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Fisheries Management Bycatch
MANAGING THE NATION'S BYCATCH: PRIORITIES, PROGRAMS AND ACTIONS FOR NMFS
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MANAGING THE NATION'S BYCATCH:

PRIORITIES, PROGRAMS AND ACTIONS FOR THE NATIONAL MARINE FISHERIES SERVICE

NATIONAL MARINE FISHERIES SERVICE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION U.S. DEPARTMENT OF COMMERCE
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EXECUTIVE SUMMARY

Bycatch—defined as fishery discards, retained incidental catch, and unobserved mortalities resulting from a direct encounter with fishing gear—has become a central concern of the commercial and recreational fishing industries, resource managers, scientists, and the public, both nationally and globally. Bycatch concerns stem from the apparent waste that discards represent when so many of the world's marine resources either are utilized to their full potential or are overexploited. These issues apply to fishery resources as well as to marine mammals, sea turtles, seabirds, and other components of marine ecosystems.

Congress has responded to these concerns by increasing requirements of the Marine Mammal Protection Act, the Endangered Species Act, and, most recently, the Sustainable Fisheries Act[1] to reduce or eliminate bycatch. The Magnuson-Stevens Fisheries Conservation and Management Act highlighted the need for bycatch management in fishery management plans by requiring that conservation and management measures shall, to the extent practicable, minimize bycatch and to the extent that bycatch cannot be avoided, minimize the mortality of such bycatch. Globally, the United Nations Food and Agriculture Organization's Code of Conduct for Responsible Fisheries, to which the United States is a signatory, also emphasizes bycatch reduction.

The national goal of the National Marine Fisheries Service's bycatch plan activities is to implement conservation and management measures for living marine resources that will minimize, to the extent practicable, bycatch and the mortality of bycatch that cannot be avoided. Inherent in this goal is the need to avoid bycatch, rather than create new ways to utilize bycatch.

Responding to these issues and increasing regulatory requirements, in 1992 the U.S. commercial fishing industries initiated a series of workshops to develop strategies to reduce bycatch and to increase the industry's and the public's understanding of bycatch issues. Their recommendations, as well as those from the recreational fishing and environmental groups and the public, have prompted the National Marine Fisheries Service to prepare this plan, clearly articulating the agency's objectives, priorities, and strategies regarding bycatch. This plan includes national and regional bycatch objectives; specific recommendations concerning data collection, evaluation, and management actions necessary to attain the objectives; and an assessment of the state of knowledge about bycatch in the nation's marine fisheries. The last of these is intended to serve as a benchmark for measuring progress in bycatch reduction.

Because there are little data available on the retained incidental and unobserved mortality components of bycatch, the assessment of bycatch focuses on the availability of quantitative discard estimates from the nation's fisheries, the significance of those discards to the health of fishery and protected stocks, and progress in addressing bycatch issues associated with each of the fisheries evaluated. Some quantitative information on finfish discards was available for about half of the species or species groups; the availability of such estimates is disproportionate among regions of the country and among fisheries within regions.

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[1] The Sustainable Fisheries Act amended the Magnuson Fishery Conservation Management Act and renamed it the Magnuson-Stevens Fishery Conservation and Management Act.

Review of bycatch reduction efforts completed or under way indicates that successful programs share common characteristics that form the basis for the following seven national objectives in this plan:

1. Determine the magnitude of bycatch and bycatch mortality.

2. Determine the population, ecosystem, and socio-economic impacts of bycatch and bycatch mortality.

3. Determine whether current conservation and management measures minimize bycatch to the extent practicable and, if not, select measures that will.

4. Implement and monitor selected bycatch management measures.

5. Improve communications with all stakeholders on bycatch issues.

6. Improve the effectiveness of partnerships with groups and individuals external to the National Marine Fisheries Service.

7. Coordinate NMFS Activities to effectively implement this plan.

To accomplish these objectives, recommendations are made in the following six areas:

1. bycatch monitoring and data collection programs;

2. research on the population, ecosystem, and socio-economic effects of bycatch;

3. research to increase the selectivity of fishing gear and to increase the survival of fish and protected species that are inadvertently encountered by fishing gear;

4. incentive programs for fishermen to improve bycatch performance;

5. analysis of the implications of conservation and management measures for bycatch; and

6. exchange of information and development of cooperative management approaches.

Recommended actions in the six areas range from developing strategies for a long-term integrated scientific approach to the collection of biological, economic, and social data to providing information that will help define the benefits and costs associated with managing bycatch. The plan does not attempt an intraregional needs prioritization. Instead, it suggests a seven-step decision-making framework to evaluate national and regional bycatch research and management.

The development of this plan has brought into focus the fact that there is a multifaceted and complex set of problems associated with bycatch that affects nearly all aspects of fishing operations. Regionally, the causes and implications of bycatch share some characteristics, but often differ since the status of exploitation of resources and the way fisheries are prosecuted and managed can vary substantially. Bycatch management can be accomplished with a wide variety of measures, depending on the specific characteristics of fisheries. As a result, no single solution to the "bycatch problem" exists. Rather, fishermen, managers, scientists, conservationists, and other interest groups must work together to craft a balanced approach to addressing bycatch—one that will promote the sustainability of our nation's living marine resources.

National Perspective

National Overview

National and international interest in the sustainability of marine fisheries has increased over the last several decades. Public awareness of marine fisheries issues in the United States has become acute since the early 1990s. The perception of commercial and recreational fisheries as being wasteful of the world's limited marine resources is becoming deeply rooted. Nowhere is this more apparent than when dealing with bycatch, the unintended capture or mortality of living marine resources as a result of a direct encounter with fishing gear.

Background

Bycatch occurs if a fishing method is not perfectly selective or if fishermen have a sufficient incentive to catch more than will be retained. A fishing method is perfectly selective if it results in the catch and retention only of the desired size, sex, quality, and quantity of target species without other fishing-related mortality. Very few fishing methods meet this criterion. Bycatch is a source of fishing mortality because some of the bycatch does not survive.

Bycatch of marine organisms is not limited just to commercial fishing operations. In fact, bycatch in recreational and subsistence fisheries totals millions of fish each year. Due to the paucity of information on the amount of bycatch of living marine resources for all the U.S. fisheries, estimates (e.g., Alverson et al. 1994) may reflect only the order of magnitude of the discard component of bycatch. Similarly, while there is growing concern about the ecosystem impacts of bycatch, there is little information on the effects of bycatch on the marine ecosystem.

Despite the uncertainty surrounding the absolute magnitude of the amount of bycatch by U.S. fisheries, the public, scientists, fisheries managers, the recreational and commercial fishing industries, and conservation organizations have become increasingly concerned that bycatch precludes better uses of living marine resources. From an ecological perspective, scientists are uncertain about the disruption of marine food chains and species dynamics and the effects on sustainability of fishery resources and on the functioning of marine ecosystems caused by bycatch. Finally, there are ethical concerns about bycatch being a potential waste of protein resources and a failure to fully utilize harvested living marine resources.

Bycatch mortality affects the sustainability of fisheries and the benefits that these resources provide the nation in two ways. First, it increases the uncertainty concerning total fishing-related mortality, which in turn makes it more difficult to assess the status of the stocks, to set appropriate optimum yield and overfishing levels, and to ensure that the optimum yields are attained and that the overfishing levels are not exceeded. Second, bycatch mortality precludes some other uses of fishery resources. For example, juvenile fish that are subject to bycatch mortality cannot contribut directly to the growth of that stock and to future directed catch.

In 1994, the Food and Agriculture Organization (FAO) of the United Nations estimated that the discard component of bycatch was nearly one-quarter (27 million metric tons) of the total world catch by commercial fishing operations (Alverson et al. 1994). Until now, a

comprehensive assessment of the amount of bycatch in U.S. fisheries has not been attempted. While bycatch by combined U.S. commercial, recreational, and subsistence fisheries probably accounts for a small percentage of the world's total annual bycatch, the magnitude of the bycatch of living marine resources may have profound population, ecosystem, and socio-economic effects on resources managed by the United States and on communities dependent on those resources.

Purpose of the NMFS Bycatch Plan

This bycatch plan is intended to serve as a guide for the National Marine Fisheries Service (NMFS) and its cooperators — the fishery management councils[1], states, commissions[2], fishing industry, the conservation community, and other special interest groups—to current programs and future efforts to reduce bycatch and bycatch mortality of marine resources. These programs represent a broad array of research, management, and enforcement activities that include fisheries covered under U.S. statues and international agreements as well as all marine mammals, "threatened" and "endangered" species, seabirds, and other living resources of the marine ecosystem.

This plan is also intended to guide the regional fishery management councils and to provide a common focus for industry-government bycatch coordination. It provides a dynamic and adaptive framework that anticipates change in program emphasis and priorities as more information on bycatch becomes available on a fishery-by-fishery basis.

While NMFS is already involved in reducing bycatch in many of the nation's fisheries through fisheries regulations, gear research, technology transfer workshops, and exploration of new management techniques, these efforts are not currently coordinated by an overall long-term strategy. This plan provides a strategy that will lend structure to NMFS' highly diverse national program of bycatch-related research and management. It will also help NMFS meet bycatch mandates of the Magnuson-Stevens Act, the Marine Mammal Protection Act, the Endangered Species Act, and the Migratory Bird Treaty Act, and is essential to meeting the "build sustainable fisheries" objective of in the National Oceanic and Atmospheric Administration's Strategic Plan (NOAA 1996).

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[1] Refers to the eight fishery management councils established in 1976 by Congress as part of the Magnuson Fishery Conservation and Management Act. They are (1) the North Pacific Fishery Management Council; (2) Western Pacific Fishery Management Council; (3) Pacific Fishery Management Council; (4) Gulf of Mexico Fishery Management Council; (5) Caribbean Fishery Management Council; (6) South Atlantic Fishery Management Council; (7) Mid-Atlantic Fishery Management Council; and (8) New England Fishery Management Council.

[2] Refers to the three interstate fisheries commissions established by Congress. They are the Pacific States Marine Fisheries Commission, the Atlantic States Marine Fisheries Commission, and the Gulf States Marine Fisheries Commission. The commissions work to promote and encourage cooperative management of interjurisdictional marine resources.

The Role of NMFS in Addressing Bycatch

As stewards of the nation's living marine resources, the National Marine Fisheries Service and its parent organization, the National Oceanic and Atmospheric Administration, have a particular responsibility to lead and coordinate the nation's collaborative effort to reduce bycatch. NMFS carries out this charge under many laws and Congressional mandates. Most of its responsibilities that bear on bycatch emanate from three statutes: the Magnuson-Stevens Fishery Conservation and Management Act (hereafter the Magnuson-Stevens Act), which regulates fisheries within the U.S. exclusive economic zone; the Endangered Species Act, which protects species determined to be threatened or endangered; and the Marine Mammal Protection Act (as amended in 1994), which regulates taking or importing marine mammals. International conventions and treaties also play a significant role in the national approach to bycatch management.

National Statutes

The Magnuson-Stevens Act provides for conservation and management of marine fishes through federal fishery management plans and amendments. The "national standards," which are identified in the Act, set standards for management that must be met in each fishery management plan. These standards are also applied to federal regulations that are implemented under the Atlantic Coastal Cooperative Fishery Management Act. The 104th Congress included in the Magnuson-Stevens Act a new national standard to address bycatch as a potential impediment to maintaining sustainable fisheries. National Standard 9 states: "Conservation and management measures shall, to the extent practicable, (A) minimize bycatch and (B) to the extent bycatch cannot be avoided, minimize the mortality of such bycatch." This standard constitutes the overall guidance and direction on bycatch for the nation and was used as the foundation policy in the development of the NMFS bycatch plan.

The Endangered Species Act (ESA) requires the federal government to protect and conserve species and populations that are endangered, or threatened with extinction, and to conserve the ecosystems on which these species depend. Some of these threatened and endangered species, including sea turtles, some Pacific salmon, marine birds and marine mammals, and some whales and dolphins, are captured as bycatch in the nation's fisheries. Under the ESA's protection process, after a species is identified as threatened or endangered, a recovery plan that outlines actions to improve the species' status is prepared and implemented. Recovery plans for marine species generally include a requirement to reduce incidental capture of protected species in commercial fishing operations. In some cases, fisheries can be terminated because they impose mortality rates on protected species that impede the recovery of the listed population. Other provisions of the ESA ensure that sources of mortality for protected species are identified and minimized or mitigated through conservation plans.

The Marine Mammal Protection Act (MMPA) seeks to maintain populations of marine mammals at optimum sustainable levels, principally by reducing the rate of mortality or serious injury to them. This includes fishing-related mortality and injury. All commercial fishermen are prohibited from incidentally taking marine mammals without specific federal authorization. The MMPA requires that NMFS classify each U.S. fishery according to whether there is a frequent (Category I), occasional (Category II), or remote (Category III) likelihood of incidental mortality and serious injury to marine mammals. It also establishes take-reduction teams to develop take-reduction plans for those fisheries with the greatest impact on marine mammal stocks (Category I and Category II).

The taking of migratory seabirds is governed by the Migratory Bird Treaty Act, which is administered by the Department of the Interior. Several species, such as the marbled murrelet and short-tailed albatross (excluding U.S. populations), are listed under the Endangered Species Act. In cooperation with the Department of the Interior's U.S. Fish and Wildlife Service, NMFS monitors and reports the bycatch of seabirds.

International Agreements

Recent United Nations Food and Agriculture Organization (FAO) agreements to which the United States is a party also specifically identify bycatch reduction as a major goal. The two overarching agreements are:

- Code of Conduct for Responsible Fisheries (November 1995). The code requires that "Management measures should not only ensure the conservation of target species but also of species belonging to the same ecosystem or associated with or dependent upon the target species," and that "States and users of aquatic ecosystems should minimize waste, catch of non-target species, both fish and non-fish species, and impacts on associated or dependent species."

- Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks (December 1995). The agreement contains bycatch management principles for these resources similar to those in the Code of Conduct.

Many other international agreements and commissions require bycatch management measures to ensure conservation of transboundary living marine resources. Some of the most important of these are the Inter-American Tropical Tuna Commission, the Atlantic Tunas Convention Act, the Convention for the Conservation of Anadromous Stocks in the North Pacific, the International Pacific Halibut Commission, and the Pacific Salmon Commission. In some parts of the world longline fishing has been shown to cause significant mortality of seabirds and is considered to be the most likely cause of the decline of breeding populations for several species. Several international resource management and conservation organizations have taken steps to reduce seabird bycatch, including the FAO's Committee on Fisheries, the International

Union for the Conservation of Nature, the Commission for the Conservation of Antarctic Marine Living Resources, and the Commission for the Conservation of Southern Bluefin Tuna.

Input from Constituents

In developing this plan, NMFS worked extensively with its partners in the fishing industry, the conservation community and the academic community to increase information sharing and to expand the network of people and institutions that are interested in a well-integrated national approach to addressing bycatch. Since 1992, numerous workshops, symposia, and reports established the framework for a constructive dialogue on bycatch management among these parties (Table 1). One of the striking similarities among all of the conferences and workshops is the recognition that effective bycatch management requires collaborative work among these groups, with each contributing its own talents and strengths.

Table 1. National bycatch workshops, symposia and reports, 1992-1996.

Title	Sponsor/Publisher	Location	Date
National Industry Bycatch Workshop		Newport, OR	February 1992
Win-Win Bycatch Solutions/FISH EXPO	National Fisheries Conservation Center	Seattle, WA	December 1994
New England Bycatch Workshop	Rhode Island Sea Grant College Program	Newport, RI	April 1995
Solving Bycatch: Considerations for Today and Tomorrow	Alaska Sea Grant College Program	Seattle, WA	September 1995
An Industry Workshop Addressing Bycatch Issues in Southeastern U.S. Fisheries	Gulf and South Atlantic Foundation	Atlanta, GA	November 1995
Building a Bycatch Strategy in the North Pacific: Western Alaska—A Matter of Cultural and Community Survival	Alaska Fisheries Development Foundation	Western Alaska	February 1996
Building a Bycatch Strategy in the North Pacific	Alaska Fisheries Development Foundation	Sitka, AK Kodiak, AK	February 1996
Market-Based Incentives to Reduce Fisheries Bycatch	Marine Policy Center —Woods Hole Oceanographic Institute	Woods Hole, MA	February 1996

Outreach Strategy to Promote a Constructive Public Discourse on Bycatch	Center for Marine Conservation	Washington, D.C.	May 1996
The Consequences and Management of Fisheries Bycatch	American Fisheries Society Annual Meeting Symposium	Dearborn, MI	August 1996

Many of the workshops pointed out that there is a dearth of scientific information to frame bycatch discussion and, in the absence of information, the issue is frequently driven by misconceptions, mistrust, and inaccuracies. Each of them made increased data collection one of its top recommendations; NMFS reached the same conclusion. In assessing the nation's bycatch, the agency recognized that in many fisheries there is simply not enough information to know the character and magnitude of the bycatch or the population, ecosystem, and socio-economic effects of that bycatch or its mitigation.

The conferences and workshops also repeatedly stressed that NMFS should avoid adopting a "top-down" national solution to bycatch. Some fisheries with a significant international component, such as those for highly migratory species, require a national policy approach based on input from many stakeholders; for many other fisheries, however, regional expertise may be the best source of innovative and appropriate bycatch management strategies. Fishermen, processors, scientists, and managers voiced their concern that a national strategy for bycatch could remove decision-making authority from the persons best acquainted with the bycatch issues of a particular region or fishery. NMFS scientists and managers shared this concern, and the entire approach to the development of the bycatch plan was driven by the recognition that, while there may be common themes among regions, there is no single national solution that can be applied to every fishery in the country. Rather, after identifying some common issues, termed "national objectives," the bycatch plan leaves further identification of the issues to regional experts.

Terms and Definitions Used in the Bycatch Plan

In developing the bycatch plan, NMFS surveyed the recent literature on bycatch and the definitions used in each publication. This survey included the Magnuson-Stevens Fishery Conservation and Management Act; Report of the Technical Consultation on Reduction of Wastage in Fisheries (FAO 1997); Solving Bycatch: Considerations for Today and Tomorrow (Alaska Sea Grant College Program 1996); the United Nations Conference on Straddling Fish Stocks and Highly Migratory Fish Stocks (UN 1995); the Food and Agriculture Organization's Code of Conduct for Responsible Fisheries (FAO 1995); the FAO report A Global Assessment of Fisheries Bycatch and Discards (Alverson et al. 1994); and the Proceedings from the 1992 Industry Bycatch Workshop (McCaughran 1992). The review also included a more informal survey of usage of the term bycatch in reports and publications from the government, industry and conservation sectors.

After careful review of the various definitions of bycatch and associated terms, NMFS considered the definitions contained in the Magnuson-Stevens Act as the basis for development of an inclusive definition of bycatch. The Magnuson-Stevens Act defines bycatch as "fish which are harvested in a fishery, but which are not sold or kept for personal use . . . " To fully meet the agency's responsibilities, as defined principally by the Magnuson-Stevens Act, the Marine Mammal Protection act, and the Endangered Species Act, NMFS expanded this definition in three ways. First, living marine resources other than "fish" as defined in the Magnuson-Stevens Act (i.e., marine mammals and seabirds) were included to consider all species taken or encountered in marine fisheries. Second, retained catch of non-target species was included. Third, fishing mortality of living marine resources that are not captured, but die after a direct encounter with fishing gear, were included. Bycatch does not include indirect mortality resulting from changes to the environment as a result of fishing activity.

The definition of bycatch in this plan is clearly more inclusive than that in the Magnuson-Stevens Act, but appropriate given NMFS' broad responsibility to conserve the nation's living marine resources. The two definitions address different, though complementary, purposes. The plan's definition provides a basis for long-term bycatch research, management, and planning for NMFS. The Magnuson-Stevens Act definition of bycatch will be used in fishery management plans and implementing regulations to support National Standard 9. However, in assessing and managing total fishing-related mortality imposed on a stock, fisheries scientists and managers will likely have to consider components of fishing mortality beyond bycatch as defined in the Magnuson-Stevens Act. The plan's definition allows scientists and managers to examine the full spectrum of total fishing-related mortality within the context of a national policy, consistent with NMFS' mission to build sustainable fisheries. Managing the Nation's Bycatch is meant to be a strategic document that will assist the agency in meeting its goals not only under the Magnuson-Stevens Act, but also under the Marine Mammal Protection Act, the Endangered Species Act, other domestic statutes, and international agreements, including the FAO's Code of Conduct for Responsible Fisheries.

A more expansive definition of bycatch is consistent with the terminology used in the International Council for the Exploration of the Seas (ICES) and that used in Alverson and Hughes (1996), which emphasizes the additive nature of various sources of fishing-related mortalities. The 1992 National Industry Bycatch Workshop, one of the earliest fora to explore bycatch issues, included both discards and retained incidental catch in its definition of bycatch (McCaughran 1992). This approach is also consistent with the work of Alverson et al. (1994), the FAO's Code of Conduct for Responsible Fisheries, and the United Nations Conference on Straddling Fish Stocks and Highly Migratory Fish Stocks. Retained incidental catch is also included as bycatch in current federal fishery regulations, such as those implementing the fishery management plans for the Bering Sea/Aleutian Islands groundfish fishery, the Gulf of Alaska groundfish fishery, and the Pacific Coast groundfish fishery. The definition in this plan recognizes that, particularly in a multispecies fishery, target catch is not a static concept, but may change by fishing season, day, or even set. The FAO's Report of the Technical Consultation on Reduction of Wastage in Fisheries also recognized the dynamic nature of target catch, but recommended that the term bycatch be used as a generic term to describe that portion of the catch made up of nontarget species or species assemblages.

The following definitions are used in this plan. A glossary of terms may be found at the end of this document. Throughout the document the use of the term mortality refers to numbers or an amount, rather than a rate. These definitions can be used as a basis to account for the impact of fishing operations on living marine resources. Information on all components of total-fishing-related mortality, including bycatch, is essential for obtaining a comprehensive view of the status of species or assemblage of species.

Bycatch Terms	Definitions
Bycatch	Discarded catch of any living marine resource plus retained incidental catch and unobserved mortality due to a direct encounter with fishing gear.
Discarded catch	Living marine resources discarded whole at sea or elsewhere, including those released alive.
Incidental catch	Catch that is not part of the targeted catch. This includes retained nontargeted catch and discarded catch. Examples are finfish catch in shrimp fishery that may be sold or kept for personal use, juvenile pollock catch that now must be retained in the Alaska pollock fishery, and seabird catch in the Pacific longline tuna/swordfish fishery that must be discarded.
Target catch	Catch of a species, a particular size or sex, or an assemblage of species that is primarily sought in a fishery, such as shrimp in a shrimp fishery or mature female fish in a roe fishery. The definition of targeted catch within a fishery is not static, for example in a multispecies fishery, the mix of species targeted and caught may be quite variable and may change over time.
Total catch	Retained catch plus discarded catch.
Landings	Portion of the total catch that is brought ashore.
Total fishing-related mortality	Mortality of living marine resources due to a direct encounter with fishing gear.
Bycatch mortality	All mortality of living marine resources associated with discarded catch plus unobserved mortality.
Unobserved mortality	Mortality of living marine resources due to a direct encounter with fishing gear that does not result in the capture of that species by a fisherman. This includes mortality due to lost or discarded fishing gear, as well as live releases that subsequently die.

Regulatory discards	Catch that is required by regulation to be discarded.
Discretionary discards	Catch that is discarded because of undesirable species, size, sex, or quality, or for other reasons, including economic discards as defined in the Magnuson-Stevens Act.
Prohibited species	A species for which retention is prohibited in a specific fishery.
Protected species	Any species that is subject to special conservation and management measures (e.g., Marine Mammal Protection Act, Endangered Species Act, and Migratory Bird Treaty Act).
Living marine resources	Any animal or plant life that spends part of its life in coastal or ocean waters.

Common Issues and Needs Among Regions

While bycatch management will largely take place at the regional and fishery levels, many bycatch issues are common to several fisheries or regions. Among them are considerations of bycatch as a component of stock assessment, bycatch of protected and regulated species, the economic implications of bycatch, and the need for monitoring programs. This chapter discusses some of the issues and needs that are common to many or all NMFS regions. Although these issues may manifest themselves differently and in unique combinations in various fisheries, consideration of their commonality may lead to more innovative and better coordinated bycatch management. The second section of this document is devoted to specific regional bycatch issues and needs.

Bycatch as a Component of Stock Assessment

Bycatch mortality can account for a substantial portion of total annual deaths of fishery resources and protected species in some fisheries. In the case of fishery resources, a fundamental question is, How important is it to include bycatch information in the assessment of the status of fishery resources?

Bycatch data are expensive to collect, and sampling rates may be substantially lower than for corresponding landings of a species, thus potentially mixing imprecise data with more precise data. There is growing concern among some researchers that unobserved mortality due to encounters with fishing gear that do not result in capture may contribute significantly—and in yet unknown quantities—to total fishing mortality and to the status of stocks. Where appropriate, research programs are needed to collect data on the potential effects of gear on fish populations and survivability of fish that encounter fishing gear without being captured. When a bycatch species is discarded, some individuals may be uninjured and survive, while others either are mortally wounded or dead. The survival rate of bycatch ranges from 0 to 100% and depends on the nature of the fishery, the gear interaction, actions that fishermen may take to increase survival, and the bycatch species. The case for including bycatch data in assessments must justify the expense and effort necessary for their accurate collection (Alverson et al. 1994).

The inclusion of fishery bycatch data in standard stock assessment calculations can sometimes drastically alter perceptions of the status of exploitation of stocks and the balance of yields accruing from changes in regulations (Saila 1983, ICES 1986). The most important considerations are the rates of discard mortality (proportion of the stock removed each year represented by the discards), and the age groups comprising discarded catch. Unobserved mortality due to encounters with fishing gear that do not result in capture are also potentially important. Analytical stock assessments generally include a retrospective aspect and a prediction. Bycatch may have variable effects on both the retrospective and predictive parts.

Retrospective assessments combine time-series estimates of catch-at-age (or size) with relative indices of abundance from fishery-dependent (e.g., catch per unit of effort (CPUE)) or fishery-independent research vessel sampling. Results of these calculations are time trends in

stock size and fishing mortality rates. Failure to include all components of the catch (landings and bycatch) may have important implications for the results. If bycatch is primarily juvenile fish, then failure to account for them adequately will result in underestimates of fishing mortality on these age groups. Underestimating young fish bycatch may have significant consequences for the calculation of stock abundance and biomass at older ages. The overall fit of assessment models may improve if bycatch of young fish is included, particularly if they result in significant mortality rates for these age groups. Inclusion of bycatch of adult fish will have a positive effect on estimates of stock biomass, on estimates of biological reference points, and, to a lesser extent, on estimates of recruitment and age structure of the population.

Bycatch must be treated consistently in all phases of the assessment process. For example, the estimation of higher recruitment levels owing to the inclusion of young fish bycatch would be partially offset by higher fishing mortality rates on these ages, sometimes resulting in equivalent stock sizes at older ages. The net result would produce the same overall fishery yields in short-term predictions. Additionally, assessments must consider potential biases in bycatch estimates based on observer sampling, owing to the selection of vessels and trips to sample, and an "observer effect"[1] on fishing practices.

The importance of bycatch to fishery predictions depends very much on the types of predictions being made, the assumptions of bycatch proportions over time (constant or variable), and the exploitation patterns at age (fraction of each age group selected by the gear). In the case of a simple year-ahead total annual catch forecast, assuming constant exploitation pattern and age distribution of bycatch, the inclusion of the small-fish component does not affect yield predictions. If, however, the bycatch proportions are variable from year to year, but are predictable, then bycatch will have a moderate impact on predicted yields. Long-term predictions, such as equilibrium yield per recruit, are the most sensitive to inclusion of bycatch in the assessment. When variable recruitment is combined with changing exploitation patterns (e.g., when predicting the yields associated with a change in mesh size), the results may be particularly sensitive to the inclusion of bycatch data, even when bycatch is a constant proportion of the catch by age group.

Inclusion of bycatch in assessments may also be critical to the evaluation of the balance of yields accruing to fisheries that share target species (Laurec et al. 1991). For example, the bycatch species in one fishery may be the target species of another fishery. By including bycatch in stock assessments, the full impact on yields of all fisheries may be evaluated simultaneously.

