were eight categories of fisheries discussed in this regional session: groundfish, fisheries north and south of Cape Cod, large mesh trawls, small mesh trawls, pots and traps, hooks, dredges and drags, and seines. Not all fisheries were prioritized for research; some were just described.

Groundfish - South and North of Cape Cod

The sink gill net fishery for groundfish was divided into two distinct groups due to target catch differences. The targets for north of Cape Cod are groundfish, flounders, dogfish, skates, bluefish, shark, hakes, and monkfish, with bycatch of harbor porpoise, striped bass, seabirds, bluefish, harbor seals, dolphin, juvenile fish, and dogfish. The catch of harbor porpoise classifies this fishery as high priority, but much research is already occurring using acoustic pingers. The pinger experiment has proven to be successful in that it involved a collaborative approach to solving bycatch issues by involving all user groups in the decision-making process.

The southern fishery targets bluefish, blackfish, scup, weakfish, dogfish, black sea bass, monkfish, and groundfish, with the same bycatch problems.

Large Mesh Bottom Trawl - Groundfish

The large mesh bottom trawl fishery targets groundfish, monkfish, skates, flounders, and lobster. The bycatch includes juvenile groundfish, flounders, soft-shell lobster, berried lobster, dogfish, invertebrates, sharks, striped bass, and bluefish. High priority exists for research to help eliminate the juvenile finfish problem.

Small Mesh Bottom Trawl

The target species for the small mesh trawls include squid, butterfish, mackerel, tilefish, scup, dogfish, ocean pout, herring, hake, shrimp, menhaden, and fluke. Bycatch includes juvenile finfish, regulated species, lobster, monkfish, skate, flounders, invertebrates, river herring (alewives and blueback) shad, ocean herring. The shrimp fishery has been investigated extensively, and the use of the Nordmore Grate device has helped to reduce the catch of juveniles. However, more research in these areas is needed.

Pots and Traps

The target species for these various fisheries include lobster, shrimp, cod, eels, conch, sea bass, scup, crab, hagfish, tautog, and tilefish. The bycatch is identified as regulated groundfish, juvenile finfish, and lobsters. The use of escape vents and biodegradable panels has made these fisheries more environmentally friendly.

Hooks

The fishery was not broken down into commercial or recreational. Target species include: groundfish, halibut, tilefish, black sea bass, conger eel, squid, dogfish, shark, striped bass, bluefish, scup, flounders, and tautog. Bycatch include juveniles of all species plus striped bass. No further information was given in this session.

Dredge/Drag Gear

Many fisheries were grouped together under this heading: mussels, urchins, scallop, sea cucumber, monkfish, flounder, quahogs, mahogany clams, lobster. Assorted bycatch problems include: juvenile groundfish, regulated groundfish, juvenile lobster, and invertebrates. No further information was given in this session.

Seine Fishery

The seine fishery for herring and mackerel was described, with possible bycatch identified as harbor seals, striped bass, and bluefish. As this fishery expands through the Internal Waters Processing agreements and the joint ventures with Russia, more information is needed regarding bycatch. It is believed to be a fairly uniform and clean fishery. Requests have been made for increased sea sampling directed to this area.

MID-ATLANTIC REGION

Six major fisheries were identified in this session: (1) directed trawl fishery, large mesh and small mesh for mackerel, squid, and herring; (2) sea scallop dredge and trawl; (3) pelagic longline fishery for swordfish, sharks, and tuna; (4) summer flounder trawl fishery/dredge bycatch fishery, pound nets; (5) mixed small mesh trawl for squid, whiting, butterfish, and scup; and (6) inshore pot fishery for lobsters.

The highest priority for research was placed on the fishery involving sea scallops because of the discard/bycatch of yellowtail flounder; medium priority on the longline and bottom trawl fisheries; and low priority on the trap and directed trawl fisheries.