Bycatch of Protected and Regulated Species

The bycatch of seabirds, marine mammals, and endangered species by commercial fishing operations and recreational anglers can have serious impacts on the populations of these animals.

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[1] The "observer effect" refers to a situation in which the fishing practices of a vessel differ in some significant way when an observer is aboard. When this occurs, the observer-collected data are not representative of the fishery as a whole.

Additionally, fishery management regulations frequently require the discard of some fish species. Various creative approaches have been used to develop ways to reduce these effects on living marine reources.

Seabird Bycatch

In the United States, seabird bycatch has been documented by fishery observer programs in several fisheries: New England sink gill-net fisheries, Pacific (Hawaii) tuna and swordfish longline fisheries, Pacific (Puget Sound) salmon gil- net and purse-seine fisheries, and Alaska groundfish longline fisheries. Seabirds also occur as bycatch in recreational fisheries. Numerous regional interagency efforts (state, federal and international) are underway to address the seabird bycatch problems. These efforts include seabird data collection by observers, gear research to identify and test the effectiveness of seabird avoidance measures, industry outreach and education on how to reduce fishery interactions with seabirds, regulatory requirements for seabird avoidance measures, and analyses to address questions about the effects of various levels of take on the populations of some seabird species.

The North Pacific Fishery Management Council adopted seabird bycatch-reduction measures for its longline fisheries in the Bering Sea and Gulf of Alaska in 1997. Measures will be implemented in the Alaskan halibut fisheries in early 1998, and are currently under consideration for the Hawaiian longline fisheries.

The United States has taken an active role in international efforts to reduce seabird bycatch. At the 1997 FAO Committee on Fisheries meeting the United States proposed that FAO organize an expert technical workgroup to develop guidelines for an international plan of action to reduce seabird bycatch.

Marine Mammal and Endangered Species Bycatch

The Marine Mammal Protection Act (MMPA) requires reduction—approaching zero mortality rates—in the bycatch of marine mammals. Dolphin bycatch in the purse seine fisheries for tuna in the Eastern Tropical Pacific provided the impetus for passage of the MMPA in 1972, and bycatch reduction in that area continues to be a driving issue behind MMPA amendments. Recent amendments to the MMPA required the establishment of collaborative take-reduction teams (TRTs) made up of individuals who represent the span of interests affected by the strategies to reduce marine mammal takes. The teams are broad-based: membership includes commercial and recreational fishing industries, fishery management councils, interstate commissions, academic and scientific organizations, state officials, environmental groups, Native Alaskans or other Native American interests if appropriate, and NMFS representatives.

TRTs are charged with developing both short- and long-term take reduction plans and strategies for marine mammal stocks. The immediate goal of a take reduction plan is to reduce, within six months of its implementation, the incidental take of marine mammals below the level that impedes the stock's ability to reach or maintain its optimum sustainable population. The

long-term goal of a take reduction plan is to reduce, within five years of its implementation, the incidental take of marine mammals to insignificant levels approaching zero mortality and serious injury rates.

To date, five TRTs have been established: (1) the Gulf of Maine Harbor Porpoise TRT, (2) the Pacific Offshore Cetacean TRT, (3) the Atlantic Offshore Cetacean TRT, (4) the Atlantic Large Whale TRT, and (5) the Mid-Atlantic Coastal Gill Net TRT.

The Endangered Species Act (ESA) requires the federal government to establish reasonable and prudent measures that do not jeopardize the existence of threatened or endangered species. Section 7 of the ESA requires that all federal agencies consult with NMFS regarding measures that can be taken to reduce impacts on endangered and threatened marine species. NMFS' own actions, such as the issuance of fishery management regulations, also fall under this requirement. NMFS is engaged in ongoing consultations to establish measures for takes of endangered species that are likely to occur as bycatch in marine fisheries, such as selected species of Pacific salmon, harbor porpoise, monk seals, marbled murrelet, Steller sea lions, and sea turtles.

Regulatory Discards

Management regulations in many fisheries require the discard of fish under quota, time/area, minimum size, bag limit, or trip limit restrictions. In some multispecies fisheries, fishing can continue on some species after the total allowable catch (TAC) has been reached for others. This can result in increased discards of the species for which the TAC has been reached.

An extreme example of the impacts of regulatory discards on a fishery is the closure of the Alaska groundfish fishery when the bycatch limit for halibut is reached. Other examples of regulatory bycatch include trip limits for haddock in the Northeast, minimum-size limits for Atlantic swordfish, trip limits in the Northwest groundfish fishery for the Dover sole complex, size limits and quotas for red snapper in the Gulf of Mexico, and high-grading induced by bag limits for many species in recreational fisheries.

A Conceptual Approach to the Bycatch Problem

The Magnuson-Stevens Act states that “Conservation and management measures shall, to the extent practicable, (A) minimize bycatch and, (B) to the extent that bycatch cannot be avoided, minimize the mortality of such bycatch.” Therefore, compared to the MMPA which includes clearly stated short- and long-term goals to reduce the mortality of and serious injuries to marine mammals in commercial fisheries, the Magnuson-Stevens Act provides NMFS and the regional fishery management councils with more discretion in determining the extent to which bycatch mortality will be decreased. However, the two acts provide comparable discretion in determining which conservation and management measures will be used to meet their bycatch reduction mandates. The effective use of that discretion requires an understanding of the nature and source of the multidimensional bycatch problem.

In this section, a conceptual framework is used to explore the nature and source of the problem. Appendix B contains a more complete exploration, conclusions and empirical assessments. The assessments, in the form of three case studies, are used to reinforce some of the conclusions, from the conceptual framework and to identify some of the types of information required to address the bycatch issues. One way to frame the bycatch issue is to answer the following five questions. What is bycatch? Why does bycatch occur? When is bycatch a problem? What is the appropriate level of bycatch mortality? Why is there often excessive bycatch mortality?

What Is Bycatch?

For the purposes of this plan, bycatch is defined as fishery discards, retained incidental catch, and unobserved mortalities resulting from direct encounters with fishing gear. Bycatch mortality is bycatch minus the discards that survive the rigors of being caught and released or those encountering fishing gear without capture.

Why Does Bycatch Occur?

Bycatch occurs if the fishing method used is not perfectly selective. A fishing method is perfectly selective if it results in the catch of exactly the desired size, sex, quality, and quantity of the target species, without causing other fishing-related mortality. Although bycatch rates often can be decreased by changing fishing methods, very few fishing methods are perfectly selective. In a commercial or subsistence fishery, bycatch mortality is a by-product of catching fish that are retained. In a recreational fishery, bycatch mortality is a byproduct either of catching fish that are retained or of catching and releasing fish.

When Is Bycatch a Problem?

Bycatch is a management problem if a lack of information on the level of bycatch increases substantially the uncertainty concerning total fishing mortality, or if it precludes a use that would provide greater overall net benefit to the nation. The precluded uses include: (1) later harvest as target catch in the same or in a different commercial, recreational or subsistence fishery; (2) later harvest as bycatch in another fishery; (3) remaining in the sea to contribute to the ecosystem; and (4) being available for viewing or other nonconsumptive uses. If bycatch mortality could be reduced without either decreasing the benefit of the harvest or increasing the cost of operating in a fishery, it would not be a contentious management problem. It would simply be eliminated.

In the case of the bycatch of dolphins in the Eastern Tropical Pacific tuna fishery, Congress acted to ensure that dolphin bycatch mortality would be reduced to an insignificant level. This action reflects an implicit determination by Congress that the benefit to the nation of this reduction, principally in terms of ecosystem and nonconsumptive uses, would exceed the costs that it would impose on the U.S. tuna fleet and U.S. tuna processors and consumers.

In situations where an overfished stock is rebuilding (i.e., populations are increasing), management restrictions such as minimum size limits can result in increased bycatch mortality.

What Is the Appropriate Level of Bycatch Mortality?

From a national perspective, excessive bycatch mortality exists in a fishery if a further reduction in mortality would increase the overall net benefit of that fishery to the nation through alternative uses of or reductions in the bycatch of species, as was the case with dolphins in the Eastern Tropical Pacific tuna fishery. When reduction in bycatch mortality is practicable, excess bycatch mortality is a wasteful use of living marine resources. In many fisheries, it may be possible but not practicable to eliminate all bycatch and bycatch mortality.

Bycatch reduction can have desirable and undesirable effects for the individual fishermen who reduce their bycatch mortality and for the nation as a whole. The effects include the following: (1) changes in the bycatch mortality of the species for which a reduction is the objective; (2) changes in population struture of the bycatch species; (3) ecological effects due to changes in the bycatch of that species; (4) changes in the bycatch of other species of fish and the resulting population and ecosystem effects; (5) changes in the incidental catch of marine mammals and birds and the resulting population and ecosystem effects; (6) changes in fishing, processing, disposal, and marketing costs; (7) changes in the economic, social, or cultural value of fishing activities and nonconsumptive uses of fishery resources; (8) changes in the effectiveness and cost of research, management, enforcement, and information exchange programs; and (9) the distributional effects of the preceding types of effects.

Examples of changes that would tend to increase the extent to which it is practicable to reduce bycatch mortality include the following: (1) the development of lower-cost methods either of avoiding bycatch or of increasing the survival rates of discarded catch; (2) changes in biological or oceanographic conditions that make it easier to avoid bycatch; (3) changes in market conditions, in population and ecosystem conditions, or in fishery regulations that increase the value of the uses of living marine resources made possible by a reduction in bycatch mortality; (4) changes in fishery regulations that encourage the development and use of lower- cost methods to decrease bycatch mortality; and (5) a change in the current, largely open access, management paradigm to a rights-based system.

Because neither the extent to which it is practicable to reduce bycatch nor the best methods for reducing bycatch mortality are static, there is a periodic need to evaluate the merits of existing and alternative conservation and management measures to reduce bycatch. The evaluation should be in terms of whether the population, ecosystem, social, and economic effects have increased or are expected to increase net benefit to the nation. The conservation measures should not be evaluated only in terms of their effects on the levels of bycatch. A mix of quantitative and qualitative analyses often will be appropriate for such evaluations.

Why Is There Often Excessive Bycatch Mortality?

A common response to this question is that greed or lack of concern by fishermen results in excessive bycatch mortality. This line of reasoning ignores the decision-making environment in which individual commercial, recreational, and subsistence fishermen find themselves. Bycatch mortality results from the fishing practices that are based on prevailing regulatory and economic circumstances and personal preferences. Thus, decisions made by individual fishermen and fishery managers are interdependent and jointly determine the levels of bycatch mortality. Collectively these decisions can result in excess bycatch mortality if the information fishermen (and processors) have understates the overall net benefit to the nation of a reduction in bycatch mortality, or if fishermen are not provided sufficient incentives to consider fully the expected overall net benefit of a reduction in bycatch mortality. High levels of bycatch mortality may be exacerbated by attempts to balance competing management objectives. For instance, in the West Coast groundfish fishery, extending the harvest of a species over an entire year has long been an objective, but as this requires trip limits, bycatch also may increase.

With respect to the lack of appropriate incentives, the most fundamental problem is that most fishery management regimes do not create clearly defined and enforceable property rights for fish in the sea, which would allow the market mechanism to be used to allocate fish among fishermen and among competing uses. Instead, fish are allocated to fishermen on a first-come-first-served basis—that is, the race for fish is used as the allocation mechanism. This means that individual fishermen do not pay for the fish and other living marine resources they use. Therefore, fishermen have an incentive to use too much fish as bycatch, just as they each would have an incentive to use too much fuel if fuel were free to them or grossly underpriced.

The other undesirable effects of this allocation mechanism often include overfished stocks, overcapitalization, boom and bust fisheries, and hazardous fishing practices. Management actions that have been taken to address some of these other symptoms of a flawed allocation mechanism often have increased further the incentive for fishermen to use fish as bycatch. For example, bycatch mortality often has been increased by species-specific trip limits in multispecies fisheries, inconsistent mesh size and minimum fish size regulations, trap limits, and total allowable catches (TACs) that decrease season lengths and increase the intensity of fisheries. Also, the strategy of treating the symptoms of bycatch and related management problems rather than eliminating the cause has resulted in a need to constantly change conservation and management measures. In many cases this has prevented more substantive progress in dealing with the bycatch problem.

Compliance with regulations is an important factor in determining whether a set of regulations designed, at least in part, to reduce bycatch mortality will be effective in doing so and will increase the net benefit to the nation. Involving fishermen in the development and implementation of fishery regulations can have a substantial positive effect on compliance. It increases the ownership fishermen have in the regulations and results in regulations based more on the specialized knowledge of fishermen to find ways to reduce bycatch mortality.

The quality of decisions made by fishery policymakers and managers also depends on the information that is available to them and their decision-making process. Increasing the availability of information that would decrease the uncertainty concerning the biological productivity of stocks of fish, the impacts of fishing activities on living marine resources, and the economic and social impacts of alternative management policies would allow for better decision- making. The value of a fishery can be increased by public review and a clear identification of the objectives for a management policy. Greater public involvement increases the need to ensure that public opinion is based on the best available science and that scientific information is portrayed accurately.

Adequacy of Monitoring Programs

Generally, the first step in addressing any bycatch concern in a fishery is to identify and quantify the magnitude of the bycatch. Ideally, this would include a long-term collection of reliable, scientifically valid data that provide both fishery-specific and species-specific estimates of the spatial and temporal variabilities in bycatch. A general recognition exists that at-sea discards account for a large portion of overall bycatch mortality. As a result, conventional methods for shoreside collection of fishery data are unable to provide adequate information about total discards or other sources of bycatch mortality.

Numerous approaches have been employed by the National Marine Fisheries Service to collect catch and bycatch data. These approaches include self-reporting through logbooks, fish tickets, or industry surveys; port sampling; quantitative modeling to estimate "missing" mortality that could be assumed as a bycatch impact; and at-sea or shoreside observer programs.

Various arrangements for collecting observer data have been implemented or considered by NMFS. These include alternative organizational structures ranging from fully federally funded programs (e.g., MMPA observer programs) to programs wherein industry fees pay for contracted observer services (e.g., North Pacific Fisheries Research Plan). Observer programs and their objectives can differ significantly with respect to levels and costs of adequate observer coverage, data integrity, agency control over data quality, conflict-of-interest issues, agency response to observer compensation or harassment issues, and the ability of a program to retain experienced, high quality observers. Due to the labor-intensive and high-cost nature of observer programs, there is a need to explore alternative data collection programs, such as electronic surveillance and video observation techniques.

The goals of any bycatch monitoring program should be to determine the species composition of catch, quantify the magnitude of discard mortality, and evaluate the effectiveness of established regulatory measures to reduce the bycatch. These goals are important to gaining a basic understanding of fishery resources and stock dynamics. They are also fundamental to forging cooperative institutional relationships with the fishing industry and other stakeholders.

The most effective means to meet this goal will vary among fisheries. Two of the most common monitoring methods are logbooks and at-sea observers. A logbook program may have

less control over the quality of the information provided than does an observer program. However, observer programs may have difficulties adequately monitoring some catch parameters, given statistical questions associated with limits on catch sampling as well as with the desired use of observer data for various estimations of catch or bycatch. The choice of an appropriate monitoring program must be determined by NMFS regional and national administrators in consultation with regional councils and industry members.

If an observer program is determined to be the best choice for monitoring a fishery, the initial step in establishing the program is to determine which fisheries need to be observed. The ranking of fisheries for this purpose should be based on a value that reflects both the potential magnitude of the bycatch problem and the expected net benefits from the program in terms of addressing the bycatch problem. The next steps are to statistically determine the level of coverage needed in each fishery, as well as establish statistically valid sampling protocols and data collection techniques necessary to characterize the bycatch and quantify each of the important bycatch species. Once the required funding and staff resources have been identified and met and the observer program is under way, the observer data should be statistically analyzed to determine its precision. If necessary, the sampling protocol should be changed to improve the data's precision and reduce bias within the samples.

Once the initial goals of either an at-sea observer program or other information collection program have been met, and the bycatch has been effectively characterized and quantified, fishery managers, in concert with affected constituency groups, should determine the most effective method to minimize the bycatch levels in their fishery. Established information collection programs must be maintained following the introduction of these management measures to determine their effectiveness in reducing bycatch and to document any unusual changes in the fishery. This is especially important, given the spatial and temporal variability of bycatch. Without this final step in the information collection program, the bycatch issues initially documented by observer data or other sources of information will remain unresolved within the fishery.

National Bycatch Assessment

In developing this plan, NMFS staff familiar with data sources and fisheries for the Northeast, Atlantic highly migratory pelagic species, Southeast, Western Pacific and pelagic, Pacific Coast, and Alaska reviewed and summarized fishery catch and discards. The purpose was to obtain a sense of what is known about the causes and effect of discards in the nation's fisheries, and to create a focus for developing agency objectives and strategies.

This assessment represents an attempt to systematically assemble and subjectively catagorize bycatch information from each of the nation's fisheries. This is a first step in a process that is intended to establish a dynamic database on bycatch. Throughout this assessment analyses were conducted only on the discard component of bycatch; information on other components of bycatch is not available for most fisheries. The following discussion focuses on the discard component of bycatch.

Methods for estimating the magnitude and impact of incidental catch are relatively undeveloped, compared to those for estimating the magnitude and impact of discards from directed commercial and recreational fisheries. Data contained in the National Assessment bycatch matrix and analyses of those data, combined with regional perspectives developed by members of the bycatch team and solicited public comment, represent the raw materials from which specific goals, objectives, and recommendations contained in this plan were developed.

Evaluation of Information on Discards and Discard Management

Bycatch data collection programs are in different stages of development nationwide. However, considerable information is available concerning the magnitude, causes, and significance of marine fishery discards in some fisheries, particularly in Alaska and for protected species. Regionally, mandated monitoring programs for protected species or fishery resources have been assessed through industry- or government-funded observer programs, or by other indirect methods of data collection.

Some quantitative information on the amount of discards is available for 52% of the nation's major fish species or species groups. More information is available for protected species, however, even with these species, fleetwide estimates of discards for most species are lacking. Outside of Alaska, there are many fisheries for which such estimates are not possible. Not surprisingly, in those cases where discard information is more comprehensive, managers have made the most progress in identifying the reasons for discards and assessing options to reduce discards. Each region of the country has some critical discard problems; the most pressing of these have been the subject of specific monitoring, assessment, and management efforts. Little or no quantitative information is available for the unobserved mortality component of bycatch.

Progress in evaluating discard impacts has been greatest for situations where discards are deemed to affect the population status of a species or species group. Less progress has been made in understanding the social, economic, and ecosystem effects of discards, primarily due to a

lack of required information. The same situation applies to the evaluation of the potential effects of alternative management measures.

Protected resources constitute only about one-quarter of all discard situations evaluated. However, they account for nearly three-quarters of cases where the significance of discards is considered high. National resources have been directed by NMFS to evaluate the significance of these discards and to develop management strategies for the most critical protected species issues. However, no similar national resource has been mobilized to evaluate important fishery resource discard issues.

The lack of data for some fisheries may indicate no significant bycatch problems exist. However, the experience of other fisheries indicates that the lack of data may eventually result in unexpected resource and management problems. A national strategy to assess bycatch in all fisheries and to maintain surveillance, even at low levels, is preferable to no information at all.

Data developed for this review were assembled into a matrix format with distinct fisheries defined by gear type, area, and target species or target species group (Appendix A). A total of 152 fisheries were identified throughout the nation—36 in the Northeast, 12 for Atlantic highly migratory pelagic species, 31 in the Southeast, 6 in the Western Pacific and pelagic, 13 on the Pacific Coast, and 54 in Alaska. The primary focus of the review and subsequent analyses was on fisheries that are regulated under the Magnuson-Stevens Act, the Marine Mammal Protection Act (MMPA) and the Endangered Species Act. However, fisheries in state waters that are regulated under inter-jurisdictional plans (e.g., plans developed by the interstate marine fisheries commissions) and fisheries where there was a significant overlap with fisheries for the same stocks in federal waters were also included in the review.

The fisheries were grouped into 31 major fishery units. Most of these units correspond to those presented in the NOAA document Our Living Oceans (NMFS 1996a; e.g., Northeast Demersal, and Pacific Coast Salmon), or to categories specified in the list of fisheries developed under the Marine Mammal Protection Act. Several additional fishery units were created by dividing some units based on unique characteristics either of the discards in the fisheries or of the fishing industry in particular areas. For example, the Alaska groundfish fishery was divided into two units — the Gulf of Alaska groundfish fishery, and the Bering Sea and Aleutian Islands Area groundfish fishery.

In addition, classification of fisheries as required by the MMPA also served as a guide in developing fishery categories. Under the MMPA, a fishery is classified into three categories based on its potential impact on a species. Information on the three categories and the percentage of U.S. fisheries in each category is provided in Table 2. More than 90% of the Category I fisheries were in the Northeast or Atlantic highly migratory species fisheries. Northeast and Alaska fisheries accounted for all of the Category II fisheries. Most Category I fisheries used fixed gear, either gill nets or longlines.

Table 2. Criteria for determining MMPA category and classification of U.S. fisheries.

MMPA Category	Potential Biological Removals[1]	Percentage of Fisheries Evaluated for This Assessment
I	>50%	7% (12)
II	1-50%	8% (13)
III	<1%	75% (119)
II / III[2]	0-50%	10% (15)

[1] See glossary for definition

[2] 10% (15) of the fisheries included in this assessment were classified as Category II / III due to the inclusion of several fisheries with different MMPA categories in a single classification..

For each defined fishery, recent (1995 unless otherwise indicated) landings, ex-vessel value,[1] and numbers of vessels participating in each fishery were compiled. Where actual participation could not be determined, the number of permitted vessels in the fishery were used. The purpose of compiling these statistics was to quantify the biological, economic, and social significance of each fishery to the extent possible. The most recent estimates of discards of each species or species group were used for each fishery. Discards for a species or species group were not estimated if no statistically reliable information was available.

A total of 148 unique species or species groups were identified as discards associated with the 152 fisheries defined nationwide. Of these species or species groups, 92 (62%) were finfish, crustaceans, or molluscs and 56 (38%) were "protected" species (i.e., marine mammals, turtles, or birds). Protected species were not included in the review unless positive identification—frequently to the species level—and exact enumeration were possible. Thus, information on discards of protected species is available in much greater detail than for fish, and caution must be exercised when comparing species or species group counts between finfish and protected resources. Some protected species are represented by a single occurrence, whereas the resolution for fish was in terms of metric tons or thousands of fish. A species or species group was frequently identified as discard in more than one fishery. For example, snow crab was listed as a discard species in 25 of the 54 fisheries in Alaska, and pelagic species were listed as discards in 9 of the 35 fisheries in the Southeast.

The quality and quantity of discard and other bycatch information on species or species groups varied considerably among the regions. Regions with large data collection programs were able to provide information at a much finer level of resolution, frequently at the species level,

[1] Ex-vessel value is the amount paid to a vessel's owner or operator for its catch, excluding any value added by at-sea processing.

than were regions that had either minimal or no quantitative information on discards in the region's fisheries. When no quantitative information on discards for a fishery was available, general descriptive categories, such as "groundfish," were created; when quantitative information was available, individual species were listed separately. Similarly, simple classification of fisheries based on targeted species and gear results in all fisheries being equivalent and can mask the importance of a fishery and potential impact of discards on it. Thus, analyses were conducted at the regional level and considered the volume of the discards in the fishery if possible. Data were compiled to provide a general picture of how much is known about discards in the nation's fisheries and to identify major trends within fisheries and regions. Due to the varying level and quantity of information available, data in the matrix cannot be used to calculate total discards for a particular region or fishery or to make comparisons about discard rates and amounts among regions.

Quantitative estimates of finfish discards were available for 52% (48 of 92) of unique discard species or species groups in the nation's fisheries. The fractions of discarded species for which quantitative estimates were available were disproportionate among regions (Table 3). These numbers do not imply that precise or accurate measures for 52% of the species discards are available. Only in Alaska groundfish and some shellfish fisheries is there sufficient information to estimate total fish discards for some fisheries. For protected species some quantitative data on bycatch are available for 61% (43 of 57) of protected species or protected species groups.

Table 3. Percentage and number of discarded species or species groups for which quantitative estimates were available, exclusive of protected species.

Region	Percent	Number (Total)
Alaska	89	24 (27)
Pacific pelagic and insular area	57	8 (14)
Atlantic & Gulf pelagic	50	5 (10)
Southeast	33	3 (9)
West Coast	30	3 (10)
Northeast	22	5 (23)

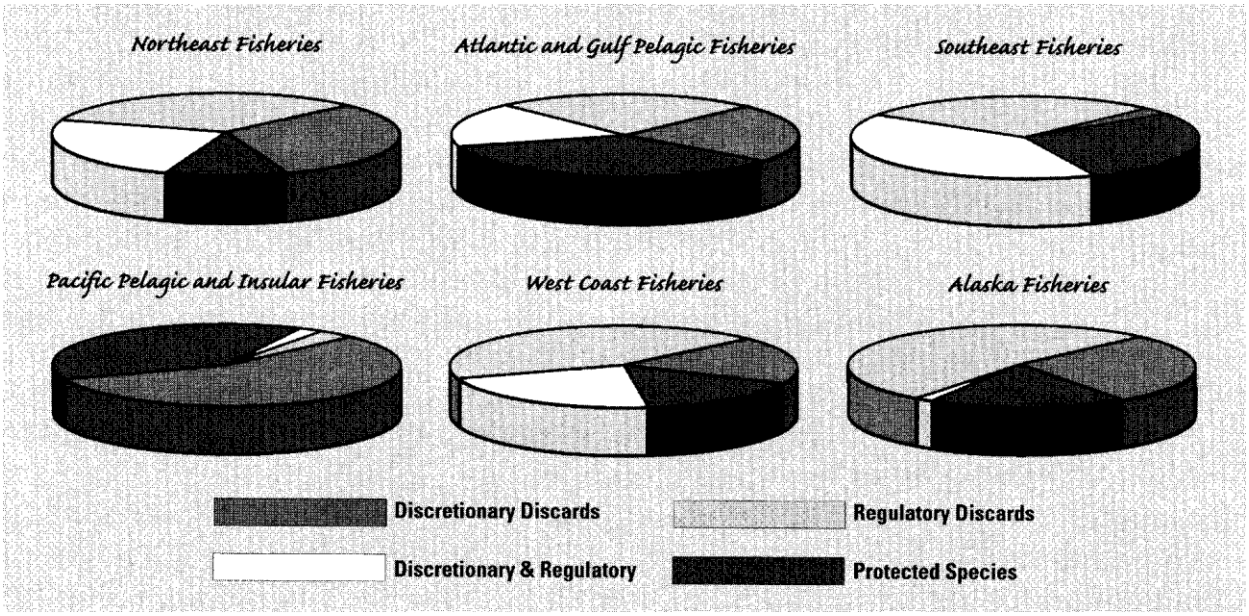
Reasons for Discards in the Nation's Fisheries

Four categories were identified as potential reasons for discards: (1) discards of protected species; (2) regulatory-induced discards—e.g., quotas, trip limits, prohibited species, size or sex limits; (3) discretionary discards, which may occur, for example, when no market exists for a particular species; and (4) catch-and-release discards, as in recreational fisheries. Analyses of the reasons for discards can be affected by the degree of classification of the species discarded. This

assessment was conducted using both nominal counts of the reasons for discarding species or species groups and quantitative measures (weight or numbers) where available.

Clearly, when only the occurrence of a species/group is considered, regulatory-induced discards are dominant in most regions (Figure 1). Regulatory and discretionary discards occur together in a significant proportion of fisheries in some regions, and account for the most substantial portion, by volume and occurrence, of discards in all regions. Protected species discards occurred in all regions. Catch and release was not the dominant factor influencing discards in any fishery.

Figure 1. Reasons for discarding species or species groups. Classification reflects occurrence, not amount, of each type of discard.



Significance of Discards in the Nation's Fisheries

Information on the current status of target and discard species was obtained from Our Living Oceans (NMFS 1996a). Two measures of stock status were specified: (1) the rate of utilization (over-, fully-, or underutilized) and (2) the current stock size relative to the size necessary to produce the maximum long-term potential yield (below, near, above). These criteria are important when considering the effects discards may have in contributing to the exploitation status of stocks.

For fishery resources, Table 4 describes each discarded fish species/group according to its status of utilization (over-, fully, or underfished) in relation to its long-term potential yield. Taken together, these two criteria indicate that the magnitude of fishery discards of some species or species groups may be important in determining the health of these stocks. For instance, for

the species for which information is available, 50% of the fish species that are discarded in the fisheries for Atlantic and Gulf highly migratory pelagic species are below their long-term potential yield and are over- or fully utilized. This means that the stocks of these species have sustained heavy fishing pressure and are depleted to levels below the maximum long-term average catch that can be sustained. For these stocks, discard mortality can be an important additional source of fishing pressure that should be accounted for in fishery analyses. Regionally, using both criteria, the status of bycatch species or species groups varies, with 82% of the discard species or species groups in the Northeast, 80% of Atlantic and Gulf highly migratory pelagic species, 75% in the Southeast, 60% on the West Coast, and 52% in Alaska classified as fully or overutilized and at or below their long-term potential yield. The status of 45% of discard species or species groups in the Pacific pelagic and insular fisheries is unknown with respect to either of these criteria.

Discard mortality, in combination with directed fishing mortality and unobserved mortality, contributes to the current status of stocks. In the case of overfished fisheries, reducing some component of fishing mortality—either directed, incidental, or unobserved mortality—is critical to rebuilding these stocks to sustainability.

The significance of discards was further evaluated through the use of two related qualitative measures— nature and level. The nature of discards identifies the following categories of concerns: population status (of the discarded species), social and economic concerns, ecosystem concerns, or public concerns. In the review, population effects of discards was listed as the primary concern if discards contributed significantly to the current status of a species or species group. Public concern was frequently listed as the primary determinant when discard of a species or species group is low relative to other sources of mortality.

Table 4. Current level of utilization and long-term potential yield of discard species or species groups.

	Long-Term Potential Yield				
Level of Utilization	% Below	% Near	% Above	% Unknown	% Total
Northeast Fisheries	64	23	13	0	100
Over	55	0	5	0	60
Full	9	18	4	0	31
Under	0	5	4	0	9
Unknown	0	0	0	0	0

Southeast Fisheries	76	13	0	13	100
Over	63	0	0	0	63
Full	12	0	0	0	12
Under	0	12	0	0	12
Unknown	0	0	0	13	13
West Coast Fisheries	70	20	0	10	100
Over	20	0	0	0	20
Full	30	10	0	0	40
Under	20	10	0	0	30
Unknown	0	0	0	10	10
Atlantic and Gulf Pelagic Fisheries	50	30	0	20	100
Over	40	0	0	0	40
Full	10	30	0	0	40
Under	0	0	0	0	0
Unknown	0	0	0	20	20
Pacific Pelagic and Insular Fisheries	9	45	0	46	100
Over	9	0	0	0	9
Full	0	9	0	0	9
Under	0	9	0	0	9
Unknown	0	27	0	45	72
Alaska Fisheries	36	28	36	0	100
Over	0	0	0	0	0

Full	32	20	12	0	64
Under	4	8	24	0	36
Unknown	0	0	0	0	0

As shown in Figure 2, population concerns dominated in the fisheries for Atlantic highly migratory pelagic species and in the Northeast, while social and economic concerns dominated in the Western Pacific area, the Southeast, and Alaska. Social and economic and population concerns were about equal in the Pacific Coast. Population issues were the overwhelming concern for protected species in all regions, except for Alaska, where public concern regarding the impacts of discards on populations of marine mammals and birds was the primary factor.

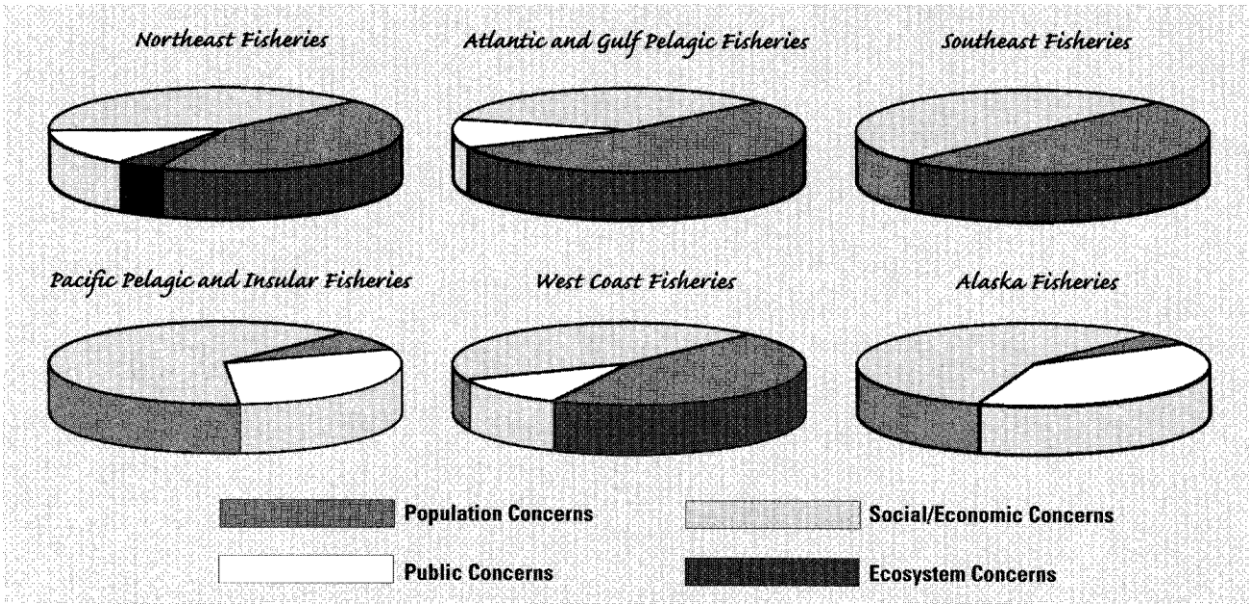


Figure 2. Primary nature of concern affecting the determination of the significance of discards for species or species groups.

Evaluation of discards may be problematic. For example, uncertainty regarding the effects of discards on population status may generate public concerns and have economic consequences for the industry. In these cases, multiple causes for concern are ranked by priority in the review, and the most important factor in determining the nature of discarding is used for this analysis (Figure 2).

The level of concern about discards describes in subjective, relative terms the importance discards have for one or more of the following attributes: population status of the discarded species, the economic and social status of fisheries that may target the discarded species, or the effects on the ecosystem from which the discarded species is taken. This is not a measure of the absolute magnitude of the discards for a species or species group. Four categories of discard level used were high, moderate, low, and unknown. Regional data on discard levels for all fisheries are compiled in Figure 3. Information for protected species was not used in this

analysis because it is available at a much greater level of resolution than for fish. Some protected species are represented by a single occurrence, whereas the resolution for fish was in terms of metric tons or thousands of fish. Note that the same discard stock may be counted more than once if it occurs in more than one fishery (hence there was a total of 447 cases). Overall, there is a tendency for the level of concern to be high or moderate for over- and fully utilized stocks. For protected resources (marine mammals, turtles and birds), the level of concern for the vast majority of discards is considered high or moderate.

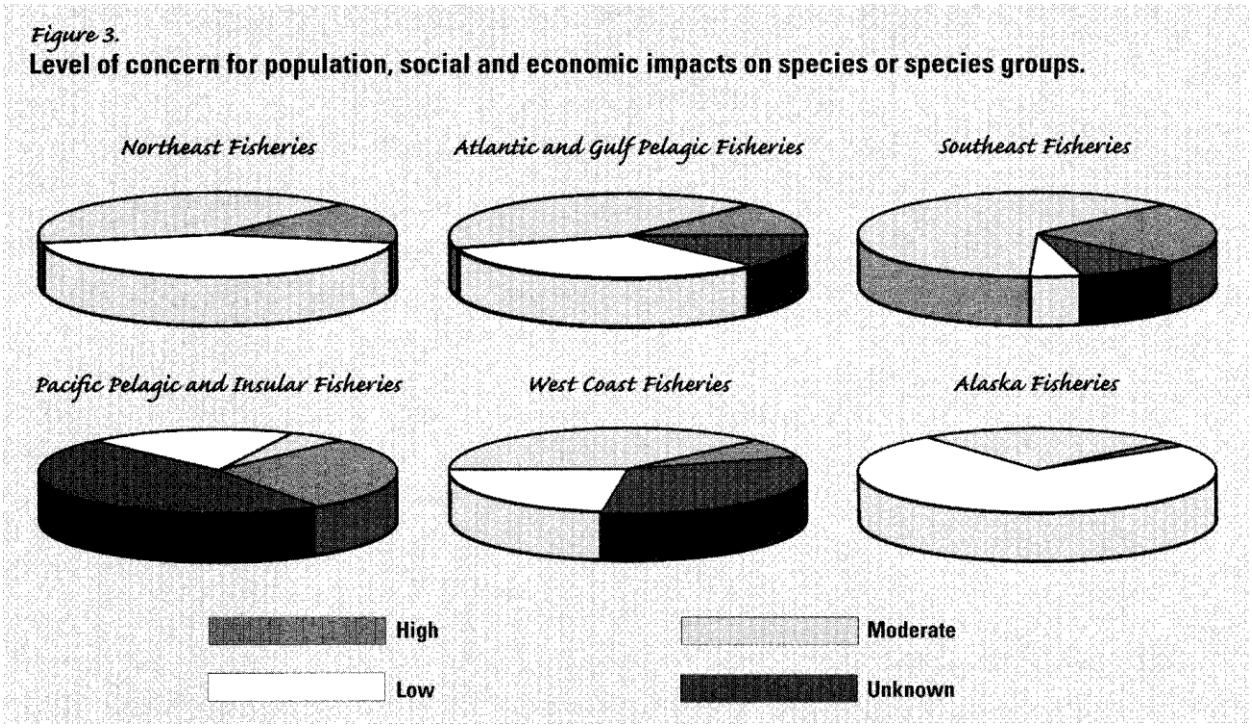


Figure 3. Level of concern for population, social and economic impacts on species or species groups.

Adequacy of Information for Managing Bycatch

NMFS developed a systematic hierarchical approach to identifying and evaluating the information available for managing bycatch. The hierarchy consists of seven steps that can be used to identify problems, evaluate potential solutions, and implement effective management programs. It provides a measurable framework that is adaptable to region- and fishery-specific characterizations that can be used widely across NMFS regions and fisheries.

The seven steps, described in detail in Appendix A, are: (1) determine the quality of information on the magnitude of bycatch; (2) evaluate the impacts of current bycatch practices on populations, fisheries and ecosystems; (3) evaluate the effectiveness of current bycatch management measures; (4) identify potential management alternatives; (5) evaluate the population, ecosystem, and socio-economic effects of each alternative; (6) choose and implement an alternative; and (7) evaluate the effectiveness of the implemented measures.

A hierarchical description of data quality and progress was used to assess the agency's current capabilities for addressing bycatch issues. Generally, little or no information is available on the unobserved mortality portion of bycatch; the results summarized here address discards only. Information relating to regional progress in completing these seven steps also follows.

Information on the Magnitude of Bycatch

The quality of information available on discards is greatest in Alaska and in Atlantic pelagic species, and poorest for the Southeast, Northeast and Pacific Coast regions. Nationwide the quality of information is only slightly better than isolated snapshots of information. Information on the unobserved mortality component of bycatch is lacking in nearly every fishery.

Impact Analyses of Bycatch

There is little information on the population, social, economic, and ecosystem impacts of discards. Some quantitative information, mixed with qualitative information, is available on the population impacts of discards. Limited qualitative information is available for evaluating the social and economic impacts of discards. No region has yet completed quantitative or qualitative evaluations of the impacts of discarding on ecosystems.

Effectiveness of Current Management Measures

The adequacy of current bycatch management measures was evaluated in terms of their population, ecosystem, social, and economic effects. The evaluation indicated that most fisheries require identification of additional management alternatives.

Identification of Potential Management Alternatives

Progress in identifying management alternatives was evaluated to determine if the practicality of proposed alternatives has been assessed in terms of industry acceptability and fishery management council policy. Nationally, major factors influencing discards have been identified, and input in terms of management alternatives is being sought in many cases. Within the regions, progress is quite variable, as those with the highest-priority discard problems have received greater attention than others.

Evaluation of Impacts of Bycatch Management Alternatives

The population, social, and economic impacts of alternatives have been evaluated to a limited extent in all regions. In general, however, these evaluations are based on qualitative information and, either no evaluations have been made or, in some cases, qualitative judgments on the ecosystem impacts of management alternatives have been made.

Implementation of Alternative Management Measures

Nationwide there has been little progress in developing the regulatory, enforcement or monitoring infrastructure necessary to implement effective discard reduction programs.

Adequacy of Monitoring Programs

Monitoring programs are best developed in Alaska. In other regions, they are generally not capable of routinely monitoring the effectiveness of bycatch reduction measures, although programs may be in place for selected high-profile fisheries.

National Bycatch Goal and Objectives

This plan reflects the aggregate knowledge and experience of the National Marine Fisheries Service and its many partners, including contributions from many regional and national bycatch workshops held from 1992 through 1995. The national bycatch goal and objectives described here were developed after consideration of these perspectives, as well as the regional perspectives provided in the second section of this plan. Bycatch planning must be a dynamic process that continually incorporates information and views from all these sources. Finally, the plan does not propose to direct activities of non-federal sectors, but rather to focus national and regional bycatch research and management needs for the NMFS.

National Goal

The fundamental national goal of NMFS' bycatch-related activities is to implement conservation and management measures for living marine resources that will minimize, to the extent practicable, bycatch and the mortality of bycatch that cannot be avoided. Inherent in this goal is the need to avoid bycatch, rather than create new ways to use bycatch.

The national bycatch goal reflects the essential bycatch management purpose of the major marine resource statutes (the Magnuson-Stevens Fishery Conservation and Management Act, the Marine Mammal Protection Act (MMPA) and the Endangered Species Act (ESA)) to reduce bycatch and bycatch mortality for species managed under the acts. It also reflects the commitment to cooperate with the U.S. Fish and Wildlife Service in monitoring and reporting the bycatch of seabirds listed under the Endangered Species Act and those protected under the Migratory Bird Treaty Act.

Despite this similarity of purpose, the acts, and thus bycatch management of the appropriate species, have several important differences. The goal of the MMPA is to reduce bycatch "to insignificant levels approaching zero mortality and serious injury rate [by April 30, 2001]" rather than the Magnuson-Stevens Act's "to the extent practicable" [Sec. 118 (b) (1) 16 U.S.C. 1387]. The ESA proscribes the taking of listed species based upon the biological status of the species (16 U.S.C. 1531 et seq.). The incidental catch of protected species, such as marine mammals and ESA-listed salmon, turtles and seabirds is managed by take-reduction teams and recovery plans, respectively. The Migratory Bird Treaty Act governs any taking of seabirds in addition to the ESA-listed species (16 U.S.C. 703 et seq.). National Standard 9 in the Magnuson-Stevens Act, highlighted the need for the statement of a similar management goal for living marine resources managed under fishery management plans.

While the bycatch management measures employed to manage protected species differ from those for other species, it is the intention of this plan to lay the groundwork for an integrated, comprehensive approach to all aspects of the bycatch problem. This will allow NMFS to build on successful existing bycatch management programs, such as the take-reduction teams, while identifying areas where further research and management are needed to address bycatch.

Specific concerns generated by the workshops, Congressional directives, and NMFS support the achievement of the fundamental national goal and have been cast as objectives for this plan.

National Objectives

The following objectives are based upon findings of the National Assessment that was conducted during development of this plan. These objectives support achievement of NMFS' national bycatch goal.

I: Determine the Magnitude of Bycatch

Determining the magnitude and character of the bycatch in a given fishery is critical to the effective conservation and management of the stocks in question. As pointed out in many of the recent bycatch workshops and symposia, the current debate on bycatch is often driven by the lack of information on how much, where, when, and what type of bycatch is occurring.

Strategy 1
Review and, where necessary, improve collection methods, data sources and applications of data to determining the magnitude of bycatch.

a. Identify required data elements for estimation of bycatch mortality.

b. Conduct a review of government and non-government sources of bycatch data, including observer programs, fishery-dependent and independent surveys, and other data collection programs.

c. Develop a methodology to estimate unobserved mortality.

d. Conduct a periodic review of the available data on the character and magnitude of bycatch.

e. Solicit the input of fishery scientists, managers, industry representatives, and conservation groups on methods to assess the quantity and type of bycatch

Strategy 2
Standardize the collection of bycatch data.

a. Coordinate pilot programs to ensure that estimates of bycatch are comparable across programs.

b. Design and test sampling protocols to provide precision and accuracy of data at the lowest cost.

c. Evaluate the accuracy and precision of the data and their usefulness in estimating the magnitude of the bycatch.

d. Make the collection of bycatch data part of the NMFS core statistics program.

e. Assess bycatch mortality in commercial and recreational fisheries.

f. Solicit the input of fishery scientists, managers, industry representatives and conservation groups on methods to establish standards for bycatch data collection.

g. Integrate the collection of economic and social information (e.g., operating costs, fleet size, and vessel characteristics) with the collection of biological information

II: Determine the Population, Ecosystem, Social, and Economic Impacts of Bycatch and Bycatch Mortality

The current state of knowledge on the impacts of bycatch and bycatch mortality on populations and ecosystems, and on the social and economic implications of bycatch, is highly variable. Some fisheries have a substantial amount of information on the population effects of bycatch, while others have very little data. Generally, very little or no information is available on the ecosystem or economic impacts of bycatch, or the social and economic impacts of bycatch reduction strategies. NMFS must determine the impacts of bycatch in order to establish research and management priorities.

Strategy 1
Identify the type and quality of the information that currently exists. Consider the availability of expertise and information from the commercial and recreational fishing sectors, the councils, conservation groups, and the interstate marine fisheries commissions.

Strategy 2
Establish research and management priorities on a fishery-by-fishery basis.

Strategy 3
Develop a fully integrated data collection system which includes biological, economic and social information.

Strategy 4
Identify ecosystem-wide issues that can be addressed through a well-coordinated research program.

Strategy 5
Assess the impacts of bycatch.

a. Use bycatch statistics programs to help determine the population impacts of bycatch.

b. Consider the lost benefits due to bycatch.

c. Assess the impact of bycatch mortality on fishing communities.

d. Develop models for assessing the indirect impacts of bycatch mortality.

e. Include analyses of single-species and multispecies impacts.

f. Identify gear impacts on species.

g. Build partnerships and increase information sharing with government and non-government scientists, particularly of ecosystem impacts of bycatch and other sources of fishing mortality.

III: Determine Whether Current Conservation and Management Measures Minimize Bycatch. If Necessary, Choose New Alternatives

Conservation and management measures to minimize bycatch to the extent practicable will be executed, primarily at the regional level. It is generally the responsibility of NMFS and the respective fishery management councils to evaluate current and proposed management measures.

Strategy 1
Evaluate current management measures.

a. Assess the precision and accuracy of quantitative and qualitative information used in the evaluation process. Include evaluation of user conflicts and competition, harvester response, and unintended effects.

b. Identify similarities between bycatch and other management problems.

c. Assess the contribution of current management schemes and regulations to bycatch problems.

d. Ensure that decisionmakers and stakeholders are informed of the relative precision and accuracy of information used in the evaluation.

e. Consider fisherman response to bycatch regulations and the economic and social impacts of the regulations.

Strategy 2
If existing measures do not adequately address defined management goals, develop, evaluate, and prioritize potential alternatives.

a. For each alternative, identify factors that affect bycatch, bycatch mortality, species population levels, social, economic and ecosystem effects.

b. Identify information requirements and availability to successfully implement alternative management measures.

c. If necessary, (1) develop alternatives that involve incentives/disincentives, compensation programs, or other market-based or individual responsibility approaches; (2) seek information on pertinent solutions from other regions; and (3) identify opportunities to increase compliance with mitigation measures.

d. Identify legal or jurisdictional constraints to proposed management alternatives.

e. Ensure that all interested groups are provided opportunities to become involved in developing and evaluating alternatives, and not merely comment on proposed plans.

f. Ensure that alternatives consider industry views and agency/council policy.

Strategy 3
Develop an implementation plan based upon a preferred alternative that includes monitoring and enforcement measures.

Strategy 4
Expand the capacity of individual fishing operations to reduce bycatch.

a. Examine incentives to develop technologies, fishing practices and monitoring methods to reduce bycatch and bycatch mortality.

b. Encourage mechanisms to fund, share, and transfer new and improved technologies and fishing practices, and to involve all interested groups in their design, testing and monitoring.

IV: Implement and Monitor the Preferred Alternative

Effective monitoring programs require assessment of bycatch and the population, ecosystem, social, and economic effects of the mitigation measure. Implementation of the preferred alternative requires the support of concerned interests, and cooperation and coordination among the fishing sectors, managers, enforcement agencies, and scientists.

Strategy 1
Ensure coordination with domestic and international organizations.

a. Identify opportunities for cooperative planning to eliminate inconsistencies among state, federal, tribal, and international fishery management organizations.

b. Promote international agreements for effective bycatch management of transboundary or straddling stocks and highly migratory stocks.

Strategy 2
Implement monitoring systems.

a. Identify opportunities for cooperative data collection, especially with fishermen and processors.

b. Evaluate monitoring and enforcement alternatives for practicality, cost, and effectiveness.

c. Identify opportunities for coordinating data management for cost-efficiency and to avoid duplication of effort.

d. Provide for timely communication of fisheries data among fishermen and managers.

e. Routinely evaluate monitoring effectiveness, including social and economic factors; incorporate results into research and management planning.

Strategy 3
Implement an enforcement and compliance system.

a. Identify opportunities for cooperative enforcement with other involved agencies (e.g., the U.S. Coast Guard and state, territorial, and tribal agencies).

b. Identify opportunities for cooperative compliance efforts with the commercial and recreational fishing communities (e.g., self-reporting, dealer reporting).

c. Evaluate new enforcement technologies that can be used to improve or reduce the costs of compliance.

d. Routinely evaluate factors contributing to noncompliance; incorporate results into research and management planning.

V: Improve Communications on Bycatch Issues

Priority must be given to improving communication among concerned interests on bycatch issues and achievements, and to providing opportunities for interactions.

Strategy 1
Identify outreach contacts for the exchange of bycatch-related information.

a. Develop, update, and distribute lists of government, industry, conservation, professional, and other organizations interested in bycatch, including contacts at each.

b. Coordinate with the NOAA Office of Public Affairs to develop, update and distribute a list of media contacts (trade publications, general news media, and conservation newsletters).

Strategy 2
Provide accurate and timely information on bycatch-related information issues, regulations, and activities.

a. Distribute timely reports on the status of bycatch and on progress in reducing bycatch.

b. Distribute timely and accurate information on regional bycatch regulations.

Strategy 3
Establish partnerships to prepare and distribute bycatch information.

a. Work with partners to develop regional and national information bycatch "media kits," including a glossary of terms, pertinent laws and regulations, visuals, NMFS contacts, and World Wide Web sites.

b. Work with partners to compile and update a computerized bibliography of bycatch literature.

c. Prepare articles for lay audiences.

d. Sponsor—in cooperation with Sea Grant, industry associations, and interstate marine fisheries commissions—technology-transfer workshops to introduce gear innovations and new fishing practices.

e. Prepare national and regional bycatch exhibits for trade and boat shows, professional society meetings, and other general public and industry displays.

f. Archive bycatch-related informational materials produced by external organizations.

VI: Improve the Effectiveness of External Partnerships

Fishermen, managers, scientists, conservationists, and other interested groups must work together to craft a balanced approach to addressing bycatch issues. NMFS and its partners must develop ways to strengthen and expand cooperative relationships to meet common bycatch management goals.

Strategy 1
Create opportunities for partner involvement in planning and monitoring bycatch reduction.

a. Promote a cooperative network of partners in the coordination of bycatch planning and research.

b. Develop infrastructure for long-term, continuous working relationships with partners to address bycatch issues.

c. Sponsor symposia and conferences for partners to exchange information and identify needs on bycatch technology and management.

d. Solicit partners' views on bycatch research needs.

e. Seek opportunities to provide incentives for industry-sponsored gear studies, experimental fisheries, and/or development of innovative management measures.

f. Inform partners of Saltonstall-Kennedy[1], MARFIN[2] and other solicitations for bycatch grants and contracts, through Web sites, public and trade media, and special bulletins.

Strategy 2
Provide easy access to NMFS bycatch databases.

VII: Coordinate NMFS Activities to Effectively Implement the Bycatch Plan

Effective communication, planning, and coordination among NMFS program offices and other NOAA units is required to make the best use of available fiscal and human resources, avoid duplication of effort and programmatic activities, and enhance overall efficiency of the agency to implement bycatch research and management initiatives.

Strategy 1
Integrate bycatch management needs and programs within NOAA and NMFS.

a. Provide for NMFS Offices of Protected Resources and Enforcement, Sustainable Fisheries, and Science and Technology, NOAA General Counsel for Fisheries, and NOAA Sea Grant representation in the bycatch planning system.

b. Integrate protected resources objectives into the bycatch plan.

Strategy 2
Develop regional implementation plans consistent with the national goals and objectives.

Strategy 3
Develop or identify funding sources for meeting the objectives of the bycatch plan.

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[1] The Saltonstall-Kennedy (S-K) Grant Program is a competitive program that provides grants for research and development projects to benefit the U.S. fishing industry. The S-K Act, as amended [15 U.S.C. 713(c)(3)] is the program's statutory authority.

[2] The Marine Fisheries Initiative, or MARFIN program, brings together scientific, technical, industry, resource conservation, and management talents to conduct cooperative programs to facilitate and enhance the management of marine fishery resources of the Gulf of Mexico and South Atlantic.

National Recommendations

Some general issues of bycatch are common to all regions—concern about waste, impacts on populations taken as bycatch (whether finfish, invertebrates, mammals, turtles, or birds), and impacts on other fisheries. Bycatch issues in the separate regions and in the diverse fisheries within regions can be very different in nature, information needs, and potential solutions to problems.

The following recommendations focus on determining the magnitude of bycatch, assessing the impact of bycatch, evaluating the effectiveness of current bycatch management measures, identifying potential management alternatives, evaluating the impacts of bycatch mitigation alternatives, implementing alternative management measures, and assessing the adequacy of monitoring programs. They identify bycatch research and management needs common to all regions, and are based on findings of the national bycatch assessment that was conducted during development of this plan. Specific regional recommendations are included in the second section of the plan at the conclusion of each regional discussion. Full implementation of these recommendations will require cooperation among all concerned interests, an organizational commitment to bycatch reduction, and stable long-term funding dedicated to bycatch management and biological, social, economic, and ecosystem research on bycatch.

The recommendations are not listed in order of their priority. Actual priorities must be determined on a fishery-by-fishery basis through a process that includes all stakeholders in the fishery.

Monitoring and Data Collection Programs

- Develop a fully integrated scientific approach to the collection of biological, economic, and social data on bycatch.

- Develop strategies for the long-term collection of fully integrated reliable, scientifically valid data that provide fishery-specific and species-specific estimates of total catch, as well as spatial and temporal variabilities in bycatch and bycatch mortality. Strategies could include the use of at-sea observer programs, satellite or other at-sea monitoring technologies, logbooks, fish tickets, or industry surveys.

- Where appropriate, increase the level and broaden the scope of observer programs sufficiently to allow quantitative estimates of total catch, discards, and incidental takes of living marine resources, with acceptable levels of precision and accuracy, for inclusion in stock assessments. A review of observer coverage levels as well as observer data collection methods and associated catch estimation procedures should be initiated to ensure that these programs meet the expectations of scientists, managers, and the industry cost-effectively.

- Develop strategies to distribute observer capability among the various fisheries requiring coverage, with the goal of completing basic quantification of bycatch. In cooperation with

appropriate fishery management councils and industry representatives, develop and implement at-sea observer programs in fisheries where coverage is required.

- Resolve legal and legislative constraints on long-term funding of data collection programs.
- Develop adequate funding and staff resources for a long-term fishery observer capability.
- Pursue options for the procurement of observer services that would reduce the potential for conflicts of interest, and provide incentives for quality observers to remain with the program.
- Integrate collection of total catch and bycatch statistics into the core statistics program of NMFS.
- Collaborate with the fishing industry to better utilize industry resources to collect bycatch information.
- Develop methods to assess unobserved mortality.
- Evaluate the effectiveness of bycatch monitoring and data collection methods, and incorporate the results into research and management planning.