Fishery: Sea Scallops

The gears used to harvest scallops are the scallop dredge (ring size 3.25 to 3.5 inches) and bottom trawl (5-inch mesh). This fishery is conducted year-round, although there is some variation depending on geographic area. The retained bycatch includes fluke, monkfish, yellowtail and other flounders, lobster, and Jonah crabs. Discards include regulated species—all undersize flatfish species—crushed lobsters and crabs, other invertebrates, undersize scallops, and skates. The reason for the high priority revolves around the bycatch of yellowtail flounder and undersize scallops. Possibilities of gear modifications to dredges to reduce this bycatch appear limited, but area closures may be more effective. Separation devices may have potential in the trawl fishery.

Fishery: Pelagic Longline - Swordfish, Sharks, and Tuna

This fishery is primarily concerned with the longline gear for large pelagics. The retained bycatch includes yellowtail and bigeye tuna, pelagic sharks, dolphin (fish), and some finfish. Discards include rays, blue sharks, blue and white marlin, sailfish, 5 percent damaged by predators, and regulatory discards of bluefin tuna, swordfish, etc.

The discussion group gave this collective fishery a medium priority, except in the area of marine mammal, turtle, and billfish species. However, the industry has provided excellent data on the fishery. Bycatch appears to be low (15 percent by number; 10 to 15 percent by weight discarded). Potential solutions include education and instructions to the fishermen as to how to legally release turtles (This has already occurred as of March 1996). Research into different hook types and dehooking techniques for billfish, as well as other gear modifications, may also be an important approach to reducing bycatch.

Fluke - Large Mesh Trawl, Scallop Dredge Fisheries

Bycatch associated with these fisheries (5.5-inch mesh) is considered to be medium- to low-priority because of the seasonal nature of the fishery. Since fluke is managed under a state quota and trip limit system, management-created regulatory bycatch becomes the major problem. The bycatch retained includes *Loligo* squid, whiting, monkfish, butterfish, weakfish, scup, bluefish, lobster, and scallops. Discards include dogfish, skates, undersized flatfish, fluke, and monkfish. Turtles can be a problem seasonally; however, TEDs are mandated during this time. Fishermen perceive that the solution lies with management decisions and rearrangement of the quota system to eliminate high grading and discards after quotas have been reached. Area closures would help also.

Mixed Trawl Fisheries - Small and Large Mesh

The multispecies fisheries are complicated since it is difficult to know what species will be present in the catch; mesh selection has no benefit in resolving the bycatch. The target species are squid, whiting, butterfish, mackerel, and scup. Bycatch includes fluke, gray sole, four spot flounder, monkfish, and lobster; discards include ling cod, skates, undersize fish, and red hake. This is mostly a winter fishery in the Hudson Canyon area. This fishery was given a medium priority, since marine mammals are not involved. In addition, there is a directed small mesh fishery for squid.

Directed Trawl Fishery - Mackerel, Squid, and Herring

These fisheries were given low priority because the bycatch problem has been solved by the fishermen themselves. With controlled trawl characteristics, seasons, and fishing areas, the catch is considered to be clean. The trawls have large meshes, ranging from 64 inches to 16 feet in fishing circle, back to $1^1/_8$ inches in the codend. Targeted species include mackerel, squid, and herring. Mackerel is caught between January and April; *Illex* squid during the summer. Discards consist of dogfish. This fishery is a good example of how fishermen can solve bycatch problems if allowed to pursue their own ideas, with some assistance from gear technologists.

Trap Fishery - Lobsters

This fishery deals with the capture of lobsters and crabs using traps. The only bycatch mentioned was tautog and black sea bass, occurring primarily during the summer months. If undersize, these fish are released alive; if legal, they are retained for sale in the live market. Concern arises because of the recreational importance of these species. The fishery could be considered medium priority and its bycatch could be easily solved through management or gear selectivity (i.e. round escape vents).