Gear Technology and Selectivity Research

- Increase regional conservation engineering programs to develop, test, and certify species- and size-selective fishing gears to address critical conservation programs in the region (e.g., groundfish, scallops, protected species). This effort should make maximum use of existing expertise in states, universities, and the industry.
- Allocate additional observer sea-days to evaluate new or existing technologies or to certify modifications to existing gear to allow fisheries to proceed under the bycatch constraints or potential biological removal limits.
- Provide adequate funding for research and development capabilities in gear technology.
- Develop and implement methods for assessing the response of fish to fishing gear to aid in the design of more selective fishing gear and to promote high survival of bycatch.

Effects of Bycatch

- Improve methods to assess the population, ecosystem, social, and economic effects of bycatch, and the effects of management alternatives for reducing bycatch.
- Develop a research program to estimate unobserved fishing mortality and its effects on populations of living marine resources.

Incentive Programs

- Evaluate existing incentive programs and their effectiveness to minimize bycatch and bycatch mortality.
- Identify new solutions that increase incentives to minimize bycatch and bycatch mortality.
- Identify legal impediments that prevent implementation of incentive programs.
- Encourage research on market-based incentive programs, including compensation programs, that could be effectively monitored and enforced without undue costs to the agency or industry.

Conservation and Management Measures

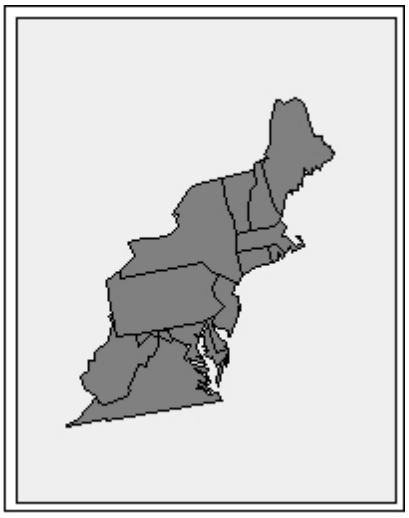
- Assess the effectiveness of current management measures to minimize bycatch.
- Develop performance measures to assess the bycatch effects of proposed conservation and management actions.
- Identify and implement more effective management measures to reduce bycatch.
- Establish monitoring and enforcement compliance programs to implement and evaluate management measures in terms of expected bycatch population, ecosystem, social, and economic effects.

Information Exchange and Cooperation

- Improve public access to bycatch information.
- Develop information exchange and distribution programs for the recreational and commercial fishing sectors, other management agencies and the general public concerning the magnitude of bycatch and efforts to reduce it.
- Promote partnerships to increase information sharing with government and nongovernment scientists.
- Develop infrastructure for long-term cooperative working relationships on bycatch management with industry, conservation groups, fishery management councils, interstate commissions, tribal organizations, and other agencies and organizations.

Regional Perspectives

Northeast Fisheries



Regional Characteristics

Northeast fisheries (Maine south to northern North Carolina) generate about three-quarters of a billion dollars in ex-vessel revenue per year, and employ about 35,000 fishermen (both full and part time; NEFSC 1995). The greatest volume of landed fish is derived from small pelagics (menhaden and Atlantic herring); the greatest value of wild-caught species is from American lobster, sea scallop, menhaden, monkfish (goosefish), and Atlantic surfclam. Groundfish fisheries, targeting gadoids (cod-like fish) and flounders in New England, and summer flounder, scup, and black sea bass in the Mid-Atlantic region, collectively generate substantial landings and income, although many of these species have been severely overfished, and populations and landings have declined greatly.

Groundfish fishing is primarily by otter trawling, which accounts for about 70% of landings. The target species or species assemblage of trawlers can be quite diverse, and is dictated primarily by where and when fishing occurs (Gabriel 1993). In the Gulf of Maine, otter trawl target species include cod and mixed flatfishes (witch flounder and American plaice; Murawski et al. 1991). On Georges Bank, cod, yellowtail flounder and mixed species are generally targeted (Overholtz and Tyler 1985). In Southern New England, groundfish fisheries primarily target whiting (silver hake), yellowtail flounder, winter flounder, and monkfish (NEFSC 1995). In the Middle Atlantic, groundfish trawling targets summer flounder, scup, black sea bass, monkfish, winter flounder, tautog, and a variety of other species (Shepherd and Terceiro 1994; Gabriel 1996).

In the Gulf of Maine, fixed-gear fisheries using gill nets and set lines (locally termed “tub-trawls” or “longlines”) target primarily cod, pollock, and white hake. Groundfish gill nets are increasingly being used to target monkfish, particularly as effort-control programs attempt to limit fishing on traditional groundfish species. Fishing for spiny dogfish has intensified in recent years as other species have declined. Gill netting for dogfish occurs in summer and early autumn in the Gulf of Maine, and during the winter off North Carolina, as the species migrates southward seeking warmer waters (Rago et al. 1994). Trawl fisheries for dogfish occur principally around Cape Cod. Most recently, a directed monkfish gill net fishery has begun to target the species, particularly in deep waters of the Mid- Atlantic.

Lobster landings are mostly taken with baited traps, with about 70% of landings from the Gulf of Maine (Maine, Massachusetts, and New Hampshire; NEFSC 1996a). Some landings of lobster occur by otter trawling, where it is legal to do so (e.g., outside of Maine). Sea scallop landings are derived principally from dredge fisheries (particularly on Georges Bank and in the Middle Atlantic; NEFSC 1996b). Trawling and diving account for the rest of scallop landings.

Other important invertebrate fisheries are for northern shrimp (trawls and pots), surfclam/ocean quahog (hydraulic dredges), and two species of squids (trawls).

Recreational fishing is a significant component of the region's fisheries, accounting for a substantial proportion of the catch of a number of species, including bluefish (~80% of catch), summer flounder, striped bass, scup, black sea bass, winter flounder, cod, and large pelagics. In 1996, about 3 million recreational anglers took 23 million fishing trips in the Northeast.

Regional Bycatch Issues

Fishery Resources

Regulatory discards (i.e., discard of undersized or trip-quota limited stocks) are an issue in the Northeast region's groundfish fisheries. Historically, managers often selected minimum legal sizes for groundfish that resulted in the selection of undersized fish, given the characteristics of nets used in the fishery, often resulting in substantial discards (Alverson et al. 1994). Regulatory discards also occur when catches of certain stocks are limited by trip quotas. Managers are attempting to reduce regulatory discards, but this must be accomplished against a background of increasingly severe regulations intended to dramatically reduce fishing mortality on nearly two-thirds of the region's resources, which are considered overfished and at a low level of historical abundance (NEFSC 1995).

Although the total magnitude of discards in the region's fisheries is not great relative to some other areas of the nation, discards of finfish and shellfish can represent a significant proportion of the catch, and thus an important source of fishing-related mortality. One of the factors that contributed to high discard rates was the open-access nature of most fisheries, which contributed to very high fishing mortality rates and recruitment and growth overfishing. Because abundance of large fish declined due to overfishing, many of the region's fisheries became "recruitment fisheries" (i.e., targeting incoming, but infrequent recruitment events). Differential targeting of these small fish, combined with inappropriate mesh size and inadequate enforcement sometimes resulted in extremely high discard rates and economic and biological waste of the resource.

Management programs that control fishing mortality rates have been adopted for most of the region's fisheries. For example, since 1994 the groundfish and sea scallop fisheries throughout the Northeast are regulated primarily by maximum allowed days at sea per vessel. The program substantially reduced the allocations of allowed fishing days in both fisheries, over the base periods before effort-based management. The effects of effort management on discards are not precisely known. Eventually, however, it is anticipated that with sufficient effort reduction, combined with other management regulations, the fisheries will become less dependent on incoming recruitment, thus reducing the potential catch of undersized animals and, thus, regulatory discards.

One consequence of reduced target species abundance is that mobile gears are towed for longer intervals between haulback. Towing times of three hours or more are not uncommon for the New England and Middle Atlantic groundfish trawl fishery (Murawski 1996). Because the

species composition of individual catches diversifies as various depth and bottom-type habitats are crossed the fisheries have become less directed to a single target species or group. The time of towing has been found to significantly influence the overall discard rate of trawl fisheries (Murawski 1996).

Trip limits contribute to the discarding of three specie —summer flounder, haddock, and Atlantic cod. Trip limits for summer flounder are invoked when individual states approach their allocated share of regionwide total allowable catch (TACs). Depending on both the length of time trip limits are in effect, and on targeting by the fleet, discarding of fish may be significant. Sea sampling of this fishery is conducted to estimate trip-limit-induced discarding, and these projected discards are included in TAC calculations (NEFSC 1996a). The potential for summer flounder discards in both the commercial and recreational fisheries represents a controversial issue in both the assessment and the management of this recovering stock.

Currently, trip limits for haddock are set at 1,000 pounds per day fished on a trip, up to a maximum of 10,000 pounds, until such time as 75% of the target TAC has been caught. The haddock trip limit then reverts to 1,000 pounds. This trip limit scheme was set to remove economic incentives to target aggregations of this critically overfished species. Obviously, if management efforts are successful in stock rebuilding, then the trip limit will become constraining to an increasing fraction of trips. Major uncertainty exists in establishing trip limits that would minimize discards of haddock taken as truly accidental catches, while not encouraging vessels to target them or to fish in areas where the incidental catch of haddock is more probable. Cod trip limits have been invoked for the Gulf of Maine region to limit exploitation of the cod resource in that region. It is too early to evaluate the effects on discard rates of this change in the management system.

Minimum size regulations, as well as economic factors contribute to relatively high discard rates in a number of Mid-Atlantic fisheries, especially for scup and, to some extent, black sea bass. Discard estimates for these species are so tentative, and potentially of such magnitude, that the lack of better discard information precludes the assessment of these stocks by traditional catch-at-age methods.

Small-mesh fisheries in the Northeast Region have undergone a great deal of scrutiny, as managers have sought to minimize the catch of undersized groundfish, particularly in trawl fisheries. The trawl fishery for northern (pandalid) shrimp now requires the use of finfish excluder devices, which, when fished properly, reduces the overall proportional weight of nonshrimp catch, particularly of flatfish and gadoids (NEFSC 1995). Sea sampling of this fishery has shown that shrimp catch rates are slightly improved when excluders are used, possibly due to changes in hydrodynamics of the net. Bycatch rates of some smaller groundfish may have increased (e.g., very small flounders and pollock), but overall, the program has reduced finfish bycatch from about half of the total quantity of catch (in weight) to about 10% (Richards and Hendrickson, unpub.).

Other small-mesh trawl fisheries of the region targeting silver and red hakes, herring, mackerel, squids, butterfish, ocean pout, and dogfish are subject to a performance criterion of

less than or equal to 5% of the total catch comprised of regulated groundfish species (e.g., cod, haddock, redfish, pollock, white hake and five flounder species). On Georges Bank, a small-mesh fishery is allowed for whiting, but only in prescribed locations (e.g., Cultivator Shoals) and only in summer months. Some fisheries have been curtailed altogether or geographically restricted to meet this performance criterion. Squid fisheries in the mid-Atlantic and southern New England potentially generate discards of a number of commercial species, but sea sampling has not been of sufficient magnitude or distribution among various components of the squid fishery (e.g. refrigerated sea water "wet" boats, freezer trawlers, offshore vs. inshore fisheries) to adequately characterize discards.

Bycatch is also an important source of allocative conflict among the region's fishermen. For example, Atlantic cod are targeted primarily by three gear types—otter trawls, gill nets, and demersal longlines. Mobile gears tend to have the highest overall discard rates. Gill nets using appropriate mesh are generally more selective than both trawls and hooks. Gear sectors are in competition for small overall target TACs for cod, and regulations are likely to change the relative proportions of the catch derived by the various gear types. Debate continues on the merits of explicit policy decisions to allocate shares of the catch to gears that exhibit low discard rates. The issue is particularly problematic, given the need to reduce overall harvest rates by about 80% from 1994 levels (NEFSC 1994a).

Kept bycatch can also be an important source of overall income to specific fisheries and source of conflict when the bycaught species is targeted by other fleets. For example, monkfish have become the single most valuable finfish taken in the offshore fishery, generating $33 million ex-vessel in 1995— nearly equal to the value of cod, haddock and yellowtail flounder combined. A large portion of the monkfish catch is bycatch in the sea scallop dredge fishery; this bycatch provides significant income to this fishery. Monkfish are being increasingly targeted by trawlers as an alternative to declining groundfish resources, and additional gears, including gill nets, are being used to target monkfish. Thus, there are conflicts regarding the appropriate use of the resource, particularly as restrictive regulations are enacted.

The greatest magnitude of discarded catch occurs when low-valued species are taken coincident with target species (Murawski 1994, NEFSC 1995). These discretionary discards can account for 40% or more of the volume of the catch. Recent diversification of the fisheries has resulted in greater utilization of these low-valued species (e.g., dogfish), but others still have little market value (e.g., small skates, sculpins) and continue to be discarded in quantity.

Recreational fisheries of the region are responsible for a substantial quantity and proportion of catch discarded (VanVoorhees et al. 1992). These discards are due to regulatory (fish below minimum sizes or bag limits), discretionary (unwanted species or sizes), or catch-and-release considerations. Overall, the rate of recreational fishery discard has increased steadily, from about 30% of the catch in 1980, to about 60% of the catch in 1996 (NMFS, unpublished data). Depending on the species, the proportion of the recreational catch that is released alive varies considerably with high and low release rates of 25-70% typical for unregulated species, and 33-70% typical for regulated species. Most of the increase has been due to the imposition of size and bag limits in specific fisheries (Van Voorhees et al. 1992). Not all discarded recreational

fish die, and the proportion surviving release can be a major factor in stock assessments of species, including striped bass, bluefish, and summer flounder.

Protected Species

Takes of marine mammals and sea turtles are problematic in several of the region's fisheries (Blaylock et al. 1995). Bottom-tending gill-net fisheries targeting groundfish in the Gulf of Maine and Southern New England entangle harbor porpoise in numbers sufficient to be of concern to the long-term stability of the harbor porpoise resource (NEFSC 1995). Reasons for these entanglements are not clear, and may vary in location from year-to-year. Takes of harbor porpoise in these fisheries are substantially above the "potential biological removal" of the stock, and bycatch mitigation is required. Gill-net fisheries in the Gulf of Maine also entangle large whales, including the endangered right whale; take-reduction team activities have been focused on these fisheries to reduce interactions. Gill-net fisheries also result in mortalities of some seabirds, including shearwaters, gulls, and gannets. Middle Atlantic coastal gill-net fisheries also take harbor porpoises and bottlenose dolphins.

Pelagic drift-net and longline fisheries for tunas and swordfish result in takes of a variety of marine mammals and turtles (Blaylock et al. 1995). Pelagic longlines, primarily set for swordfish and tuna, take leatherback and green sea turtles, as well as pilot whales and dolphins. Pelagic drift-nets take marine mammal species, such as saddleback dolphin, bottleneck dolphin, and Risso's grampus dolphin, and occasionally other species, such as pilot whales, beaked whales, and other dolphins.

Although infrequent, entanglements of whales in lobster gear are of particular concern. Given the status of right whales (Blaylock et al. 1995), any fishing activities that generate mortalities of this species are subject to mitigation measures. Thus, the lobster pot fishery has been reclassified as Category I (likely to exceed potential biological removal for protected species) under the Marine Mammal Protection Act on the basis of right whale interactions.

Nearshore trawl fisheries in the Middle Atlantic have generated some takes of sea turtles, particularly in summer months. The use of turtle excluder devices in coastal trawl fisheries in the Middle Atlantic, when turtles are present, has been proposed. Coastal gill-net fisheries in the Middle Atlantic set for monkfish, dogfish, bluefish, and other species are currently being monitored to assess their potential impacts on marine mammal species.

Regional Bycatch Programs

Bycatch monitoring and assessment programs are an integral part of bycatch management programs in the Northeast.

Bycatch Monitoring and Assessment

Bycatch in Northeast commercial fisheries is monitored primarily through the Fishery Observer Program of the Northeast Fisheries Science Center (NEFSC 1995). Several states also

undertake some monitoring activities in their waters. The Fishery Observer Program is funded through several NMFS offices, and primarily focuses on estimates of takes of protected species. A private contractor currently coordinates the deployment of observers. Training of at-sea observers is conducted by NEFSC staff, who are also responsible for archiving observer data files. This program has operated since 1989.

The observer program conducts about 1,500 vessel deployments per year, comprising about 3,000 days at sea. The vast majority of at-sea observer coverage for the region's fisheries is expended to monitor protected species takes. The sink gill-net fishery in the Gulf of Maine accounts for about one-third of the sea sampling coverage due to the need to monitor harbor porpoise takes. About 6% of the sink gill-net trips are sampled annually. Proportionally, the most heavily sampled fisheries are the drift-net fishery for swordfish and the purse seine fishery for tuna. Coastal trawl and gill-net fisheries in the Middle Atlantic Region are monitored for takes of turtles and marine mammals.

Days-at-sea allocated for nonprotected species surveillance have been prioritized to monitor fisheries for northern shrimp, summer flounder, sea scallop, and to a limited extent, large-mesh groundfish trawlers. Overall, however, the level of coverage of observed trips is very low (much less than 1% of the fleet-days at sea) and insufficient to generate reliable estimates of discard mortalities for inclusion in stock assessment for all but a few species due to the lack of precision and concerns that such few trips may be biased. The level of coverage is not sufficient for evaluating the effectiveness of bycatch mitigation measures in most fisheries.

Preliminary analyses of statistical properties of sea sample data indicate that the sensitivity of discard estimates to the design features of sampling programs, the level of sampling, the choice of estimator, and the assumption that selected trips are unbiased (Brodziak 1991, Hayes 1991, NEFSC 1991).

For some fish stock assessments, bycatch mortalities are such a large fraction of the catch that they cannot be ignored without seriously compromising the assessment. These cases include yellowtail, summer, witch, and winter flounders, American plaice, and scup. In these cases, analysts have used available discard sampling information, and sometimes have combined historical information from captains' interviews and estimates derived from use of fishery-independent resource surveys (e.g., the yellowtail flounder assessment in NEFSC (1994b)). Historical size-selection patterns of the fishery have been applied to population-length compositions from survey data to estimate the proportion of the catch likely discarded by the fishery. Such methods have produced surprisingly consistent estimates, but are useless when the selection patterns of the fishery change (due to increased mesh, population size, and other regulations).

Discard data are also sought from fishermen in their mandatory logbook submissions. Preliminary information from this self-reporting program was correlated with observer estimates from identical trips (NEFSC 1996a). Although analyses suggest no obvious discrepancies, this may be due to the effect of the presence of the observer. Much more analysis of information and

communication with fishermen is necessary before self-reported estimates of discards can routinely be incorporated into stock assessments.

Recreational discards are based almost exclusively on interview information provided as part of the marine recreational fishery statistics survey (VanVoorhees et al. 1992). Private boats have not been subject to sea sampling coverage, and only a few party boats have been so sampled to date under the Northeast fishery observer program.

Bycatch Management

Bycatch management in northeast fisheries uses minimum mesh size regulations, trip limits, finfish excluder devices, and closed areas, among other measures, to reduce bycatch of finfish and protected resources.

Fishery Resources

Bycatch management has been fundamental to the development of overall proposals to eliminate overfishing and rebuild depleted stocks. Managers are particularly concerned that valuable fish are not wasted due to regulatory-induced discards, particularly given the depleted nature of many of the Northeast Region's resources. Nevertheless, the overriding concern at this point is to eliminate the overfished condition of most of the region's stocks, and to rebuild them.

Amendment 5 of the Northeast Multispecies Fishery Management Plan increased trawl and gill-net mesh sizes in most fisheries to a minimum of 6 inches (stretched). At the same time, however, minimum fish sizes were not increased, so as to reduce the capture of undersized groundfish. Because of the performance criterion for small-mesh fisheries of :s5% regulated groundfish, there has been increased interest in the development of species-selective trawling gear. Various designs are being proposed and tested for potential application to groundfish and sea scallop fisheries.

In December 1994 three large areas on Georges Bank and in Southern New England were closed to all fishing gears, except lobster pots, to protect groundfish resources. Southern New England was an area of historical concentration of age-2 yellowtail flounder, traditionally the age class most subject to discarding. The closed areas on Georges Bank are historical concentration areas for haddock and cod.

Minimum net mesh sizes apply to a variety of other fisheries in an attempt to minimize catch of juveniles and improve yield per recruit. Because of the highly mixed nature of catch, and the fact that different target species have different optimum mesh sizes, no one mesh is best for all cases.

Trip limits apply for the summer flounder fishery, when individual state allocations of the total allowable catch have been met. Likewise, a trip limit for haddock is applied year-round. Managers have sought alternatives to the trip limits that would give equivalent conservation

benefits while reducing the need for regulatory discards. Alternatives considered include expanded closed areas, larger mesh sizes, and closed seasons.

Other regulations designed specifically to address bycatches have included mandatory use of finfish excluder devices in the northern shrimp fishery and increased minimum net mesh and ring size requirements for sea scallop dredges (the top of the dredge is usually a net, while the bottom and sides are steel rings). Discretionary discards have not been the subject of specific regulations.

Protected Resources

Managers are attempting to reduce harbor porpoise takes through a series of phased time and area closures. These closed areas potentially benefit the overfished groundfish species as well. Specific boundaries of closure areas are primarily based upon the historical "hot spots" of porpoise bycatch. Although the timing of the peak bycatch may change from year to year, the "hot" locations remain relatively constant.

Acoustic deterrence of harbor porpoise from gill nets is also under experimentation. Some preliminary experiments with these "pingers" have been promising, but it is unclear if the use of these devices as a general bycatch reduction measure would be sufficient by themselves, or in combination with reduced area closures, in decreasing harbor porpoise mortalities below the potential biological removal. A take reduction team is examining information from field experiments and related modeling and fishery observer data to determine their effectiveness.

The swordfish drift-net fishery in the Atlantic has been responsible for hundreds of marine mammal mortalities. A long-term average is approximately one marine mammal taken per overnight set. The offshore species taken include the critically endangered North Atlantic right whale, as well as sperm whale, common dolphin, and 5 species of beaked whales. The fishery is currently under an emergency closure and may only be reopened with very stringent requirements placed on it by the Atlantic Offshore Take Reduction Team (TRT). These requirements include time/area closures, open access to the swordfish quota (to eliminate the derby fishery), use of a net set allocation, limited entry, and 100% observer coverage.

The Atlantic longline fishery also has also come under scrutiny from the Offshore TRT as that fishery takes a large number of marine mammals and sea turtles. However, in the longline fishery the vast majority of these takes are released alive. Questions about the long term survival of these released animals are being asked by the team and studies are being initiated to determine their fate. Several effort-reduction measures on the longline fishery have been introduced, including a limit on the number of hooks and total length of line deployed, limited entry to the fishery, increased observer coverage, reverse retrieval of gear, and a requirement to move to a new area after a marine mammal interaction.

The Gulf of Maine lobster pot fisheries are currently designated as Category I fisheries due to serious injuries and mortalities of right and humpback whales. Gear modifications and gear marking requirements have been developed to reduce the likelihood of such interactions.

Because of the relatively rare occurrence of these interactions, the precision and accuracy of these estimates remains low.

Regional Recommendations

The most important bycatch monitoring need is for data collection programs sufficient to estimate the magnitude of bycatch mortalities and incidental catch of protected species for inclusion in stock assessments. While observer coverage does not need to be universal, current coverage for most fisheries is not high enough to estimate fish discards or protected species bycatch with acceptable precision for inclusion in stock assessments or for impact evaluation. Given the diversity of regional fisheries, the amount and breadth of observer coverage need to be expanded greatly if the goal of adequate discard estimates for all important resources is to be achieved.

There is also a need to provide ongoing advice to managers on whether the use of specific gears or fishing in particular areas will compromise their bycatch reduction goals. This can be best accomplished by using some observer coverage in an experimental, rather than monitoring, mode. This approach needs to be expanded, particularly if greater emphasis is placed on gear-based solutions to bycatch problems.

Assessing the population consequences of bycatch involves evaluating all sources of mortality on harvested populations, including landings, natural deaths, and injuries and mortalities of animals that encounter the gear, but are not retained (e.g., fish that squeeze through the meshes, are injured by rollers, or that drop off prior to the gear being hauled aboard). Collecting discard data must be included in a core statistics program that provides mortality estimates with acceptable precision. Unobserved mortalities of nonretained animals are potentially the most difficult to measure, and will require a combination of field and laboratory experiments to obtain usable estimates.

Evaluating the economic and social impacts of bycatch requires information on factors, such as costs of mitigation alternatives, prices, and participation by various fleet sectors. Without such information, evaluation of appropriate mitigation measures will be subjective.

Regionally, emphasis on the continued reductions in fishing effort prescribed in the Northeast Multispecies and Sea Scallop Fishery Management Plans may be the single most effective bycatch mitigation measure currently in place. These reductions, if effective in reducing fishing mortality rates, should decrease effort directed to recruits and thus increase retention rates. However, until stocks are rebuilt and age compositions of the populations are expanded, there will be a great emphasis by management on gear-based solutions, trip-based quotas for some species, and closed areas.

Effort reductions should also reduce some takes of protected species in fixed-gear fisheries. In the short term, however, efforts to reduce bycatch of protected species will most likely focus on seasonal area closures combined with gear technology adaptations.

Managers, fishermen, environmental groups, and the general news media have all expressed the need for timely, accurate, and widely available information on discard rates of various fisheries and fleet sectors. Given the increased profile of bycatch issues, additional resources allocated to effective communication of bycatch goals, programs, and information are required. Following are specific recommendations for Northeast fisheries:

- Increase the level and broaden the scope of the fishery observer program sufficiently to allow quantitative estimates of discards of fishery resources and incidental catch of protected species, with acceptable levels of precision and accuracy for inclusion in stock assessments.

- At the discretion of the Regional Administrator, allocate additional observer sea-days to evaluate new or existing technologies or to certify modifications to existing gear to allow fisheries to proceed under the bycatch constraints or potential biological removal limits.

- Increase the ability to assess the population, ecosystem, social, and economic effects of discards, and the impacts of management alternatives developed to reduce them through integrated data collection and analysis systems.

- Increase research on acute and long-term mortalities of animals encountering fishing gears, but not retained. Specifically, evaluate the fate of animals that escape through net meshes, the hook and release mortality of recreational fishes, and the effects of bottom-tending mobile fishing gears on benthic communities.

- Increase regional conservation engineering programs to develop, test and certify species- and size-selective fishing gears to address critical conservation programs in the region (e.g., groundfish, scallops, protected species). This program should make maximum use of existing expertise in states, universities, and the industry.

- Develop effective information exchange and distribution programs to communicate with the industry, regulators, and general public concerning the magnitude of bycatch and efforts to reduce it.

Atlantic and Gulf Pelagic Highly Migratory Species Fisheries

Regional Characteristics

U.S. fishing vessels, both commercial and recreational, fish for Atlantic highly migratory species (HMS) in the Atlantic Ocean, Gulf of Mexico, and Caribbean Sea. Commercial U.S. fisheries for Atlantic HMS target tunas (including bluefin, bigeye, albacore, yellowfin, and skipjack), tuna-like species (bonito, mahi-mahi, and wahoo), swordfish, and sharks. Recreational fisheries target tunas, tuna-like species, shark, and billfish. There is no directed U.S. commercial fishery for Atlantic billfish, and the sale of Atlantic-caught billfish in the United States is prohibited. A once-popular recreational fishery for swordfish has declined due the decrease in the availability of swordfish in nearshore waters.

NMFS manages Atlantic tunas, swordfish and billfish under the dual management authority of the Magnuson-Stevens Fishery Conservation and Management Act and the Atlantic Tunas Convention Act (ATCA). ATCA authorizes the Secretary of Commerce, acting through NMFS, to issue regulations to implement the recommendations of the International Commission for the Conservation of Atlantic Tunas (ICCAT). This international cooperative body manages the fisheries for and conducts research on the stocks of Atlantic tunas, swordfish, and billfish. It does not have management authority for Atlantic sharks, though its scientific body is collecting data on shark bycatch in fisheries targeting ICCAT species.

Because a fishery management plan for Atlantic tunas has not yet been implemented under the Magnuson-Stevens Act, they are managed under ATCA in the United States. NMFS is developing a comprehensive fishery management plan for Atlantic tunas, swordfish, and sharks that will amend the existing shark and swordfish plans and create a new plan for tunas. Atlantic billfish are managed under ATCA as well as under the fishery management plan for Atlantic billfish; NMFS is currently amending the billfish plan to meet new requirements of the Magnuson-Stevens Act.

Several stocks of Atlantic HMS have been subjected to prolonged decline due to a combination of domestic and international overfishing. In a recent report to Congress on the status of U.S. fishery stocks relative to overfishing, Atlantic bluefin tuna, Atlantic swordfish, the 22 species that comprise the large coastal shark management unit, and Atlantic blue and white marlin were identified as overfished (NMFS 1997b). Under the Magnuson-Stevens Act, NMFS must develop rebuilding programs for those species identified as overfished. Rebuilding of Atlantic HMS stocks is complicated by the fact that these species are fished by many nations. For example, in 1996, 7% of Atlantic-wide billfish mortality was attributable to U.S. fishing

activities; the remaining 93% can be attributed to other countries. Despite the implementation of and compliance with conservation-oriented billfish management measures (e.g., minimum size requirements, ban on sale) by U.S. recreational and commercial fishermen, the relatively small U.S. influence on total mortality frustrates domestic efforts to rebuild the stocks. Without the cooperation of other countries in implementing and enforcing conservation-oriented management measures, stock rebuilding is greatly impeded. For overfished HMS stocks where the U.S. share of total mortality is low, development of a cooperative international strategy to slow Atlantic-wide overfishing is essential to an effective domestic rebuilding strategy.

Regional Bycatch Issues

Bycatch issues in the fisheries for Atlantic highly migratory pelagic species are driven by population concerns about depleted stocks of HMS and protected species and also by allocation concerns among user groups.

Fishery Resources

The directed swordfish fishery is limited by regulation to longline, harpoon and drift gill-net gear. Catches by other gear are restricted to bycatch trip limits of two to 15 swordfish per trip, depending on gear type. Longline vessels account for the vast majority of swordfish landings, followed by drift gill-net vessels and harpooners. Drift gill net vessels primarily target swordfish, but also take tunas and sharks. Finfish bycatch in the drift gill net fishery includes bluefin tuna, little tunny, skipjack tuna, rays, and ocean sunfish, most of which is discarded (Cramer 1996a). The drift gill net fishery has been closed under an emergency rule since December 1, 1996, due to concern about interactions with right whales.

The pelagic longline fishery for Atlantic HMS targets primarily swordfish, sharks, bigeye tuna and yellowfin tuna. The longline fishery may also retain bluefin tuna under an incidental catch limit that is subject to target catch requirements. The discard of undersized swordfish, bluefin tuna, and billfish is an important issue in the pelagic longline fishery for swordfish, tuna, and sharks. In 1996 the longline fishery discarded approximately 579 metric tons of swordfish, equivalent to about 40,000 fish (NMFS 1997a). Time/area closures are frequently proposed as management measures to reduce mortality on undersized swordfish, although further analysis is warranted.

Bycatch of Atlantic billfish in the pelagic longline fishery for tunas, swordfish, and sharks is a contentious population- and allocation-related issue. Atlantic billfish (blue and white marlin, spearfish, and sailfish) are prized by recreational anglers and are encountered as bycatch in the longline fishery. Due to concern about the declining populations for these species, NMFS prohibited the landing and sale of Atlantic-caught billfish in the United States. When a longline vessel hooks a billfish, the leader must be cut as close to the fish as possible without removing the fish from the water.

Estimates of the billfish bycatch discarded dead in the U.S. commercial longline fishery in 1996 were 196.6 metric tons for blue marlin, 67.6 metric tons for white marlin, and 71.6 metric

tons for sailfish (NMFS 1997a). Both blue and white marlin are classified as overfished (NMFS 1997b), and the stocks are estimated to be at 61% and 32%, respectively, of the levels needed to support maximum sustainable yield.

Recreational and conservation groups are very concerned that billfish mortality as bycatch in the longline fishery is impeding recovery of these overfished stocks. The longline industry, on the other hand, is concerned that insufficient data on the magnitude of landings and of post-release mortality in the recreational catch-and-release billfish fishery may obscure a significant source of fishing mortality to billfish stocks. Both user groups express concern that, because the U.S. share of Atlantic billfish mortality is low (generally less than 10% of Atlantic-wide mortality), bycatch management for these species must include stock-wide conservation and management measures that are adopted by all nations that fish the stock.

ICCAT has recommended that the United States implement measures designed to reduce dead discards of Atlantic bluefin tuna captured incidentally in the fisheries for other tunas, swordfish, and sharks in 1996-97. Discards of Atlantic bluefin tuna are generated by regulatory minimum size requirements and, of particular concern, by incidental target catch requirements for the longline fishery. Longline and drift gill net vessels may obtain an Incidental Catch permit that allows them to retain “large medium” and “giant” Atlantic bluefin tuna (defined by regulation as 73-81" and >81" curved fork length, respectively) as incidental catch. The amount of bluefin tuna that can be retained is based on several factors, such as vessel type, location of fishing, and season. Vessels that hold Incidental Catch permits must meet a variety of target catch requirements in order to retain incidentally captured bluefin tuna. In 1996 U.S. longline vessels discarded an estimated 570 dead bluefin tuna (about 73 metric tons), and U.S. drift gill- net vessels discarded an estimated 32 dead bluefin tuna (about 4 metric tons). Dead discards of bluefin tuna for 1996 decreased by almost half compared with 1995 levels.

The purse seine fishery for Atlantic tunas is a limited-access fishery that targets bluefin tuna, particularly giant bluefin, yellowfin tuna, and skipjack tuna. Bycatch can occur in this fishery when vessels set on mixed schools of tunas that include undersized fish and fish that cannot be marketed. Discard data are generally unavailable for several other fisheries for Atlantic highly migratory pelagic species, including the harpoon and handline fisheries. In these fisheries, Atlantic bluefin tunas less than the minimum size are discarded.

Bycatch of sharks, in both directed shark fisheries and other fisheries, is of increasing concern. Sharks are particularly vulnerable to overfishing due to most species' low fecundity, slow maturation, and long reproductive cycles. Furthermore, shark species are difficult to distinguish from each other, and discard data often do not accurately reflect the species composition of the discarded sharks. Small coastal shark bycatch can comprise a large portion of the total catch in southeast shrimp trawl fisheries. Stock status and basic life history are poorly understood for many species of small coastal sharks, and there is concern that high volumes of bycatch may be depleting these populations.

Bycatch issues in the recreational fisheries for Atlantic HMS are driven primarily by allocation concerns and by the difficulty of estimating total fishing mortality in the recreational

sector. Data on recreational angling are collected through the NMFS Large Pelagic Survey, a combination of dockside intercepts and phone interviews conducted between Maine and North Carolina, and by the Marine Recreational Fishery Statistical Survey. NMFS also conducts tournament sampling. These survey techniques estimate the type and amount of fishing mortality and fishing effort for marine and large pelagic species from the recreational sector. Due to the highly disparate nature of recreational fisheries, it is very difficult to standardize techniques for estimating fishing mortality. Also of particular concern in these fisheries is the lack of information on post-release mortality in catch-and-release fisheries.

Protected Species

Concern about bycatch of protected species is particularly high in the drift gill-net fishery for tunas, swordfish and sharks. This fishery is classified as a Category I fishery under the Marine Mammal Protection Act. Concern is also high in the Category III pelagic longline fishery for tunas, sharks, and swordfish.

Based on 1996 observer reports, bycatch of protected species for drift gill-net vessels included True's beaked whales, Sowerby's beaked whale, spotted dolphin, striped dolphin, long-finned pilot whales, short-finned pilot whales, loggerhead turtles, and leatherback turtles. The swordfish-directed drift gill-net fishery is currently under an emergency closure due to concerns about bycatch of the protected right whale. Bycatch of protected species in the 1996 longline fishery included leatherback, loggerhead, and Kemp's ridley turtles, most of which were released unharmed (Cramer 1996a). Representatives of the drift gill-net and longline fisheries participated in the work of the Offshore Cetacean Take-Reduction Team, which was charged, in part, with determining how to reduce bycatch of marine mammals in these fisheries to levels approaching zero. The team recommended a number of options, including time/area closures, acoustic devices to warn cetaceans of fishing gear, and effort controls to reduce the derby nature of the drift gill-net fishery.

Bycatch of protected species also occurs in the purse seine fishery for Atlantic HMS. In 1996, 95% of purse seine trips were covered by NMFS-contracted observers. Observers recorded the capture and release unharmed of one humpback whale, one minke whale, and six pilot whales. No purse seine trips were observed in 1997.

Regional Bycatch Programs

Currently, participants in the HMS commercial fisheries submit daily logbook reports, weigh out and/or tally sheets, and dealer reports. Recreational fishermen are subject to the Large Pelagic Survey and the Marine Recreational Fishery Statistics Survey. Atlantic bluefin tuna fishermen are required to report their catch on a toll-free phone line. NMFS is planning two pilot surveys to supplement data collection in the recreational fisheries for HMS in 1998.

In addition, scientific observer coverage of the U.S. pelagic longline fleet was initiated by the Southeast Fisheries Science Center (SEFSC) in early 1992. In conjunction with the Northeast Fisheries Science Center's Woods Hole Laboratory, the SEFSC uses contracted and NMFS

observers to collect catch-and-discard data aboard longline vessels fishing in the waters of the northwest Atlantic Ocean, Gulf of Mexico, and Caribbean Sea. Selection of vessels is based on a random sampling of the number of sets reported by the longline fleet (approximately 5% of sets are observed). A total of 2,857 sets was observed by personnel from the SEFSC and NEFSC programs from May 1992 to December 1996. Observers have recorded over 50,000 fish (primarily swordfish, tunas and sharks), as well as marine mammals, turtles and seabirds caught and discarded during this time period.

A higher proportion of drift gill-net trips is sampled due to concern over potential bycatch of protected species (marine mammals and sea turtles). In 1996, the NEFSC placed observers aboard six different domestic drift gill-net vessels targeting tuna, swordfish, and sharks. Observers made 13 trips (totaling 140 days) on these vessels in 1996, representing 81% of the total 16 trips made in the fishery in 1996. Bycatch management measures for the drift gill net and longline fisheries are being considered by NMFS upon recommendation by the Atlantic Offshore Cetacean Take-Reduction Team.

In response to the 1996 ICCAT recommendation that calls for the United States to adopt measures designed to reduce dead discards of bluefin tuna during 1997-98, NMFS has performed preliminary analyses to examine the viability of different options for reducing discards. The options being considered include changing the current target weight catch requirement, limiting the number of days per trip, and implementing time/area closures. Logbook and dealer weigh- out slips from 1991 through 1995 were collected, and initial results indicate significant differences between the number of bluefin tuna caught and discarded per trip by season and region. NMFS plans to expand these analyses to develop more conclusive results as a basis for management action. In the meantime, restrictive management measures on the target fisheries in which bluefin are taken as a bycatch appear to be having an effect on bluefin discards. Swordfish and shark quotas have been reduced (50% for large coastal sharks), and limited entry is scheduled to be implemented in both fisheries. The recently-formed HMS Advisory Panel will assist NMFS in considering options, such as time/area closures, to reduce discards of billfish and undersized tunas, swordfish, and sharks.

Data on shark catch and bycatch are being collected by ICCAT's Scientific Committee on Research and Statistics. Increasingly concerned about shark bycatch in Atlantic-wide directed tuna fisheries, the committee initiated a shark bycatch data collection program in 1995. Data for 1996 indicate that, for the entire Atlantic, 47 shark species were taken as bycatch in longline fisheries, 16 in drift gill net fisheries, and 11 in purse-seine fisheries (ICCAT 1997). Data in the U.S. commercial shark fisheries are collected through logbooks and dealer reporting and through an observer program run by the Gulf and South Atlantic Fisheries Development Foundation. Data in the recreational fisheries for Atlantic sharks are collected through NMFS' Large Pelagic Survey and Marine Recreational Fisheries Statistical Survey, as well as by tournament sampling.

Regional Recommendations

With several economically and recreationally important stocks of Atlantic HMS overfished, bycatch issues are particularly contentious in these fisheries. In many cases, these fisheries

operate as multi-species fisheries with overlap in gear use, participants and target species. Bycatch recommendations focus on reducing discard mortality for overfished species, such as Atlantic bluefin tuna, blue and white marlin, swordfish, and large coastal sharks. Stock rebuilding and ongoing allocation disputes also demand improvements in bycatch mortality estimates and minimization of bycatch mortality. Following are recommendations for Atlantic HMS:

- Improve data on the character and magnitude of bycatch to allow quantitative estimates of discards in the fisheries for use in stock assessments and making management decisions.

- Improve gear-handling techniques to reduce discard mortality.

- Conduct research on gear-deployment methods that will reduce interactions between and mortality of protected species that encounter fishing gear.

- Work cooperatively with the fishing industry to transfer new knowledge and techniques between fishermen and researchers.

- Reduce bycatch and bycatch mortality of undersized swordfish and tunas.

- Improve knowledge of (1) basic biology and stock status of shark species in the Northwest Atlantic and (2) of the effects of bycatch mortality on shark populations.

- Increase research on the role of apex predators in structuring marine ecosystems, and assess the effects of bycatch of these stocks.

- Reduce mortality and bycatch mortality of billfish captured in the directed fisheries for Atlantic HMS.

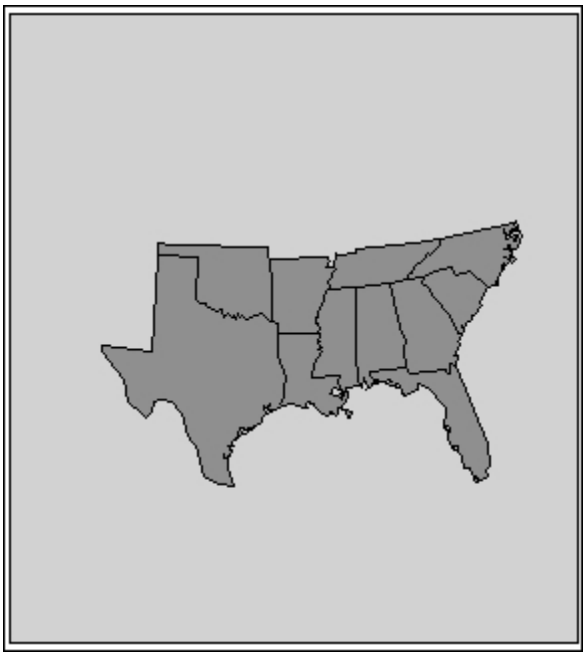
- Determine the status of sailfish populations.

- Conduct research on post-release mortality of recreationally caught billfish, tunas, and sharks.

- Improve data collection and monitoring of the recreational tuna, shark, and billfish fisheries.

Southeast Fisheries

Regional Characteristics



Southeast fisheries (North Carolina to Texas) generate about $900 million in ex-vessel revenue per year (NMFS 1997). Fisheries of the Southeast reflect the very diverse fauna of the region, with many small fisheries working over 200 stocks.

Two fisheries dominate economically. The menhaden purse seine fishery is the volume leader in the Southeast, with annual landings approaching 2 billion pounds. About 60% come from the Gulf of Mexico and 40% from the Atlantic. The shrimp trawl fishery generates the largest revenue regionally, and sometimes nationally. The Gulf of Mexico shrimp fishery accounts for about 70% of the entire U.S. wild shrimp production. About half the commercial value of fisheries other than shrimp and menhaden consists of shellfish fisheries (blue crabs, oysters, and other invertebrates), generally harvested from state waters, and managed by the states. The remainder of the commercial harvest consists of finfish from many stocks; including reef fish (red snapper, red grouper, etc.); coastal pelagic (e.g., king and Spanish mackerel), and oceanic pelagics (sharks, swordfish, and tunas).

Marine recreational fishing is a very important part of the Southeast harvest. Typically, 4-6 million participants make 30—40 million trips annually. The bulk of recreational harvest consists of small fish of the drum family (croakers and seatrouts) and catfish, but many of the prized commercial species are also prized recreationally (e.g., red snapper and other reef species, and king and Spanish mackerel). This shared usage makes every conservation issue an allocation issue as well.

In many cases, management targets have been set toward retaining the historical shares of catch between commercial and recreational components. For example, the allocation ratio for the recreational and commercial fisheries for red snapper are set at about 50:50, and at about 70:30 for king mackerel. The recreational sector as a whole appears to respond very quickly to changes in abundance of individual species—if abundance of a species increases from year to year, catch patterns suggest that recreational fishing effort may be quickly shifted to it, while total effort may remain roughly constant. This has led to some management paradoxes, in that to maintain yield targets, reductions in bag limits have sometimes been needed to respond to improvements in abundance.

Regional Bycatch Issues

The commercial shrimp trawl fishery consistently generates the highest ex-vessel value of any fishery in the United States, totaling $468 million in 1996 (NMFS 1997). In the Southeast United States, the shrimp trawl fishery, made up of thousands of small, independent firms, catches and discards all manner of living marine organisms, the vast bulk of which are of little interest commercially or recreationally. Inconspicuous within this bycatch are juveniles of much less abundant, but highly prized, species that are killed at a rate that has a substantial impact on their populations. More conspicuous, but less frequent, are captures of endangered marine turtles. The shrimp industry is large and diverse (about 20,000 vessels). The major challenge may be to make "stakeholders" out of the thousands of shrimpers who individually have a very minor impact, but collectively have a very major impact.

Capture and drowning in shrimp nets was identified as the single largest source of mortality for sea turtles, especially the highly endangered Kemp's ridley turtle (NRC 1990). Mortality can be reduced considerably with the use of turtle excluder devices (TEDs), which have been available for many years. However, the road to full implementation of these devices by the fishery has been long and contentious. Shrimpers claim the devices cause loss of shrimp from the nets, but data collected by observers aboard commercial shrimp vessels do not support that claim. In the Gulf of Mexico, where turtle catch rates are low, the average shrimper without TEDs might encounter a turtle every three or four months. The quantity of shrimp effort is so high, however, and the turtle populations so depressed, that the fleet's impact on the turtle population was considerable. Interestingly, along the Atlantic Coast, turtle catch rates were much higher, and perhaps as a consequence, resistance to the use of TEDs was much less hostile.

Finfish bycatch by the shrimp industry has been cited as a potential problem in the scientific literature since the 1930s. The weight of finfish caught and discarded by the shrimp fishery exceeds the weight of the shrimp harvest, in some areas by severalfold. Much of the bycatch consists of juveniles and small adults of several hundred species. The bulk of the bycatch consists of species such as croaker, spot, and longspine porgy that are of limited commercial or recreational interest in most areas. Within the mass of fish taken, however, are juveniles of prized species such as red snapper, king and Spanish mackerel, and weakfish. Although not conspicuous in the bycatch because of their much lower abundance, the shrimping effort is high enough that the impact of the bycatch removals on the populations of these highly valued species can be considerable. In the Gulf of Mexico, most attention has been focused on red snapper, which, due to a temporal and spatial distribution similar to that of the target shrimp, may be one of the most highly affected species. Along the Atlantic Coast, bycatch of weakfish and mackerels has also been a major issue.

Steps toward managing and reducing finfish bycatch have centered on development of bycatch reduction devices, although area or seasonal closures may also be useful for bycatch reduction for some species. Several candidate devices show strong promise in reducing finfish bycatch without compromising shrimping efficiency. Finfish species were found to differ considerably in their behavior in trawls, affecting the efficacy of bycatch reduction efforts much more than expected. Red snapper proved to be one of the most difficult bycatch species to

exclude; this species is structure-oriented and a shrimp trawl makes a very attractive structure to the juvenile red snapper.

As with the TED issue, many in the industry remain skeptical of the need for finfish bycatch reduction and distrust devices offered as solutions. As with turtles, the low catch rates of the prized species hidden within the bulk of the bycatch means an individual shrimper may feel little stake in contributing to bycatch reduction. For example, the average catch rate of red snapper in the Gulf of Mexico shrimp fishery is about six fish per hour. However, it is the 4-5 million hours of effort per year by the fleet that significantly impacts the snapper population.

Ultimate management authority for implementation of bycatch reduction devices is spread among the Gulf of Mexico Fishery Management Council, the South Atlantic Fishery Management Council, the Atlantic States Marine Fisheries Commission, and the individual states. Most of these entities are currently considering or in the process of implementing bycatch reduction regulations.

Other southeastern bycatch issues center on the general lack of knowledge needed for quantifying bycatch in particular fisheries. While the bycatch of the offshore shrimp fishery has been extensively studied, the quantities taken by the inshore shrimp fishery are essentially unknown. There have been a few attempts to characterize the bycatch of the menhaden purse seine fishery, but the high variability of bycatch among sets has made analysis problematic. Menhaden catch is fairly clean (a few percent is bycatch), but even a few percent of a billion pounds a year might have a considerable impact on some populations within the bycatch. Bycatch in longline, bandit reel, and pot fisheries has been characterized in several studies, but there are no long-term programs for estimating bycatch, and recent observer effort has been reduced. There have been quite a few bycatch studies on menhaden over the last 100 years, although each study has tended to be limited in coverage (temporal, spatial, at dock versus at sea). Regulatory bycatch is an issue in some fisheries, such as capture of red snapper out of season in general reef fish fisheries in the region. Regulatory discard of undersized fish is a contentious issue in almost every fishery with minimum-size regulations in the region.

Large numbers of finfish are released alive by recreational anglers in the Southeast. In 1996, recreational anglers released over one half of the total estimated recreational catch of 170 million fish. The proportion of the catch released alive varies considerably by species, ranging from over 90% being released for some species, such as sea robins and dogfish, to less than 20% for highly prized species, such as king mackerel and dolphins. Releases of many species (e.g., red snapper, groupers and red drum) are governed by size limits and bag limits in existing management plans. Typically, over 50% of the recreational catch of these species are released alive. Even though anglers report that fish are being released alive, there is still a question of how many of the released fish actually survive. Short-term studies indicate that upwards of 70% of some species may survive, however, survival may be affected by environmental conditions prevailing at the time of release and care in handling.

Regional Bycatch Programs

Partnerships with other fishery management agencies (e.g., state fishery management agencies, interstate marine fisheries commissions, state Sea Grant College programs, and the Gulf and South Atlantic Fishery Development Foundation) have been crucial to addressing bycatch issues in the Southeast Region. Efforts in this region pre-date many of the regional and national workshops held in other areas of the country. The Southeast formally began to address bycatch in the shrimp trawl fishery in 1990 and developed a strategic research document focusing on this important issue (Hoar et al. 1992). This strategic document led to implementation of a formal Regional Research Program, coordinated by the Gulf and South Atlantic Fishery Development Foundation. The major components of the program were observer programs to quantify bycatch mortality, and gear technology research and development to reduce finfish bycatch.

The Regional Research Program actually established several separate observer programs to counter industry mistrust of data collected solely by the government. NMFS, the Gulf and South Atlantic Fishery Development Foundation, and the Texas Shrimp Association all deployed observers. The separate programs were highly coordinated: a common protocol was developed, all observers received the same training, a collected database from all programs was developed and is managed by the NMFS Galveston Laboratory, and estimates of bycatch of the various species are supplied to area stock assessment scientists for inclusion in total removals.

A four-phase development program for bycatch reduction devices for shrimp trawls is currently under way under the Regional Research Program. Throughout the development process, each of the following phases is coordinated by a gear review panel composed of gear technical specialists from both NMFS and the shrimp industry.

Phase 1: Initial design and prototype development—In this phase, the full technical range of trawl design and modification approaches is identified. Emphasis initially was placed on existing gear. Industry techniques, ideas solicited from fishermen, net shop designs, and research studies conducted by various groups are evaluated. Fish behavior, gear interaction, and gear performance studies are conducted on each design using scuba, acoustic instrumentation, remote video cameras, and other techniques made necessary due to local water conditions. This work evaluates fish behavior and feasibility of concept.

Phase 2: Proof of concept—The objectives of this phase are to evaluate prototype devices on key species, determine finfish reduction rates, and establish shrimp catch rates. Proof of concept testing also evaluates the adequacy of the design for safety and for problems with operational use.

Phase 3: Operational evaluation—The main objective in this phase is to test the new gear against a standard gear under conditions encountered during commercial operations. Observers are placed aboard cooperating commercial vessels to collect the data.

Phase 4: Industry evaluation—The commercial shrimp industry is responsible for fleet testing of candidate designs for bycatch reduction devices. Vessels are used to test devices on commercial shrimp grounds and to maintain logbooks on results. Observers are placed on a subset of vessels whose captains agree to keep logbooks to collect bycatch data by species.

Establishing and maintaining the distinction among these four phases has proven surprisingly useful, both to the orderly progression of candidate gear through the development program, and to communicating the nature of different types of data and research. Within this framework, actual research and development of candidate devices have been carried out independently by NMFS, Sea Grant, state agencies, universities, and industry, drawing on a variety of funding sources, primarily the Saltonstall-Kennedy (S-K) and MARFIN (Marine Fisheries Initiative) grants programs.

Research on the economics and sociology of management of shrimp fishery bycatch was initiated by the NMFS Southeast Regional Office in the late 1980s and continues to the present. Universities that successfully competed for funding under the MARFIN and S-K grants programs have conducted additional research. Economic analysis of bycatch issues in other fisheries has been sparse and the only fishery explicitly considered to date is the red snapper fishery.

Bycatch characterization and reduction research has been conducted for other fisheries in the Southeast, but not through a formal program structure as for shrimp. Longline fisheries for tuna, swordfish, and sharks have a history of observer programs for general characterization of the fisheries, including bycatch. However, none of these programs has been sustained over consecutive periods or conducted throughout the range of the fishery during a single year, even within U.S. waters.

MARFIN and S-K grants have also funded characterization research on bycatch in the menhaden purse-seine fisheries of the Gulf and Atlantic coasts. The menhaden industry has already developed some gear innovations to release bycatch alive during harvest. Estimates of fish caught, but not retained, in recreational fisheries are made through the national Marine Recreational Fisheries Statistics Survey (MRFSS) program for much of the Southeast Region. There have been S-K awards for short-duration projects assessing recreational bycatch in some geographic areas not covered by MRFSS. A number of MARFIN and S-K grants have been awarded to examine mortality of hooked and released fish; species addressed include red snapper, red grouper, king and Spanish mackerel, and sharks. Short-duration observer programs have been conducted in some areas in the Gulf of Mexico to examine bycatch of the commercial hook-and-line fishery for reef fish. There have been S-K research grants directed at bycatch of sturgeon in coastal shad fisheries. Short-term research has been conducted on bycatch in trap fisheries for finfish and crustaceans, with most projects focused on developing escape structures for unwanted or prohibited catch, and for reduction of ghost fishing by lost traps.

Evaluations of impacts of bycatch on the fish stocks, and thus on directed fisheries, are made through traditional stock assessments whenever estimates of bycatch are available. Evaluations of the effects of bycatch in the shrimp fisheries are most advanced. Incorporation of bycatch

information from other fisheries in stock assessments is often less adequate due to lack of time-series estimates for bycatch.

Bycatch management in the Southeast shrimp fisheries is progressing rapidly. TEDs have been required in all but hand-operated shrimp trawls for several years. The state of North Carolina took the lead in establishing bycatch reduction device (BRD) requirements in state waters in 1992. Both the South Atlantic and Gulf of Mexico Fishery Management Councils are actively implementing BRD-based management of bycatch in shrimp fisheries. The South Atlantic Council began requiring BRDs in shrimp trawls in April 1997. Amendment 9 to the Gulf Council's shrimp plan, requiring BRDs in shrimp trawls, was approved by NMFS in July 1997. Bycatch reduction for weakfish caught in shrimp trawls is required under the management plan coordinated by the Atlantic States Marine Fisheries Commission, and is implemented by the states.

Regional Recommendations

Several adjustments must be made to the Regional Research Program upon implementation of BRD-based management of bycatch in Southeastern shrimp fisheries. Continued monitoring of bycatch in shrimp trawls will be necessary to establish mortality rates with reduction gear in place. BRD monitoring should explicitly address shrimp-loss rates because this factor determines whether or not a particular design is "practicable." New BRDs are certain to be proposed and developed. Provisions must be made for all four phases of device testing under whatever regulations are finally adopted; procedures must be finalized to certify new BRDs as meeting the requirements for reduction when appropriate. (The South Atlantic Council has already adopted a certification protocol.)