SOUTHEAST REGION

Seven major fisheries were discussed in this session based on species and gear: shrimp, menhaden, marine mammal interactions, gill net fishery, trap fishery, and crab trawl. The recreational fishery was also separated out and discussed. The shrimp fishery was considered to be a high priority for research, as was the need for recreational fishery statistics; all others were considered to be low priority.

Shrimp Fishery

The shrimp fishery encompasses a variety of gear types and methods: otter trawls, skimmer trawls, butterfly nets, and cast nets. The target species include brown, white, pink, rock, and royal red shrimp and seabob. There are 112 species included in the bycatch/discard, including juvenile finfish (50 percent croakers, whiting, and porgies), spot, menhaden, king and Spanish mackerel, weakfish, invertebrates, and turtles. The fishery operates year-round, inshore to 50 fathoms, out to 100 fathoms for royal reds. The bycatch problem is considered high priority, and considerable progress has been made to reduce interactions with other species through the use of TEDs, BRDs (fisheye, extended funnel, snake-eye, Morrison TEDS). Fishermen claim that the problem is not so much bycatch (except certain species) as utilization of the catch. Markets have opened for this product, i.e. feed for aquaculture operations. Time–area closures have been tested but do not appear to be successful. Some gear modifications based on fish behavior have been shown to be successful.

Menhaden

The menhaden fishery using purse seines was given a low research priority. Bycatch is identified as sharks, bluefish, red drum, skates, and rays. This was not discussed in any more detail.

Gill Net Fishery in Florida - Mackerel, Pompano, and Bluefish

This fishery was not identified as having a priority, perhaps because recent legislation in Florida to ban gill nets makes it no longer a viable fishery. Bycatch includes turtles and manatees. There was no further discussion.

Trap Fisheries - Lobster, Stone Crab, Blue Crab, Golden Crab

Not much was known about these fisheries in regard to their bycatch or mortality of bycatch. The use of escape vents and biodegradable panels in traps has made fishing more environmentally friendly.

Marine Mammals (coastal dolphin) and Turtles

The bycatch of these species in coastal areas depends on the gear type used, gill nets and shrimp trawls being the most predominant. More information is needed to categorize these fisheries, although impact is believed to be small.

Crab Trawl

The crab trawl was identified because of bycatch of undersized fish. However, very little information was available to discuss this fishery. Possible solutions might include mesh size selectivity.

Recreational Fishery

The recreational fishery utilizing hook and line was given a medium to low research priority. The target species are many, but primarily weakfish, flounder, spotted trout, and red drum. Bycatch includes juvenile and undersize fish and hard-head catfish. There are inshore, offshore, and near-shore categories of fisheries. Consensus was that very little information exists as to impact—mortality, catch-and-release education, and effort.

> *The shrimp fishery encompasses a variety of gear types and methods... There are 112 species included in the bycatch/discard, including juvenile finfish...*

Where Do We Go From Here?

Joseph DeAlteris
Rhode Island Sea Grant

We would like to thank you for your time and effort in making the East Coast Bycatch Conference a success. We hope that everyone will leave with a feeling of accomplishment and that the time invested in this effort was worthwhile.

The general conclusions reached in the conference were (1) that bycatch on the East Coast is a tractable problem, (2) that the fishing industry, with the help of the government and the environmental community, has solved some problems, but (3) that there remain additional problems to work on. The most demanding issues deal with interactions with marine mammals and turtles, and with discards of juvenile groundfish. The success stories of the Nordmore Grate and BRDs did not happen overnight. They took considerable time and effort, as well as continued funding to conduct the necessary experiments. There are no easy and fast solutions to the problems.

Finally, the general consensus was that communication and education are the best tools for addressing the remaining problems. No longer can bycatch be considered a secret evil. It must be openly discussed and recognized in order to be resolved. For this reason, the papers and ideas presented in this conference will be published and distributed to continue the education process. All participants were part of this process—and will become the educators of the future.

Thank you for coming and being a part of the effort to create the sustainable fisheries of the future.