Over the longer term, impacts on the stocks are not known for many species most prominent in the bycatch. Full stock assessments will have to be developed for several of these species due to their primary importance in the coastal ecosystem, and their secondary—but not trivial—importance in the fisheries of the region. Possible multispecies impacts of bycatch and its manipulation is already a contentious issue in the region. Research and modeling have begun, and probably must be expanded.

Priorities for other fisheries are dominated by the need to estimate bycatch either initially and/or on a continuing basis. For those fisheries where bycatch exerts a significant impact on other stocks, estimating bycatch must be considered in the same light as estimating commercial and recreational harvest—a responsibility continuing into perpetuity. Priority fisheries include the inshore shrimp fishery, longline fisheries, menhaden fisheries, and reef fish fisheries.

Partly because of the success in developing TEDs and BRDs, reduction through gear technology will probably be viewed as the primary candidate for a management tool in nontrawl fisheries in the Southeast, although research into modifying fishing strategies and into season/area management options should prove productive.

Ecosystem models to determine the impacts of bycatch reduction in the Gulf of Mexico are currently under development. This is important to establish the cost/benefit analyses for the various bycatch reduction options. Following are specific recommendations for Southeast fisheries:

- Establish estimation of bycatch removals as an integral part of collecting basic fishery statistics.

- Develop stable, long-term funding for a long-term fishery observer capability.

- Develop strategies to distribute observer capability among the various fisheries requiring coverage in such a manner as to complete basic quantification of bycatch for all critical fisheries, and to provide continuing coverage in those fisheries deemed to exert significant impact on populations of species taken in the bycatch.

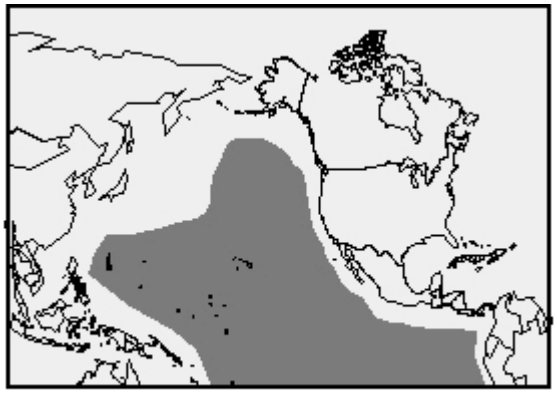
- Provide stable funding for research and development capabilities in gear technology. This will enhance NMFS' ability to work cooperatively with experts in gear technology spread among other agencies, universities, and industry, providing rapid innovation and development of bycatch management tools.

- Improve and develop multispecies modeling capabilities that focus on bycatch management issues and impacts. Bycatch estimation is of little value without a context to evaluate impacts. Stock assessment provides that context at the population level, and multispecies modeling provides it at higher levels of organization.

- Improve and develop economic and social research and monitoring programs that provide the context for bycatch impact evaluation.

- Initiate a program to collect detailed shrimp fishing effort data to aid in estimating mortality of bycatch species.

Pacific Pelagic and Insular Fisheries



Regional Characteristics

Pacific pelagic and insular fisheries (Hawaii, American Samoa, Guam, Northern Mariana Islands, and other U.S. islands in the Pacific) are biologically healthy, economically valuable, and important for cultural and subsistence users. Fishery management regimes in the area appear to be effective. Three Western Pacific ports (Pago Pago, American Samoa; Agana, Guam; and Honolulu, Hawaii) rank among the 10 U.S. fishing ports with the highest value of landings. The ex-vessel value of marine fish landings in these ports in 1994 totaled $341 million (34% of the total ex-vessel value of the landings in the top 10 U.S. ports).

While research and proactive management appear to be effective, care must be taken to maintain the productivity of these fisheries. Many basic population and ecosystem aspects of the fisheries are poorly understood. This is particularly true of the nature and impact of bycatch, which are increasingly controversial issues that could eventually limit the continuation of fisheries, such as the large and economically important longline fishery for highly migratory species. Bycatch issues involving threatened and endangered sea turtles, monk seals, dolphins and other marine mammals, seabirds, and other living marine resources must be accorded a high level of attention.

Regional Bycatch Issues

Bycatch issues for Pacific pelagic and insular fisheries focus on population concerns, particularly for seabirds and protected turtles and marine mammals.

Western Pacific Longline Fishery for Highly Migratory Species

The Western Pacific pelagic fisheries landed approximately 14,100 metric tons of pelagic species in 1995, valued at approximately $53 million. The number of vessels in the Hawaii longline fishery increased from around 40 in 1983-87 to 141 in 1991. The Western Pacific Fishery Management Council established a moratorium on new entry to the fishery between 1991 and 1994, and established a limited entry system (166 Hawaii longline permits) for this fishery in 1994. In 1995, 110 vessels were active in the fishery (the fewest since 1988), although the number of trips and the number of hooks set increased by 11%.

Early concerns about protected resources focused on the endangered Hawaiian monk seal. Primary bycatch species of current concern are turtles, seabirds, and sharks. Monk seals, turtles,

and seabirds are each the subject of legislative prohibitions (Endangered Species Act, Migratory Bird Treaty Act) and have generated considerable controversy and management attention.

In 1991, the Western Pacific Fishery Management Council established an exclusion area of 50 nautical miles (nm) around the northwestern Hawaiian islands to protect endangered monk seals. It also closed an area within 50-75 nm of the main Hawaiian islands and within 50 nm of Guam to prevent gear conflicts between longliners and smaller fishing boats targeting pelagic stocks. In 1994, the council implemented a mandatory vessel monitoring system for the Hawaii longline fishery to track the position of longliners within the U.S. exclusive economic zone (EEZ) to ensure that the vessels complied with the exclusion areas.

An important consideration in the central and western Pacific Ocean is that swordfish and tuna stocks migrate through the U.S. EEZ and international waters. The U.S. component of the longline fishery for these stocks is less than several percent of the total effort in the area. There are disjunct comprehensive international mechanisms for gathering and reporting statistics, and separate international management authorites to manage these species in the Pacific.

The NMFS Honolulu Laboratory staff compiles data for the domestic longline fishery from the mandatory federal logbook program, which began in 1990, and from a market monitoring program, which began in 1984.

Sea Turtle Bycatch

There is substantial and growing concern about the status of populations of all species of sea turtles. Sea turtles are designated worldwide as threatened and endangered species. Population declines are especially prominent in the Pacific Islands because of nesting habitat loss and excessive, intensive harvesting for commercial, cultural and subsistence purposes. The principal species of concern in the Pacific are green, hawksbill, olive ridley, leatherback and loggerhead turtles. The last two are the species of principal concern regarding incidental take in pelagic longline fisheries in the Pacific, conducted mainly by Japan, Taiwan, Korea, and the United States. Monitoring and assessment of sea turtle bycatch is carried out primarily through the Hawaii longline observer program.

In a 1994 biological opinion, NMFS concluded that the Hawaii-based pelagic longline fishery adversely affects, but does not jeopardize, sea turtle populations. Nevertheless, limits were set on estimated incidental take and mortalities. The estimated 1994 and 1995 take and mortalities of turtles in total and by species were within allowable limits stipulated in the most recent biological opinion, except for loggerheads in 1995 (Table 5). Consequently, NMFS has now reinitiated an Endangered Species Act Section 7 consultation on the longline fishery interactions with sea turtles, with a focus on loggerheads.

Table 5. Take and mortality of sea turtles in the Hawaii longline fishery.

Species	1994			1995			Allowable Take in Any Single Year	
	Take	~90% CL_{take}	Mortality	Take	~90% CL_{take}	Mortality	Take	Mortality
Logger-head	207	70-403	31	413	153-764	62	305	46
Leather-back	122	41-233	18	81	0-187	12	271	41
Olive Ridley	78	0-180	12	81	0-191	12	215	23
Green	34	0-95	5	NR	NR	NR	119	18
Hawksbill	NR			NR			2	1
All Species	441	238-688	67	575	272-970	87	849	129

Note: CL = confidence level; NR = none recorded.

In general, lack of information about sea turtle survival, age at maturity, and other biological parameters, coupled with a dearth of data on human harvests and incidental takes and the great expense of an adequate observer program, makes assessment of the impact of this interaction particularly difficult. There is a need for international cooperation in collecting and analyzing data on the effects of the Pacific longline fishery on sea turtle populations.

Sharks

The Hawaii longline fishery targets primarily swordfish and tunas, but has a substantial bycatch of pelagic sharks. As noted in Table 6, shark bycatch doubled between 1991 and 1993 and then declined by one-third in 1995. This probably reflects changes in the operations of the fisheries during that time, rather than variations in shark stocks. Blue sharks make up more than 90% of the shark bycatch; all blue sharks that are kept are believed to be finned.

There is no U.S.-directed shark fishery in the central and western Pacific. Most sharks that are taken incidentally in the Hawaii domestic longline fishery are not marketable because of their species or size, and are discarded. Of the 68.8% of sharks that are released, observer reports indicate that 80% of them are alive, although the long-term mortality is not known. The fins of some sharks, especially blue sharks, are taken and dried on board for future sale, and the carcasses discarded.

Table 6. Shark catch in the Hawaii domestic longline fishery.

Year	No. of Sharks Caught	CPUE (No./1,000 hooks)	% Blue Sharks	% kept (All Sharks)
1991	71,183	5.77	92.0	3.2
1992	94,897	8.11	94.1	3.8
1993	154,608	11.87	97.2	10.8
1994	114,656	9.56	96.1	14.4
1995	101,773	7.52	93.7	31.20

The estimated total round weight of sharks that are kept for processing is approximately 1,590 metric tons (mt). The estimated weight of dried shark fins is 22.2 mt. The value of processed shark products to the Hawaii longline fishery in 1995 was $830,000.

Some data on shark catch and disposition are obtained by the domestic longline observers and from logbook data. Relatively little information is available on the biological status of pelagic shark species, and the volume and impact of shark bycatch and discards. There is a need for better collection of shark bycatch data in both domestic longline fisheries and those that occur throughout the western Pacific.

Seabirds

Controversy over the bycatch of several species of albatross in the Western Pacific longline fishery is growing both locally and internationally. The impact of seabird mortality in the longline fisheries is unknown, but is probably quite large. Albatross ingest bait and hooks, or become entangled in longline gear during gear set and retrieval. Very few seabirds survive hooking or entanglement.

An estimated 54,000 breeding pairs of black-footed albatross and 616,000 pairs of Laysan albatross exist in the world. More than 99% of both species nest in the northwestern Hawaiian Islands. Although inadequate scientific knowledge of seabirds makes it very difficult or impossible to assess the true impact of fishing or other causes of mortality, there is little question that the populations of these two species of albatross are in serious decline.

Preliminary analysis of longline observer data indicates that in 1,286 Laysan albatross and 2,135 black-footed albatross were taken in 1994 in the Pacific longline fishery. In 1995, the longline fishery took 1,942 Laysan albatross and 1,796 black-footed albatross. In the opinion of the U.S. Fish and Wildlife Service, the black-footed albatross population cannot sustain this level of take.

The National Marine Fisheries Service will continue to work with the U.S. Fish and Wildlife Service to estimate mortality and develop mitigation measures. Recently, the Western Pacific Fishery Management Council reprinted (in English and Vietnamese) the booklet Catching Fish Not Birds — A Guide to Improving Your Long Line Fishing Efficiency (Nigel Brothers, Parks and Wildlife Service, Tasmania, Australia), which it is distributing widely. And, in cooperation with the U.S. Fish and Wildlife Service, the Council recently held the first in a series of workshops with leading participants in the longline fishery whose basic theme was that "every hook that catches a bird will not catch a fish."

Potential methods of albatross bycatch reduction include (1) putting weights near the hooks to sink the bait faster; (2) using faster-sinking thawed, rather than frozen, bait; (3) setting longlines at night when birds are not as active; and (4) flying streamers and other devices to scare the birds away while the longlines are being set.

Monk Seals

The Hawaiian monk seal is the only endangered marine mammal found entirely within U.S. waters. Its abundance has declined by 60% since the late 1950s, and the current population is about 1,300-1,400 animals. Beach counts overall have declined by 5% a year. To some degree, growth of smaller populations in some areas is offsetting losses in other areas.

The Western Pacific Fishery Management Council addressed initial concerns about interactions with monk seals by imposing a strict prohibition on longlining within a 50-mile area surrounding the northwest Hawaiian Islands. No direct bycatch of monk seals in the fishery is currently known, but extreme care must be taken because of the endangered status of the species. Fishermen are concerned that the closure zones are unnecessarily large and exclude them from valuable fishing opportunities. Because this concern is expected to grow, research into monk seal ecology must continue.

A specific fisheries-related peril of particular concern is the entanglement of monk seals in marine fisheries debris. Each year, monk seals are found entangled in fishing nets on the beach or in nets snagged on coral reefs. The source of these nets is not known. The observed minimum rate of entanglement in beach debris alone is about 1% of the entire monk seal population per year. Lethal entanglement in unobserved shallow reef areas is probably greater.

Marlins

There is growing pressure to ban the sale of blue marlin that is landed incidentally in the swordfish and tuna longline fishery. Blue marlin is a principal target species for the recreational and charter fisheries, especially in Hawaii. The Western Pacific Council has been asked to consider expanding a longline area closure to reduce the catch of blue marlin near a major sport fishing center. For commercial vessels, the landed value of this species is very important economically, with some fishermen claiming that revenues from incidentally caught marlin often makes or breaks a fishing trip. Also, there is concern that blue marlin may be overfished, and that bycatch of blue marlin may have an increasing impact on the conservation of this species.

The economically important and influential recreational fishery asserts that the commercial incidental harvest of marlins diminishes the economic and social returns to the recreational sector, compared with a purely recreational, increasingly catch-and-release fishery.

Western Pacific Crustacean Fishery (Northwestern Hawaiian Islands)

Bycatch of protected species, such as monk seals, has been addressed effectively in this fishery through (1) designing the size of trap openings to prevent entrapping monk seals; (2) closing the waters around Laysan Island less than 10 fathoms deep and within atolls; and (3) implementing framework regulatory measures to allow rapid action (including closure of the fishery, if necessary) to respond to actual or suspected mortality of seals in the fishery.

Until the 1996 fishing season, the harvest quota system in the commercial lobster fishery included minimum size limits and a prohibition on retention of egg-bearing lobsters. A significant concern under this system was the belief that the mortality of the bycatch of small and egg-bearing lobsters that resulted from on-deck injury and exposure, and predation upon return to the ocean, is extremely high—perhaps greater than 75%.

The immediate bycatch problem has now been addressed to some degree by a recently implemented "retain-all" system in the fishery, under which fishermen can retain subadult and berried lobsters that are then counted as part of the quota, rather than being lost uncounted because of on-deck or post-release mortality. However, the retain-all approach is relatively untested in lobster fisheries and must be monitored closely to confirm its efficacy and impact.

Subadult and egg-bearing lobsters may make up 50% or more of the total catch in some areas. If fishermen still "high-grade" to an appreciable extent (retain only the most valuable portions of the catch, which are probably the larger lobsters), many subadult and berried lobsters could suffer discard mortality and be lost to the population.

Current regulations require that all traps deployed in the northwestern Hawaiian Islands include two escape panels, each with four escape vents to help subadult lobsters escape. However, a large proportion of the catch is composed of subadults.

Eastern Tropical Pacific Tuna Purse Seine Fishery

The Eastern Tropical Pacific tuna purse seine fishery (primarily for yellowfin and skipjack tuna) has been controversial because of the bycatch and subsequent mortality of large numbers of dolphins that were caught when the purse seiners targeted and encircled mixed schools of tuna and dolphin. The bycatch of small tunas, turtles, sharks, billfish, and other species is now receiving attention because of the relatively recent change to fishing around schools of tuna and or fishing near logs and other floating debris, rather than setting on dolphin.

Observers are required on all vessels to record and report bycatch. The bycatch of dolphins is managed largely as an international issue through the Inter-American Tropical Tuna Commission. Because dolphin bycatch was substantial in the 1970s, purse seine gear was

improved and procedures were developed to safely release dolphins. Subsequently, U.S. legislation provided that a tuna product could not be designated "dolphin safe" if dolphins were involved in the catch. This resulted in a dramatic 97% reduction of mortality in the overall fishery to low levels in recent years — from nearly 130,000 dolphins in the late 1980s to about 4,000 dolphins in 1994. The U.S. fishery (about six vessels) reduced its take to fewer than 500 dolphins in 1992. Despite these reductions, dolphin bycatch has remained a volatile issue.

An emerging bycatch issue in this "nondolphin" tuna purse seine fishery is that sets made on tuna under logs or other aggregating debris catch the community associated with such debris—such as small, immature tunas, mahi mahi, wahoo, billfish, sharks, rays, and other important living marine resources. Turtles are not supposed to be retained, and markets are not available for small tunas, sharks, and most other of the bycatch species. Thus, fishermen usually discard this bycatch dead. Adequate information is not available on the size and species composition of bycatch in this fishery, or on the biological impacts of bycatch in this fishery, but there is growing concern. Proposals that could moderate the impact of log fishing were hotly debated in the U.S. Congress in 1996, but failed to pass into U.S. law. As part of the 1988 Marine Mammal Protection Act amendments, the National Research Council performed a review of alternative methods of harvesting tuna without encircling dolphins, and made a number of recommendations that are being explored.

Western and Central Pacific Tuna Fisheries

The Central-Western Pacific tuna purse seine fishery has a bycatch that is largely unknown, but is probably similar to that in the Eastern Pacific, except that setting on dolphin is not a practice in the Western Pacific. Lack of a market or low price inhibits the retention and utilization of bycatch in this fishery.

The Oceanic Fisheries Program of the South Pacific Commission concluded that, "...not enough information was available to accurately determine the levels of by-catch in the western and central Pacific tuna fisheries." However, the review noted that, "...although definite estimates were not possible, observer data suggest that by-catch may constitute between 0.35% and 0.77% of the total catch (by weight) for unassociated sets, and between 3.0% and 7.3% for log sets. Purse seine sets on floating objects (compared to unassociated sets) produce the largest amounts, highest incidence, and greatest variety of fish and other species" (Bailey 1996). Data collected under the South Pacific Commission program are retained by the commission and are available to the United States only on an aggregated basis.

The review reported further there is no evidence that dolphins are deliberately set on or incidentally caught in the Western Pacific; marine turtles are occasionally caught, but the majority are released alive; significant numbers of sharks are taken, but overall estimates of exploitation are impossible due to non- and under-reporting on logsheets (a problem common for most nontarget species); accidental marine mammal capture is rare; and seabird capture is well documented, with management measures proposed. Also, mortality of small bigeye tuna as bycatch in the purse seine fishery may adversely impact bigeye tuna stocks.

The report also noted that observer data collection is the most reliable means for collecting information in the fisheries. However, only two compliance-related and scientific-data-related observer programs were operational in the Western Tropical Pacific in the 1980s — one was operated by the Micronesian Maritime Authority; the other, the U.S. Multilateral Treaty Observer Program, was established and supervised by the Forum Fisheries Agency. There has recently been an increase in several other observer activities in the region.

The low level of coverage of fishing activities makes it difficult to estimate levels of bycatch. In 1995, 4.3% of purse seine trips and 0.3% of longline trips had observer coverage. The report concludes further that, "...it remains evident that the current levels of monitoring fall well short of providing the information required for effective conservation and monitoring of the species in question" (Bailey 1996).

California/Oregon Drift Gill-Net Fishery for Swordfish and Sharks

The West Coast fishery for offshore pelagic species (primarily for swordfish and sharks off California) is conducted with drift gill nets, longlines, and harpoons. The drift gill-net fishery has a bycatch of marine mammals, sharks, sea turtles, and billfish. Because of the marine mammal interactions, this fishery is a Category I fishery under the Marine Mammal Protection Act. A number of other species with market value, such as tunas and sharks, are taken incidentally to the directed swordfish catch. Small numbers of blue sharks, pelagic rays and inedible fish are also taken.

Marine mammal stocks of particular concern (strategic stocks) include the short-finned pilot whale, Baird's beaked whale, mesoplodont beaked whales, Cuvier's beaked whales, pygmy sperm whale, sperm whale, and humpback whale.

The California Department of Fish and Game regulates the fishery with laws passed by the California legislature. California state law limits the number of vessels in the drift gill-net fishery to 185 permits statewide; about 90 of these are estimated to be active on a full-time basis. In 1993, approximately 990 metric tons, or about 82% of the total landings, were swordfish.

Fishermen are required to maintain and submit a logbook detailing their fishing activities. Management consists primarily of area closures, seasons, limited entry, and minimum mesh sizes. Fishermen, as a practicality, set nets several meters below the surface to avoid higher billfish and mammal catches.

Since 1990, the NMFS Southwest Region has placed observers in the drift gill-net fishery to monitor incidental taking of marine mammals, collect specimens, and record other bycatch data, such as net-related variables and location of mammals in the net. Each year, overall marine mammal mortality is estimated from observer data and estimates of total effort in the fishery. Relatively few strategic stocks were observed taken over the five-year observed period. Of all observed sets (759 in 1994, or approximately 15% of total sets made), 1.4% contained one or more cetaceans from a strategic stock, and 10.5% contained one or more cetaceans from other stocks. Continued observer data collection is very important for this effort.

The existing Mexican drift gill-net fishery also interacts with some of the species of concern, and may have high marine mammal takes without any regulations regarding marine mammal bycatch. Therefore, the take-reduction team "...suggests that NMFS consider ways to resolve this issue and strongly encourages international cooperation aimed at conserving marine mammal populations."

Bycatch in Other Fisheries

The U.S. troll fishery for albacore, which operates in both the North and South Pacific, produces a very small bycatch of turtles (unknown species) and finfish, mostly dolphinfish, yellowtail, and skipjack tuna. This fishery also discards an unknown amount of small (less than 59 cm) juvenile albacore for economic reasons. The quantity of discarded albacore is not likely to exceed 10% of the total number of fish caught (2.8 million fish in 1996). The mortality of the discarded fish is unknown, but is presumed to be high. This information is based on a limited amount of observer data from the North Pacific.

Few or no known bycatch problems exist in the northwest Hawaiian Islands bottomfish fishery or in the Hawaii precious corals fishery.

Regional Bycatch Programs

Because of various biological opinions regarding sea turtle bycatch, NMFS has implemented several "reasonable and prudent measures" and "conservation recommendations." When turtles are taken on longline gear, fishermen are required to return them to the sea whether the turtles are alive or dead. NMFS places observers on vessels according to a statistical design to document turtle takes. Because of uncertainties regarding the level of turtle interactions in the fishery as reported through the logbook program, monitoring and assessment of sea turtle bycatch are carried out primarily through the NMFS Southwest Region's Hawaii mandatory longline observer program. The observer program, which began in 1994, employs a pilot stratified random survey design to estimate the take rate (turtles per hook) in the aggregate and by species. The trip-coverage rate of the program to date is about 4%. Workshops have been held to develop and inform fishermen of methods to reduce the bycatch of turtles. Also, six recovery plans for U.S. Pacific species of sea turtles are nearing final agency approval.

In February 1996, NMFS convened a take-reduction team in accordance with provisions of the Marine Mammal Protection Act to develop a take reduction plan to reduce the incidental taking of marine mammals in the California/Oregon drift gill-net fishery for swordfish and sharks. The immediate goal of the plan is to reduce, within six months of its implementation, the incidental mortality and serious injury of strategic stocks to less that the "potential biological removal" levels established for those stocks. The plan's long-term goal is to reduce the rates to zero within five years of implementation.

The draft take reduction plan, reached by consensus, contains four primary strategies to reduce take rates: (1) a multiyear test of the effectiveness of acoustical devices (pingers) to determine whether to require their use; (2) fleetwide deployment of a six-fathom minimum buoy

line extender length (nets set several meters below the surface reduce the bycatch of marine mammals and billfish); (3) skipper workshops to generate and consider potential additional take-reduction strategies; and (4) continuation of California's current policy of not issuing new shark and swordfish drift gill-net permits to replace those that lapse. NMFS and the take-reduction team will continue to meet every six months to monitor the plan's implementation until NMFS determines that the plan's objectives have been met.

The take reduction plan also recommended that additional research be conducted, including determining the optimal minimum extender length, increasing the level of observer coverage, increasing the understanding of cetacean hearing ranges and why pingers work in some cases, and considering "buying out" permit holders to reduce potential effort.

Regional Recommendations

The issue of sea turtle bycatch in the Hawaii longline fishery has the focused and effective attention of conservation groups. It is very important that NMFS devote greater resources to (1) identify factors associated with the take of turtles in longline gear; (2) develop further cooperation in the international arena to assess the status of Pacific sea turtle populations and the impact of the Hawaii longline fishery on them; and (3) investigate other dimensions of this bycatch problem. Immediate approaches will include developing and implementing an alternative survey design for conducting the longline observer program, expanding the trip- coverage rate of the observer program to 10%, determining factors associated with turtle takes, and developing and implementing mitigation measures in the longline fishery.

Shark bycatch in the Hawaii tuna/swordfish longline fishery has also generated a great deal of public concern. It is necessary to (1) increase research to estimate bycatch for all shark species, (2) evaluate logbook performance in documenting disposition of sharks, (3) undertake biological research in support of stock assessment, and (4) pursue cooperative research of bycatch with major foreign fishing nations.

Interactions between fishing operations and endangered monk seals are of great concern in Western Pacific fisheries. Because of the largely unknown nature of this problem, further work is required to (1) monitor and assess the six main reproductive populations of monk seals; (2) study monk seal ecology (particularly in the pelagic habitat), biology, and natural history; and (3) investigate and mitigate problems impeding recovery of this endangered species. Additional resources should also be devoted to removing netting and other marine debris that pose entrapment dangers in the monk seal environment. Following are other recommendations for managing bycatch in Western Pacific fisheries:

- Increase the level, broaden the scope, and ensure the continuity of fishery observer programs sufficiently to allow quantitative estimates of catch and other fishery data, including discards of fishery resources and protected species, with acceptable levels of precision and accuracy.

- Increase the ability to assess the effects of discards (population, ecosystem, social, and economic effects), and of management alternatives.

- Increase research on immediate and post-release mortalities of animals encountering fishing gear—but not retained—in particular sea turtles that have been hooked or entangled and released.

- Work closely with the Western Pacific Fishery Management Council, industry, environmental interests, and others to develop alternative solutions to real and perceived bycatch problems, including transfer of knowledge and techniques to reduce the bycatch of seabirds in the longline fishery.

- Improve knowledge of basic biology and stock status of shark species in the Pacific, and of the effects of fishery-related mortality on shark populations.

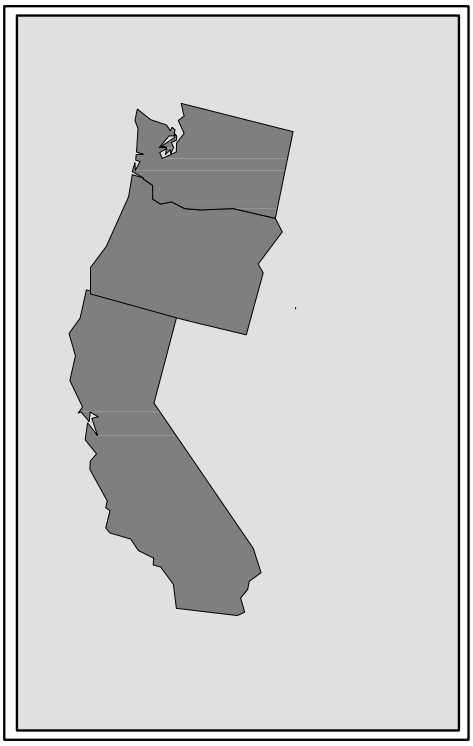
- Implement recommendations of take-reduction plans to reduce incidental taking of marine mammals in the California/Oregon drift gill-net fishery for swordfish and sharks.

- Enhance research on the impacts of fishing on blue and striped marlin populations, through domestic research programs and international scientific cooperation.

- Develop mitigation techniques to reduce mortality of lobster bycatch, including research on (1) gear design and operations, and (2) handling and release techniques.

- Develop and evaluate modifications to existing fishing gear to allow a reduction in the retention of the “legal bycatch” of small size classes of lobster, and increase the subsequent recruitment of lobsters to the fishery.

West Coast Fisheries



Regional Characteristics

Fisheries of the West Coast (coastal California, Washington and Oregon) primarily target several species of groundfish and salmon, while anchovy, sardines, mackerel, shrimp, crab, squid, and other shellfish and molluscs provide important alternative markets. These fisheries are harvested using a variety of gear types (trawls, seines, pots, hook and line, etc.) that produce about 462,000 metric tons (mt) annually, and have an ex-vessel value of approximately $300 million. About one-third of the harvest is taken within coastal state waters (0-3 mile zone).

In the groundfish fishery, nearly 200,000 mt of Pacific whiting are taken annually by large mid-water trawl and catcher/processor vessels that have replaced foreign and joint-venture fleets of the 1970 and 1980s. Bottom trawls harvest about 75,000 metric tons annually of other groundfish species, including several species of rockfish, flatfish, lingcod, and Pacific cod, as well as a deep-water complex of thornyhead rockfish, Dover sole, and sablefish.

The five species of Pacific salmon support important commercial, recreational, and tribal fisheries in the states of Washington, Oregon, California, and Idaho. Salmon are part of the culture and heritage of the Pacific Northwest, having been harvested for ceremonial and subsistence purposes by Native Americans for millennia. Commercial, recreational, and tribal fishermen harvest salmon from the Pacific Ocean, Puget Sound, estuaries, and rivers along spawning migration routes using trolling gear, seines, gill nets, and hook and line. Salmon fisheries yield about 23,000 mt annually. Harvests have been declining, however, as habitat degradation and overfishing have threatened specific populations of salmon. Several species of salmon have been or are proposed for listing under the Endangered Species Act.

Recreational angling is important to the West Coast fisheries, with about 80% of the estimated 25 million fish landed annually taken from California waters, about 15% taken from Washington waters, and about 5% taken from Oregon waters. Anglers reportedly spend about $850 million each year in the West Coast fisheries. A large portion of the recreational catch is released, including releases of protected species. Additional information on post-release survivability of these fish would be useful.

Management and enforcement of West Coast fisheries rely heavily on actions of the Pacific Fishery Management Council and on the cooperation among the federal, state, and tribal fishery management agencies.

Regional Bycatch Issues

Pacific Groundfish

Bycatch in the Pacific groundfish fishery comes in many different shapes and forms and is a significant issue. Bycatch discards occur in every sector of the groundfish fishery. Discarded bycatch includes (1) nongroundfish species (prohibited species, such as salmon, Pacific halibut, and crab) that are the target species in other fisheries, (2) targeted groundfish species that are caught in a species complex and discarded to stay within species or species-complex trip-landing limits, (3) discards of target species resulting from harvest guidelines or quotas being achieved for some species and not others, and (4) unmarketable groundfish and nongroundfish species.

With the exception of the midwater trawl fishery for Pacific whiting, bycatch is not comprehensively monitored or precisely estimated. Lack of a comprehensive at-sea observer program to collect bycatch and other biological data is the main reason information is either lacking or estimates are considered to be very "soft." Some usable data has been collected through limited observer programs conducted under research activities or under experimental fishing permits. Bycatch information on many groundfish species is needed to better assess and account for total mortalities in the different fishing strategies. Bycatch of salmon includes species listed under the Endangered Species Act.

Pacific Whiting

Pacific whiting are taken by large mid-water trawls in the spring and summer each year. The annual whiting harvest guideline is allocated among those vessels that deliver at sea to floating processors (motherships), those that catch and process at sea (catcher/processors), and those that land whiting at shoreside processing plants (shoreside). Pacific whiting landings generally range between 150,000 mt and 300,000 mt annually, making up the single largest component of the Pacific groundfish fishery. The majority of the catch is either headed and gutted or made into surimi and is, primarily, exported.

Salmon bycatch is a sensitive issue because the extremely depressed status of many wild salmon stocks, some of which have been listed as either "threatened" or "endangered" under the Endangered Species Act, has resulted in significant restrictions to directed commercial and recreational salmon fisheries, with serious economic impacts to coastal communities. Salmon bycatch can be a problem at the beginning of the season when vessels are exploring for abundances of whiting of the right size for processing. Salmon bycatch occurs intermittently with little consistency in season or location where it occurs.

Estimating the total salmon bycatch is possible because all at-sea processing vessels have at-sea observers on board, and vessels landing shoreside currently are allowed to land unsorted catches under the authority of experimental fishing permits, so that the bycatch of salmon can be counted when the catch is unloaded at shoreside plants. Salmon bycatch by the at-sea processing sector is discarded, whereas salmon recovered at shoreside plants are confiscated by the state and given to charity. All of the at-sea processing vessels that participate in the Pacific whiting fishery

also participate in the North Pacific groundfish fisheries off Alaska, where they are required to carry at-sea observers. No similar regulatory requirement currently exists for at-sea processors in the Pacific whiting fishery because all have voluntarily agreed to carry the same NMFS-certified observers necessary to fish off Alaska ever since the processors began participating in the whiting fishery in 1990. The Pacific Fishery Management Council (PFMC) has recommended that all at-sea processor vessels longer than 125 feet that participate in the Pacific whiting fishery also be required to carry an at-sea observer. The implementation of this regulation has been delayed because all vessels already carry observers voluntarily; nevertheless, it is likely to be promulgated soon to legally ensure that each at-sea processor continues to carry an observer.

The current biological opinion (NMFS 1995) resulting from consultation under Section 7 of the Endangered Species Act requires that a monitoring program be continued at a level that maintains the current capability under the experimental fishing permit program to estimate the salmon bycatch by vessels that deliver whiting to shoreside processing plants. Each experimental fishing permit requires the vessel operator to take an observer, if asked, and requires that his entire catch be delivered, unsorted, to a shoreside processing plant where technicians sample the entire catch. The intermittent nature of salmon bycatch and the fact that not all hauls are sampled and some sampled hauls are only partially sampled, introduce significant uncertainties when extrapolating salmon bycatch for a single vessel or area, but are more reliable for estimating the total bycatch for the entire season and area. Salmon bycatch has averaged about 11,000 fish (98% chinook salmon) during the last decade.

Marine mammal bycatch in the Pacific whiting midwater trawl fishery is also of concern. Since 1990, limited mortality takes have included individuals from six marine mammal species, specifically, California sea lion, Steller sea lion, harbor seal, northern elephant seal, Pacific white-sided dolphin, and Dall's porpoise. During the 1996-97 fishing season, observers reported an annual marine mammal mortality take of six to eight marine mammals, a level that is not considered significant.

This observer program is providing information not only on the actual bycatch of salmon, but on the bycatch of other groundfish species as well. Some species of rockfish, such as yellowtail rockfish and Pacific Ocean perch, are occasionally taken as bycatch in large numbers, but are accounted for by the monitoring programs. The bycatch of yellowtail rockfish is an immediate concern because the most recent stock assessment indicates yellowtail have been overharvested and future catch must be reduced. Yellowtail rockfish bycatch in the Pacific whiting fishery, which is either discarded or made into fish meal, is deducted from the annual harvest guideline, thus reducing the amount of yellowtail available for the directed fishery. In 1996, for example, the yellowtail rockfish bycatch was estimated at 631 metric tons, of which only 12 metric tons was retained. Pacific Ocean perch are overfished, are subject to a rebuilding program, and have had an annual allowable biological catch of zero for many years. The stock shows no signs of rebuilding. The total rockfish bycatch during 1994-96 has averaged around 1,000 mt annually.

The whiting industry and the PFMC have developed a variety of bycatch avoidance measures, some voluntary and some regulatory. The industry has adopted a PFMC-endorsed voluntary guideline of 0.05 salmon per metric ton of whiting as a bycatch rate ceiling for the entire whiting

season. Time and area closures have also been implemented to avoid areas of high chinook salmon abundance. For example, at-sea processing and all trawling for Pacific whiting in depths shallower than 100 fathoms are prohibited off California to reduce the salmon bycatch. At-sea processing vessels are also testing a pilot program based on real-time feedback to vessels identifying bycatch "hotspots" encountered by individual vessels within the fleet so that other vessels may avoid those areas.

Bottom Trawl Fishery

The bottom trawl fishery targets individual rockfish, flatfish, roundfish, and different species aggregations of rockfish, as well as the deep-water complex consisting of thornyheads rockfish, Dover sole, and sablefish. All types of regulatory discards plus discretionary (economic) discards occur in the bottom trawl fishery. Reasons for discard include prohibited species designation (Pacific halibut, salmon, crab); unmarketable size or species; and overages of trip- landing limits, harvest guidelines, and quotas.

Information on bycatch has been derived from a variety of sources, primarily research studies or other short-term programs that sample only a small portion of the bottom trawl fleet. Fishermen are required to record bycatch in logbooks, but these have not been used to generate bycatch estimates because of inaccuracies in bycatch records. The Pacific Fishery Management Council has developed the guidelines for a comprehensive data collection program, including at- sea observers, but it has never been implemented due to lack of funding.

Monitoring the total removals by the fishery is an important component of any fishery analysis program. In the bottom trawl fishery, total landed catch is well monitored by the state-run fish sales ticket system, but catch discarded at sea is still unknown for most segments of the fishery.

Based on various "snapshots" from specific research studies, it is thought that the annual salmon bycatch in the bottom trawl fishery may range from 6,000 to 9,000 fish, nearly equal to the magnitude of the bycatch in the whiting fishery, although this cannot be corroborated because of lack of sufficient at-sea monitoring. Chinook salmon, several populations of which are listed under the Endangered Species Act, are particularly vulnerable to bottom trawls.

Pacific halibut also frequent waters where the groundfish and the shrimp bottom trawl fisheries occur. The distribution of halibut is very spotty throughout waters off Washington, Oregon, and northern California, which constitute the extreme southern range of halibut. Halibut are found primarily in localized concentrations called halibut "hotspots." The International Pacific Halibut Commission is currently developing a new stock assessment method. It is also devising a method for determining the total allowable catch by management area that includes bycatch compensation features that deduct the adult bycatch from the current equilibrium yield, thereby directly reducing fixed-gear (longlines and fish pots) harvest guidelines.

Because of the lack of an at-sea observer program, the estimates of Pacific halibut bycatch in the bottom trawl fishery are based on the incidence of halibut observed during an experimental

observer program designed to investigate the extent of discards induced by trip-landing limits during 1985-87. Pacific halibut bycatch rates were estimated by multiplying the observed bycatch rate in the experimental program by the estimated total hours of fishing obtained from logbooks. The most recent estimate of Pacific halibut bycatch in the bottom trawl fishery is 448 mt. In the absence of more accurate estimates of halibut bycatch, overestimates of the bycatch could directly reduce the fishing opportunity for the directed longline and recreational fisheries for halibut, with the extreme possibility of virtually eliminating both directed fisheries.

The primary economic management objective for groundfish management on the West Coast is to have seafood processors provide a continuous, year-round flow of fish to fresh fish markets to produce a variety of benefits, including promoting continuous employment in coastal communities. However, overcapitalization, increased effort, and either declining or stable total allowable catch have resulted in the need to significantly slow catch rates to spread the catch of each species or species complex for which there is a harvest guideline over the entire year.

The PFMC has chosen trip-landing limits as the vehicle to slow the catch. Because almost all species managed by trip limits are harvested in a multispecies mixture with other trip-limit species, vessels are forced to discard valuable market species once the trip limit for that species is reached, while the vessel continues to fish on the trip limit for other species. As trip limits become more restrictive and as more species come under trip-limit management, discards increase.

Although data are not precise, estimates of trip-limit-induced bycatch are made for some trip-limit species and are either factored into the in-season catch estimates so the harvest guideline includes total mortality or deducted from the allowable biological catch before setting the harvest guideline pre-season. The level of discard managers currently assume as trip-limit-induced ranges from 5% for Dover sole to 20% for sablefish. However, if discard estimates are too high, then the industry is foregoing some short-term yield; if discard estimates are too low, then the long-term health of the fish stock may be jeopardized. The PFMC has attempted to reduce trip-limit-induced discards by extending the trip-limit period from weekly, daily, or single trip-landing limits to monthly. Now most species are managed under two-month cumulative trip-landing limits.

Quota-induced discards also can occur when fishermen continue to harvest other species when the harvest guideline of a single species is reached and further landings of that species are prohibited. Discretionary discards of unmarketable species or sizes are known to occur widely, although they are largely unmeasured.

In the absence of a comprehensive at-sea observer program, other more limited programs have been conducted to obtain bycatch data. Limited research studies have been funded by NMFS and under the Saltonstall-Kennedy grant program to investigate bycatch in different fishing strategies and recommend changes in strategies or gear modifications. These included the experimental observer program conducted between 1985 and 1987 by the University of Washington, which provided some useful insights into bycatch by fishing strategy. However, a program to comprehensively estimate discard rates and mortality is still necessary to provide

accurate data on total catch and mortality. Recently, the Oregon Trawl Commission, an Oregon industry group, has initiated a limited voluntary observer program linked to an enhanced fishery logbook program to estimate bycatch discards in the deep-water complex fishery under an experimental fishing permit. Observers began riding vessels in November 1995. Since then the program has expanded to include vessels landing in both Washington and California. The project has observed nine vessels on 52 trips and has put enhanced logbooks on board four additional vessels.

The other major West Coast bottom trawl fishery is the shrimp trawl fishery. Bycatch discards in the shrimp trawl fishery are known to include groundfish species, Pacific halibut, chinook salmon, and squid. Although the amount of groundfish bycatch in the shrimp trawl fishery is unknown because of the lack of an at-sea sampling program, its existence is recognized. Discard wastage is intended to be minimized by federal regulations that provide a landing allowance (other than the bycatch allowance, the fishery is state-managed). Through 1996, shrimp trawlers were permitted to land up to 1,500 pounds of groundfish per trip to prevent discard wastage. Because of the recent reduction in the yellowtail rockfish allowable catch, however, the 1997 fishing regulations will reduce the bycatch landing allowance from 1,500 to 500 pounds per trip. Some work has also been done under a Saltonstall-Kennedy grant to develop and test finfish excluder devices; some shrimp fishermen are now using them routinely.

The International Pacific Halibut Commission estimates the Pacific halibut bycatch in the shrimp bottom trawl fishery to be 56 mt.

Other Groundfish Fisheries

Other groundfish fisheries include bottom longline and pot (fish trap) fisheries for sablefish; other line (vertical longline, etc.) fisheries for rockfish; bottom gill nets for rockfish; and the recreational groundfish fishery, which is significant for some species such as lingcod and bocaccio rockfish. Very little is known regarding the amount of bycatch discards; mortalities; and the social, economic, or biological impacts of the bycatch in these fisheries.

For the West Coast sablefish longline fishery, the International Pacific Halibut Commission estimates the Pacific halibut bycatch based on a relationship between halibut and sablefish exploitation rates by the sablefish fisheries of the West Coast and Alaska, since there are no direct data derived from the West Coast sablefish fishery. The current Pacific halibut bycatch estimate is 41 mt.

Pacific Salmon

The federally managed ocean salmon fisheries are divided into commercial troll and recreational fisheries. Both groups use hook-and-line gear. Inside-water commercial fisheries, which are managed by the states and treaty tribes, use gill nets and purse seines. Bycatch in the ocean commercial troll and recreational salmon fisheries has two major components. The first is the catch and discard of depressed or endangered salmon species, for which there is no total allowable catch in a mixed-stock fishery with other salmon species. The second is the catch and

discard of salmon species either coastwide or by management area, where the quota for one species of salmon is taken before the quota for the other species.

The primary salmon species taken in the ocean fisheries are chinook and coho salmon. Since 1994, because of very depressed coho salmon stocks (both hatchery and wild), retention of coho has been prohibited off the coasts of both Oregon and California. Even though retention was prohibited, it was estimated that hook-and-release mortality of coho salmon taken incidentally in chinook salmon fisheries was 8% for the recreational fishery and 26% for the commercial troll gear fishery, with an additional 5% for each fishery for drop-offs (fish hooked, but not landed). Coho salmon bycatch rates would be higher if chinook harvests were not constrained to limit the bycatch of coho salmon. The reverse has occurred off the coast of Washington where coho harvests have been allowed some years, but chinook salmon retention is prohibited to protect weak and endangered Columbia River chinook salmon stocks. Estimates of salmon encounter rates and hook-and-release mortalities in nonretention fisheries are limited to a few specific areas, but are essential to assess the impacts of harvest on weak and endangered stocks. Recent studies have updated past estimates, but more work is necessary. Some of this work has been conducted using fishermen funded by the Northwest Emergency Assistance Program.

The states of Oregon and Washington have begun to mass-mark hatchery coho salmon, beginning with the 1995 brood year, with the intent of prosecuting selective fisheries on returning adults in 1998. In a selective fishery, fishermen would keep only fin-marked hatchery fish, while releasing unmarked native or wild fish. To evaluate the potential impacts on wild fish, better information is needed on both encounter and hooking-mortality rates of unmarked fish. These studies are a high priority for funding under the Salmon Disaster Relief Program, which began in 1994 in the wake of major salmon stock collapses.

The bycatch of seabirds (common murres and endangered marbled murrelets) occurs in gill-net and purse-seine fisheries in the Columbia River and Puget Sound. In recent years, biological opinions prepared by the U.S. Fish and Wildlife Service have required observer programs to assess the incidence of seabird bycatch. The Saltonstall-Kennedy program is currently funding experimental gear research in the purse-seine fishery. Bycatch of marine mammals, mainly harbor porpoise, occurs in the net fisheries. In a recent Stock Assessment Report (Barlow et al 1995), NMFS found that the minimum total fishery mortality and serious injury of harbor porpoise cannot be considered insignificant and that the status of the harbor porpoise stock be reviewed during 1997.

Pacific Coastal Pelagic Fisheries

The major target species in the Pacific coastal pelagic fishery are the northern anchovy, jack mackerel, Pacific sardine, and Pacific mackerel. These species are naturally dynamic, highly responsive to environmental conditions, and subject to wide fluctuations in abundance and distribution, even in the absence of a fishery. They are very important as live bait in the recreational fisheries for gamefish, groundfish, and salmon. The species also support a low-volume, but high-value fishery for dead bait, pet food, and dried fish as well as lower-value fisheries for canning or reduction.

The fisheries are distributed internationally, with components in the exclusive economic zones of Mexico and Canada. There is no bilateral agreement with Mexico regarding anchovy management. The fishery management plan allocates 70% of the annual optimum yield to the U.S. reduction fishery, and 70% of the quota for nonreduction purposes to the U.S. exclusive economic zone.

Commercial landings are monitored from information provided from processors' "fish tickets" and a California Department of Fish and Game port sampling program.

The Pacific Fishery Management Council manages the anchovy fishery under the Northern Anchovy Fishery Management Plan. Pacific sardine and Pacific mackerel are managed by the state of California. Jack mackerel north of lat. 39° N. are managed under the Pacific Coast Groundfish Fishery Management Plan.

Several of the species are particularly important in the ecosystem. Anchovies, for example, are an important food source for the endangered brown pelican. Coastal pelagics are important for the endangered least tern. While these species are a key component of marine food webs and the primary prey of many seabirds, it is not currently possible to estimate the total amount of the species that is necessary to sustain the predator populations. However, the fishery management plan for anchovy specifies a threshold for its optimum-yield determination to prevent anchovy depletion and provide adequate forage for marine fish, mammals, and birds.

Coastal pelagic species support a multispecies fishery in which bycatch is common. Bycatch usually consists of other coastal pelagic species, but may include other species as well. The directed fishery for anchovy has little bycatch. Bycatch of sardines and Pacific mackerel may be important from an economic or allocative point of view when harvest quotas or guidelines for one species are reached and another is not. Under a multispecies quota management system, discards of species for which the quota has been met may increase while fishing activity continues for other species in the complex. However, with this possibility in mind, California regulates bycatch with a system of bycatch allowances and overall incidental reserves by retaining a portion of any harvest guideline to apportion at a later time if the fishery for one species could be closed because the harvest guideline has been reached for another species. This management approach appears to work well.

Because of the nature of the stocks, it is unlikely that bycatch poses a biological risk to the species. Little or no information on bycatch of marine mammals or protected species is available, but the impact is thought to be nonexistent or very small.

Regional Recommendations

The need for monitoring bycatch and determining ways to minimize bycatch mortality remains a high priority in West Coast groundfish fisheries and Pacific salmon fisheries. Several populations of Pacific salmon have either been listed or are being considered for listing under the Endangered Species Act are taken in directed fisheries or as bycatch in groundfish fisheries. Observer data on salmon bycatch have been available since 1990 from all at-sea processing

vessels in the Pacific whiting fishery on a voluntary basis. There are no ongoing comprehensive at-sea observer programs in the bottomfish fishery to determine bycatch of salmon, Pacific halibut, or other regulated species. The Pacific Fisheries Management Council has recommended mandatory at-sea observer programs for at-sea processors with vessels 125 feet long or longer in the Pacific whiting fishery and is currently formulating recommendations for bycatch data collection that will most likely require an at-sea observer program for bottomfish fisheries.

In recent years, the bycatch of seabirds (e.g., common murres and endangered marbled murrelets) and marine mammals has been monitored in gill-net fisheries. Better documentation of the bycatch in these fisheries is needed, as well as additional gear research to reduce or avoid the taking of sea birds and marine mammals. Based on research done to date, the state of Washington has imposed time, area, and gear restrictions to reduce the bycatch of seabirds in the Puget Sound sockeye salmon net fishery.

Pacific coastal pelagic species are important in West Coast recreational fisheries, limited commercial fisheries and are essential components of the eastern North Pacific Ocean ecosystem. While current state and federal management of individual pelagic species appears adequate to minimize bycatch, little is known about the interaction of these species as a complex, the impacts of commercial and recreational fishing (e.g., magnitude of discarding), and environmental effects, such as El Niño, on population fluctuations.

The high cost of obtaining information and data on the magnitude of bycatch requires the a greater effort to utilize all existing data and to be more selective about collecting new data. Improved cooperation on the collection and sharing of bycatch information and data with the states, tribes, commercial and recreational fishing industry, academia, conservation groups, and other interested parties provides an opportunity to enhance “core” statistics and information bases that will be essential to evaluate the population, ecosystem, social, and economic impacts of proposed bycatch management measures. Following are specific recommendations for West Coast fisheries:

- Assess the magnitude of bycatch in West Coast groundfish fisheries. With the exception of the mid-water whiting fishery, little is known about the magnitude and composition of the bycatch in the bottomfish trawl fishery.

- Develop and implement an at-sea observer program in the Pacific groundfish bottom trawl fishery cooperatively with the Pacific Fishery Management Council and the Pacific Coast fishing industry.

- Resolve legal and other issues that are impediments to commercial and recreational industry involvement in groundfish bycatch data collection and research. NMFS and the industry need to develop a more collaborative relationship that can better utilize the fishing industry to assist in the collection of bycatch data.

- Explore management and enforcement policies that discourage regulatory discards in groundfish fisheries.

- Collaborate with the groundfish, salmon, and coastal pelagic fishing industries to better utilize industry resources to collect commercial and recreational bycatch information.

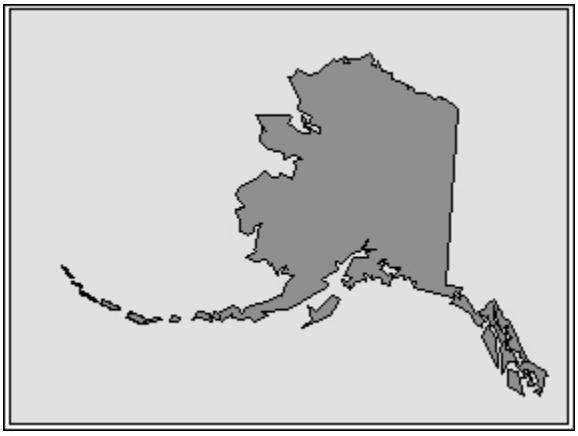
- Develop better estimates of hook encounter and hooking mortality rates of salmon taken in commercial and recreational salmon fisheries. Encounter and mortality rates are key components of assessing the impacts of single-salmon-species fisheries on nonretention species, and of the impacts of selective fisheries for mass-marked hatchery salmon on wild salmon stocks.

- Develop selective harvest techniques in ocean and freshwater fisheries that can be used to target healthy, harvestable stocks of salmon while protecting weak or recovering salmon stocks.

- Minimize the salmon bycatch in nonsalmon fisheries through the collection of better information on the magnitude, distribution and stock composition of salmon bycatch, and using the information to develop and implement either voluntary or mandatory bycatch-minimization measures.

- Develop better documentation of the seabird bycatch in the purse-seine and gill-net salmon fisheries, and conduct additional gear research to reduce or avoid the taking of sea birds and marine mammals.

Alaska Fisheries



Regional Characteristics

Groundfish Fisheries

Alaska groundfish were harvested primarily by foreign nations until the mid-1980s. The foreign catches were replaced in the late 1980s by joint venture harvests by domestic fishermen delivering to foreign processors. Fully domestic operations developed rapidly in the late 1980s and by 1991 were the only form of operation. Currently, about 90 percent of the groundfish harvest is taken with trawl gear, although harvest amounts with hook-and-line, pot, and jig gear are increasing. The selectivity of these gear types in the multispecies groundfish fisheries varies by target species, area, and time of year.

Groundfish stocks generally are in a healthy and stable condition. The optimum yield of the groundfish resource is established as a range in the Bering Sea and Aleutian Islands (BASI) management area (1.4 - 2.0 million mt) and the Gulf of Alaska (116,000 - 800,000 mt). All Alaska groundfish stocks have fluctuated in abundance over the years, but no widespread trend toward decline is evident (NPFMC 1996a, 1996b). The annual harvest of Alaska groundfish approaches 2.3 million mt.

Management of the Alaska groundfish fisheries is directed to maintain total harvest amounts within annually specified total-allowable-catch amounts. An extensive program that includes monitoring by NMFS-certified observers and an industry catch-reporting requirement is used to estimate total fishing mortality. Management tries to account for all sources of fishing mortality; estimated discard amounts of groundfish are charged against the annual total-allowable-catch amounts. When NMFS determines that the allowable harvest level for a species has been taken, the fishery is closed for the year. In 1995, the total harvest of Alaska groundfish species (2.14 million mt) accounted for only about 64% of the total acceptable biological catch (3.33 million mt; NPFMC 1996a, 1996b).

Commercial Crab Fisheries

The management of the king and Tanner crab pot gear fisheries in the BSAI area largely is deferred to the state of Alaska under the federal Fishery Management Plan for the Commercial King and Tanner Crab Fisheries of the Bering Sea/Aleutian Islands Area (NPFMC 1996c). Other crab fisheries are managed by the State of Alaska without federal overview.

The history of the eastern Bering Sea crab fisheries extends back to the 1930s, but large-scale commercial efforts were not undertaken until development of the foreign king crab fisheries in the 1950s. Foreign Tanner crab fisheries were developed in the 1960s. Foreign fishing for king

crab ceased in 1974, and foreign fishing for Tanner crab in U.S. waters was prohibited under the Magnuson Act in 1980 (Otto 1989). Offshore areas of Bristol Bay have supported large domestic fisheries for red king crab, snow crab (Chionoecetes opilio), and Tanner crab (C. bairdi).

In recent years, however, these stocks have declined to low levels. In the 1995 eastern Bering Sea fishery, 60.6 and 1.8 million snow and Tanner crab were harvested, respectively. The 1994-95 Bristol Bay red king crab fishery was closed due to low abundance, but was reopened in 1996. Commercial fisheries for other species of crab exist, but at volumes less than those for the three species that historically have supported large commercial operations.

Salmon Fisheries

The management of the Alaska salmon fisheries is deferred to the state of Alaska under the federal Fishery Management Plan for the Salmon Fisheries of the EEZ off Alaska (NPFMC 1990). State management of the salmon fishery is based on sustainable optimal yield. It has resulted in healthy salmon stocks for all species and record harvest levels for all species except chinook salmon, which remains under conservative management. Management of the Alaska salmon fishery strives to protect, to the extent possible, any depressed stock, including those originating south of the Alaska border.

Commercial fishing is conducted in both state and federal waters using troll, drift gill-net, set gill-net, and purse-seine gear. All five Pacific salmon species are harvested by commercial, recreational, and subsistence fishermen. Chinook salmon are the most highly prized species because of their large size and excellent food quality. In Alaska, approximately 1 million chinook salmon are harvested annually. While this is less than 1% of the annual salmon catch off Alaska, chinook salmon typically are the focus of a disproportionately larger amount of management and regulatory effort because of the conservation concerns and intense allocation issues for this species. Increased focus on the Southeast Alaska commercial salmon troll fisheries occurred with the listing of Snake River sockeye, Snake River spring/summer chinook, and Snake River fall chinook in 1991 and 1992 under the Endangered Species Act (NMFS 1997c).

Pacific Halibut Fishery

Commercial and recreational fisheries exist for Pacific halibut off Alaska. The International Pacific Halibut Commission (IPHC) has the primary responsibility for managing the Pacific halibut resource off Alaska. Under authority of the North Pacific Halibut Act, the North Pacific Fishery Management Council is authorized to develop regulations that are in additional to, but not in conflict with, regulations adopted by the IPHC. The Council adopted an individual fishing quota (IFQ) for the commercial Alaska halibut fishery in 1992. NMFS implemented the program in 1995. Under the IFQ program, individual fishermen were assigned a quota share based on past participation in the fishery and other criteria developed by the Council. The annual halibut quota established by the IPHC is allocated among fishermen based on their individual quota share. These quota shares are transferable harvest privileges within specified limitations. Under the IFQ program, fishermen are able to harvest their halibut IFQ whenever and however

such harvest is most economical to their fishing operation, subject to program limitations and seasons. In 1996, over 18,000 mt of halibut were harvested in the IFQ fishery. Recent improvements to the halibut stock assessment models used by the IPHC resulted in an estimate of halibut abundance that is above the long-term potential yield.

Other Fisheries

The commercial scallop fishery off Alaska is managed under the Fishery Management Plan for the Scallop Fishery off Alaska (NPFMC 1996d). Federal regulations governing this fishery generally mirror Alaska state regulations. Participation in the federal water scallop fishery is constrained by a vessel moratorium implemented in 1997. A total of 18 vessels currently are eligible to participate. Alaska recently has implemented a separate limited-entry program for state waters. The North Pacific Fishery Management Council currently is pursuing an amendment to the federal fishery management plan that would defer most scallop fishery management measures to the state. The commercial landings of shucked scallop meats have varied widely since the late 1960s, with peak annual landings in excess of 1.8 million pounds. In 1996, about 583,000 pounds of shucked meat were landed.

Other fisheries off Alaska that are managed by the state include commercial and subsistence herring fisheries, as well as numerous small-scale coastal fisheries for finfish, shellfish, and other invertebrates.

Regional Bycatch Issues

Groundfish Fisheries

Since the late 1980s, a dramatic increase in harvesting and processing capacity in the domestic open-access groundfish fisheries has resulted in an extremely competitive race for fish, with every vessel pressured to catch its share of the quotas before the fleet harvests the groundfish quotas or before prohibited species bycatch restrictions close the fishery. This situation frustrates any inclination vessel operators may have to alter fishing practices to reduce bycatch if such action puts them at a competitive disadvantage relative to other participants in the fishery. For this reason, the controversial option of individual fishing quotas has been promoted by some fishery participants as a means to allow a market-driven incentive to reduce bycatch.

The overall bycatch and discard rate in the Alaska groundfish fishery is not exceptional compared to other major fisheries in the world (Alverson et al. 1994), although individual fishery or vessels rates can be high. However, the 2.3-million-mt fishery is so immense that the absolute volume of discards and the foregone opportunity they represent have raised national and industry consciousness, and pose a significant concern to other fisheries dependent on some of the bycatch species. For example, the 1995 Bering Sea mid-water pollock fishery harvested over 1.1 million mt of fish, of which almost 46,000 mt were discarded (a discard rate of only 4%) (NMFS 1996c). The Bering Sea rock sole, flathead sole, and other flatfish trawl fisheries typically experience high discard rates relative to other Alaska groundfish fisheries (about 55% of the total catch in 1995), although other small-scale trawl and hook-and-line fisheries have

exceeded this rate. Overall, the 1995 discard rates in the Alaska trawl and hook-and-line fisheries were 14% and 18%, respectively. By volume, however, discard amounts in the trawl fisheries accounted for 91% of the total 1995 discards in the Alaska groundfish fisheries (NMFS 1996c).

The NMFS Alaska Region catch reports for 1995 estimate that total discards in the groundfish fisheries include about 285,000 mt of groundfish, 7,190 mt of dead halibut, 123,300 (individual) salmon, 1,020 mt of herring, and almost 8 million (individual) crab (mostly Tanner crab). Pacific halibut, salmon, herring, and crab are prohibited species in the groundfish fisheries and must be discarded under existing regulations. Regulations also limit the amount of a groundfish species that may be retained on board a vessel if the species is closed to directed fishing. Catch amounts of these species that exceed the maximum retainable bycatch amount must be returned to the sea. Most groundfish discard reflects discretionary decisions on the part of industry (e.g., undersize fish, no market, male fish in roe fisheries), although regulatory discards also account for a significant portion of the groundfish bycatch that is returned to the seas. The absolute percentage of discretionary versus regulatory discards is not known.

The bycatch of prohibited species (Pacific halibut, crab, salmon, and herring) in the groundfish fisheries has been a major focus of attention since the days of foreign fishing. Stocks of some of these species have declined, particularly some crab stocks, and management agencies are concerned about all sources of mortality, including bycatch mortality. Furthermore, the pressure to address the allocative implications of bycatch mortality of these fully utilized species, as well as concerns about the potential impact of fishing operations on crab habitat, have propelled the NPFMC to recommend numerous management measures to address these concerns and mitigate potentially adverse impacts on declining stocks of prohibited species. Foremost among these measures is the establishment of area closures and prohibited species bycatch limits that, when reached, result in groundfish fishery closures.

Bycatch limits, area closures, and other prohibited-species bycatch mitigation measures limit the overall bycatch mortality of these species in the groundfish fisheries, and have protected sensitive habitat areas. However, they also have created barriers to harvesting groundfish total-allowable-catch amounts, and have generated tremendous allocative controversy among various users of species taken as bycatch in the groundfish fisheries. Furthermore, the multispecies nature of the bycatch problem in the groundfish fisheries creates a situation where a solution for one species' bycatch problem often exacerbates the bycatch problem for a different species.

Recently, several high-valued groundfish species that have relatively low acceptable biological catch levels have posed significant bycatch issues that are similar to those experienced for prohibited species. These species, such as Greenland turbot or several species of rockfish, often are not open to directed fishing because the full total allowable catch (TAC) is needed to support bycatch needs in other fisheries. However, bycatch amounts of these species can be retained up to a specified percentage of other retained catch. Once a species' TAC is reached, however, further retention is prohibited. In some cases, continued bycatch amounts approach or reach the overfishing level, and fisheries that cannot avoid the bycatch of the affected species are closed. These closures can prevent fishermen from harvesting other groundfish quotas. In many

cases, allocative issues can develop to the extent that the bycatch in one fishery can be sufficiently large to exceed the TAC and can approach overfishing levels early in the year, thus preempting other fisheries that start later in the year from opening or harvesting available groundfish quotas.

Concerns about marine mammal bycatch in the Alaska groundfish fisheries exist, particularly for killer whale interactions in the hook-and-line gear fisheries and Steller sea lions in the groundfish trawl fishery. Incidental takes of Steller sea lions averaged 12 per year during 1991-95 in the Bering Sea/Aleutian Islands groundfish trawl fishery, a level of take that may be a cause for concern for a stock that continues to decline for unknown reasons (Hill et al 1997). Recently, the mortality of marine birds (including the short-tailed albatross, an endangered species) in the Alaska hook-and-line gear fisheries has received a great deal of attention. In 1997, regulations were implemented for the groundfish hook-and-line gear fisheries that require mandatory use of bird avoidance gear and fishing methods. The NPFMC also has adopted these measures for the Pacific halibut fishery. The biological opinion developed as part of a recent Endangered Species Act section 7 consultation for short-tailed albatross (USFWS 1997) requires NMFS to develop a research plan to assess the effectiveness of seabird bycatch mitigation measures, with the understanding that measures implemented to date would be adjusted as necessary to reduce seabird bycatch mortality.

Commercial Crab Fisheries

The selective nature of commercial crab pots results in very limited bycatch amounts of noncrab species. Although bycatch of groundfish and Pacific halibut does occur, the small amounts caught have not instigated resource management or allocative concerns. Crab bycatch mortality in the directed crab fisheries is receiving increased scrutiny given the overall decline in crab stocks. Crab bycatch includes females of target species, sublegal males of target species, and nontarget crab. Due to the difference in legal size versus market size for snow crab, a portion of the legal crab are not retained. The number of crab taken as bycatch in the 1995 commercial crab fisheries is estimated at over 75 million (Appendix A).

Some discarded crab die because of handling mortality or predation. Estimates of handling mortality rates range widely based on gear type, species, molting stage, number of times handled, temperature, and exposure time (Murphy and Kruse 1995). Crab mortality also is caused by ghost fishing, which is the term used to describe continued fishing by lost or derelict pot gear. Crab captured in lost pots may die of starvation or by predation. The impact of ghost fishing on crab stocks remains unknown, although management agencies hope that pot limits and mandatory pot gear escape mechanisms have reduced ghost fishing due to pot loss in recent years.

Salmon Fisheries

The bycatch of nonsalmon species in the directed salmon fisheries is not monitored or quantified under the assumption the bycatch amounts are small and do not affect population levels. The bycatch problem in the state-managed Alaska salmon fisheries centers around the

interception of other salmon species or runs. This interception creates allocation issues, and in some cases, gives rise to conservation concerns.

Of particular interest are the salmon fisheries in Southeast Alaska, which intercept salmon, including ESA-listed Pacific Northwest stocks, passing through the marine waters off the coast of Alaska on their way to more southerly spawning grounds. This interception is the focus of ongoing negotiations and debate among Alaskan, Canadian, and Pacific Coast fishermen, management agencies, and governments. Another important bycatch issue in the commercial and recreational hook-and-line fisheries is the capture of undersized chinook salmon which must released. While the majority of these fish survive the hooking encounter, large numbers can be hooked and substantial mortality incurred. Larger mature chinook salmon must also be released during commercial troll and net fisheries for coho salmon and other species once season quotas for retaining chinook salmon are reached. These quoatas are part of the United States/Canada salmon treaty process. Under these conditions in the commercial troll fishery for coho salmon, the non-retention catch of chinook salmon often exceeds 100,000 maturing fish that are subject to significant hook and release mortalities.

Due to bycatch of marine mammals, the salmon gill-net fisheries are classified as Category II fisheries under the Marine Mammal Protection Act. A limited observer program in the Prince William set and drift gill-net fisheries documented significant seabird bycatch, and the persistence of intentional lethal taking of marine mammals. NMFS is currently developing a comprehensive observer program for other Alaska gillnet fisheries with the primary focus of determining the nature and extent of marine mammal interactions in these fisheries; seabird bycatch information will also be collected.

Other Fisheries

Bycatch of crab in the Alaska scallop dredge fishery is limited by area-specific crab bycatch limits. Observer data are used to estimate crab bycatch. When the bycatch limits are reached in an area, it is closed to fishing for scallops. Observer data do not suggest that significant bycatch of other species occur in the scallop fishery.

The Pacific halibut fishery does not have an observer program to monitor the discard mortality of undersized halibut or other species in the fishery, although logbook data are used by the International Pacific Halibut Commission to estimate halibut dead loss in the fishery. Logbook data also are collected on bycatch of some groundfish species. Seabird bycatch mortality in the halibut fishery is of concern, and regulations have been proposed to implement mandatory gear and fishery operation restrictions to reduce seabird bycatch.

The impact of nongroundfish fisheries on marine mammals or other protected species is largely unknown because of the lack of data on interactions. To date, an Alaska take-reduction team has not been formed because reliable information regarding take levels of marine mammals in unobserved Alaska commercial fisheries is not available to make a determination as to whether a take-reduction team is warranted.

Regional Bycatch Programs

Research and monitoring programs to address the bycatch problem off Alaska primarily are based on data collected from an industry-funded mandatory observer program. Research is focused on (1) how bycatch operates within various fisheries and gear types, (2) gear modification to reduce bycatch rates, (3) mortality associated with discards by gear and fishery, and (4) the relationship of bycatch in terms of abundance to the stock status of bycatch species and the effect of bycatch on other fisheries.

Numerous regulatory approaches have been implemented to address or reduce bycatch in the Alaska groundfish and shellfish fisheries. These include bycatch limits for prohibited species, gear restrictions, season delays or time/area closures, a vessel incentive program, an individual fishing quota program for hook-and-line sablefish and halibut, mandatory retention and increased utilization of pollock and Pacific cod (proposed program that would be expanded to include rock sole and yellowfin sole within five years), and voluntary industry initiatives. The affected industry has been instrumental in the development and successful implementation of most of these programs. Despite a high level of compliance with these programs, difficulties exist in assessing the effectiveness of these regulations in promoting either a long-term reduction in bycatch to the extent practicable or positive responses in abundance of species of concern. Although absolute bycatch mortality of prohibited species is reduced by bycatch limits and time/area closures, few of these measures actively promote independent efforts to understand the cause and effect of bycatch.

Bycatch Monitoring and Assessment Strategies

Groundfish Observer Program

An important element in determining the magnitude and character of the bycatch problem in the Alaska groundfish fisheries is the monitoring program that has been implemented for the domestic fishery since 1990. Observer catch data are submitted to NMFS on a weekly (or daily, if necessary) basis. Observer data on groundfish catch and bycatch rates of halibut, salmon, crab, and herring are blended with industry-reported groundfish catch to derive a “blend” estimate (based on an established “blend algorithm”) of groundfish catch and associated prohibited-species bycatch amounts. This information is used for in-season monitoring of groundfish catch and prohibited-species bycatch amounts, and for analysis of present and future management measures. The observer program also collects data on the viability of Pacific halibut bycatch for use in estimating discard mortality rates in specified groundfish fisheries.

The observer data on species catch composition and amount in the groundfish fisheries provide substantial, but not complete, information on the characteristics of bycatch. In recent years, other observer priorities have prevented the collection of adequate size and sex composition data for crab bycatch. Stock identification information is relatively limited, and considerable uncertainty exists concerning the handling mortality rates for discards. Increasing concern about seabird bycatch has prompted interest to collect additional information on seabird

interactions that observers are currently unable to collect because of other data collection priorities.

The observer program also does not provide estimates of the bycatch mortality that occurs when fish and shellfish come in contact with fishing gear, but are not brought up with the gear. This includes fishing mortality caused by lost gear and fish that escape the gear, but not without incurring fatal injuries.

The mandatory groundfish observer program has an annual cost of more than $8 million, of which more than $6 million is paid by the vessels and processing plants that are required to have observers. To fish, vessels 125 feet long or longer must have an observer on board at all times. Vessels 60-124 feet long must have an observer on board 30% of the days that fishing gear is retrieved and groundfish are retained. Mother ship and shoreside processors receiving less than 1,000 mt of groundfish during a month must have an observer present 30% of the days groundfish are received or processed; those processors that receive greater amounts of groundfish must have an observer present each day of operation.

Alaska State Shellfish Observer Program

At-sea observers are required by Alaska state regulation on all vessels processing king or Tanner crab at sea throughout Alaska and on all vessels participating in the brown king crab fishery in the Aleutian Islands area. At-sea observers are required as a special permit condition for all vessels participating in other crab fisheries. Alaska state regulations also require 100% observer coverage on vessels fishing for scallops, although certain exemptions exist for the small-boat fleet fishing in Cook Inlet. Federal regulations implementing the Fishery Management Plan for the Alaska Scallop Fishery (NPFMC 1996d) mirror the state's observer coverage requirements.

Data collection by shellfish observers is essential to the Alaska Department of Fish and Game (ADFG) as a primary means for gathering the data that are used for research, in-season management, and development of management measures, as well as for enforcement of regulations. Shellfish observers currently collect data to assess the magnitude of bycatch and bycatch discard in the crab and scallop fisheries. ADFG believes the mortality of crab discarded in the shellfish fisheries is significantly less than 100%, although the actual mortality rate can vary among fisheries and vessel types.

Currently, crab and scallop vessel owners/operators must pay for observers. The state is exploring alternative cost-recovery programs to nullify the issue of costs to vessel operators. Alternative programs could provide more management flexibility to deploy observers in a manner appropriate to meet the changing needs for shellfish resource management and research.

Other Observer Programs

At present, no other observer programs exist other than for the groundfish and shellfish fisheries. NMFS is developing a proposal for the implementation of a marine mammal

interaction monitoring program for commercial fisheries off Alaska. The proposed program is based on a feasibility study conducted in 1995 through a contract with Marine Mammal Protection Act funds (Wynne and Merklein 1996). The intent of the proposed program would be to achieve a basic understanding of the rate of mortality and serious injuries occurring to marine mammals in Alaska Category II fisheries.

The initial proposal is intended to be the start-up phase for a long-term monitoring program to assess the impact of commercial fisheries on marine mammal stocks, and to collect information on the level and types of interactions. To date, logbooks have been the primary source of information on marine mammal/commercial fisheries interactions in Alaska because only two of the current 13 Category II fisheries in Alaska have been observed. Under the proposed observer program (subject to funding), eight previously unobserved fisheries would be monitored for one fishing season each over the next three years (1998-2000) to obtain an initial, reliable estimation of mortality and serious injury levels. All eight fisheries target salmon and are Alaska state-managed fisheries.

Catch Reporting and Monitoring

A comprehensive record-keeping and reporting program has been established for the Alaska groundfish fisheries, which supplements the data collected by observers. Processor vessels are required to maintain daily cumulative production logbooks that record the amount of discards, and the amount and type of product produced from retained catch. This information is submitted to NMFS weekly, although monitoring requirements for a fast-paced fishery may require that this information be submitted daily. Shoreside processors record landed weight of each species and associated discard amounts. This information also is reported to NMFS on a weekly or daily basis. NMFS estimates total groundfish catch based on a combination of observer data and weekly catch reports from processors. Discard rates from these observer data are applied to the shoreside groundfish landings to estimate total at-sea discards from both observed and unobserved vessels.

The principal objective of the groundfish observer program is to provide adequate estimates of total catch by species and not to differentiate between retained and discarded catch. For at-sea processors, the observers generally estimate total groundfish catch directly, as opposed to estimating retained catch and discarded catch separately and adding the two estimates. However, the total catch estimate for shoreside processors is the sum of observer estimates of at-sea discards by catcher vessels and the catch that is delivered to shoreside processors and reported in the processors' weekly reports.

Voluntary Industry Information Systems

Participants in the Bering Sea bottom trawl fisheries for flatfish voluntarily have developed an information system to distribute to the fishing fleet timely data on prohibited-species bycatch rates and bycatch hot spots (Gauvin et al. 1996). In the program, observer data on catch and bycatch are electronically transmitted from each participating vessel to Sea State, a private contractor located in Seattle. Sea State conducts statistical expansions from observer data to

calculate an average bycatch rate per vessel for each 24-hour period. Daily bycatch rates are then placed in a format where the relationship between bycatch rates and locations is accessible to vessel operators and vessel companies. Sea State relays this information to participants every 24 hours via fax or by a computer file loaded into a plotting program provided to the vessel. The goal of the program is to allow the fleet to rapidly respond (both individually and collectively) to high bycatch rates and to reduce bycatch rates of prohibited species. Assessments of observed vessel bycatch rates in the Pacific cod and flatfish fisheries indicate that vessels participating under the Sea State program experience significantly reduced bycatch rates compared to non-participating vessels. The Sea State program is recognized by industry and management agencies as an effective tool for monitoring bycatch in the groundfish fisheries.

A separate information system has been voluntarily developed for vessels participating in the Bering Sea hook-and-line fishery for Pacific cod (Smith 1996). Participants in this fishery developed a careful release procedure to decrease the mortality of Pacific halibut incidentally taken while targeting Pacific cod. This procedure ultimately was incorporated into regulations implemented by NMFS. Working with Fisheries Information Services (FIS), a private consultant, the freezer-longline fleet organized an industry monitoring program for halibut bycatch mortality. Each week, vessels fax preliminary observer data on the physical condition of released halibut to FIS. FIS calculates the halibut mortality for each vessel and faxes it back to the vessel operators who immediately learn if they are fishing in a high bycatch area or if their crew are mishandling halibut. Two-thirds of the fleet participated in the program during 1995, which is credited by the fleet to have reduced halibut discard mortality substantially.

Bycatch Management Program

The management of the crab and scallop fisheries generally is geared to minimize crab discard mortality through gear restrictions, season closures, bycatch limits, and area closures. In response to concerns about bycatch in the Bering Sea/Aleutian Islands area and Gulf of Alaska groundfish fisheries, the North Pacific Fishery Management Council (NPFMC) has recommended, and the Secretary of Commerce has approved and implemented, a variety of management measures that, in part, were intended to help control the bycatch of prohibited species as well as reduce discard of groundfish. Of the more than 40 amendments to the Fishery Management Plan for the Groundfish Fishery of the Bering Sea and Aleutian Islands Area (NPFMC 1997) that have been considered by the NPFMC since 1982, about a third addressed primarily bycatch issues, and about another fourth addressed some aspect of bycatch management.

Time/Area Closures

Time/area trawl closures are implemented around Kodiak Island, around the Pribilof Islands, and in the Bristol Bay area of the southeastern Bering Sea to protect sensitive king and Tanner crab habitat areas and to avoid bycatch of crab during the molting season. Some of these closures are year-round, others are seasonal. Time/area closures are also implemented to reduce the bycatch rates of chum salmon in the Bering Sea pollock fishery.

Bycatch Limits

Bycatch limits for C. bairdi Tanner crab, red king crab, herring, chinook salmon, and chum salmon are established for Bering Sea and Aleutian Islands (BSAI) management area trawl fisheries. Bycatch limits for C. opilio Tanner crab have been approved by the North Pacific Fishery Management Council. Halibut bycatch mortality limits also are established for all the BSAI and Gulf of Alaska groundfish fisheries. Bycatch limits for king crab and Tanner crab also are established for the commercial king and Tanner crab fisheries as well as the scallop fishery. These bycatch limits may be apportioned among fisheries as bycatch allowances.

Bycatch limits are effective measures to control bycatch amounts of specified species, but the potential costs to the affected industry through foregone harvest opportunity can be large. With the exception of the halibut bycatch mortality limits, the attainment of a fishery bycatch allowance triggers a time/area closure. The attainment of a fishery bycatch mortality allowance for halibut in the BSAI or Gulf of Alaska closes the entire BSAI or Gulf to that fishery.

Vessel Incentive Program

A vessel incentive program (VIP) was implemented in 1991 to reduce halibut and red king crab bycatch rates in the Bering Sea and Gulf of Alaska groundfish trawl fisheries. Under the VIP, halibut and red king crab bycatch standards are established semiannually.

Vessel operators and owners that exceed these standards based on observer data are subject to prosecution. Large enforcement and legal staff resources are required to develop and prosecute a VIP case. Appeal procedures may delay the final resolution of a potential violation for years. To date, three cases have been brought before an administrative law judge and were ruled in favor of the National Marine Fisheries Service. A fourth case was settled out of court.

The VIP has raised the consciousness of the industry relative to individual vessel bycatch rates, but whether the program has resulted in fleet-wide reductions in halibut or crab bycatch rates is difficult to assess. Frustration exists within the industry because Constitutional due process and other legal and enforcement constraints do not enable NMFS to take more timely action against individual vessels that exhibit chronically high bycatch rates, take a disproportionate amount of established bycatch limits, and to increase the rate at which fisheries are closed upon attainment of those limits.

Gear Restrictions

Pelagic Trawl Gear. Regulations specify a configuration for pelagic trawl gear to more effectively minimize the incidental take of halibut and crab, limit the number of crab that may be on board a vessel at any time, encourage vessel operators to fish pelagic trawl gear off the bottom when NMFS has closed fishing with nonpelagic trawl gear.

Mandatory Procedures for Careful Release of Halibut in the Hook-and-Line Gear Fisheries. Pacific halibut discard mortality rates in the Alaskan groundfish fisheries are

routinely estimated from viability data collected by at-sea observers. These data are analyzed by staff of the International Pacific Halibut Commission and NMFS, which result in recommendations to the North Pacific Fishery Management Council for managing halibut bycatch limits in the upcoming fishing year.

Current regulations require vessels using hook-and-line gear to release halibut in a manner that minimizes handling mortality. The intent of this measure is to reduce not only mortality rates but also reduce the amount of halibut required by these fisheries to harvest available amounts of groundfish under halibut bycatch restrictions.

Pot Gear. Regulations require that groundfish pot gear be fitted with halibut excluder devices and biodegradable escape panels.

Season Delays or Seasonal Apportionments of Total Allowable Catch

Fishing seasons for specified groundfish species are delayed to avoid high bycatch rates of halibut. Similarly, annual total allowable catch amounts and/or prohibited species bycatch allowances may be seasonally apportioned to minimize fishing operations when bycatch rates for prohibited species are high.

Allocation of Bering Sea Pacific Cod Among Gear Types

Regulations establish the allocation of Bering Sea/Aleutian Islands Pacific cod among vessels using trawl and fixed gear. Although this management provision is not solely based on bycatch considerations, it is thought to reduce halibut bycatch mortality in the cod fishery by allocating more of the total allowable catch to the fixed-gear fishery, which has a lower halibut bycatch mortality rate, and by allowing the fixed-gear fishery an increased opportunity to fish in ways that further reduce halibut bycatch mortality rates.

Regulations also authorize the seasonal apportionment of the amount of Pacific cod allocated to vessels using fixed gear. Their intent is to avoid significant harvests of Pacific cod during summer months, when halibut bycatch rates are highest.

Individual Fishing Quota Program

An individual fishing quota (IFQ) program for the Alaska sablefish and halibut fisheries was implemented in 1995. The program is expected to reduce halibut bycatch mortality in part by slowing the pace of the sablefish hook-and-line gear fisheries. Until a fisherman has used all of his halibut IFQ, legal-sized halibut taken in the sablefish fishery must be retained rather than discarded. The total catch of halibut is assumed to be more effectively monitored as a result. NMFS estimates that the total halibut discard mortality in the 1995 Alaska hook-and-line sablefish fishery was 148 mt, as compared to 615 mt in 1994 (NMFS, Alaska Region, unpublished data).

Voluntary Industry Initiatives to Reduce Prohibited-Species Bycatch

Several voluntary programs have been developed by trawl industry members to reduce halibut bycatch in the yellowfin sole and Pacific cod fisheries. Industry initiatives also resulted in the publication of analyses of historical observer data on fishery-specific bycatch rates of halibut and other prohibited species, and in rulemaking that authorizes the release of observer data on vessel bycatch or bycatch rates of prohibited species. This information is used by the industry to identify sensitive times and areas of prohibited-species bycatch and to provide an initial assessment of proposed management measures to address the halibut bycatch problem. More recently, participants in the Bering Sea flatfish fisheries have developed an in-season information system to reduce prohibited-species bycatch rates.

In 1993, the industry formed the Salmon Research Foundation to address the chinook salmon bycatch problem in the Bering Sea trawl fisheries. Vessels volunteering to participate in the foundation's program agreed to pay a $20 fee for each chinook salmon taken during trawl operations. Monies collected from the voluntary fee programs were intended to fund selected research projects designed to address the salmon bycatch problem. Subsequent action by the North Pacific Fishery Management Council and NMFS to establish salmon bycatch restrictions and associated time/area closures greatly diminished the industry's initiative to continue the voluntary fee-collection program and fulfill the intent of the foundation. Nonetheless, fees collected in 1993-94 were used by the foundation to fund extra observer coverage in 1995-96 to collect tissue samples necessary to enhance chum salmon stock identification research under way by NMFS. Reports have been submitted on the genetic stock identification for samples taken in 1994 and 1995.

Salmon Donation Program

At the urging of the industry and the North Pacific Fishery Management Council, together with the experience gained under an experimental donation program, NMFS has implemented a program authorizing the voluntary retention, processing, and donation of salmon incidentally taken in the groundfish fisheries to economically disadvantaged individuals through a NMFS-authorized distributor. Currently, a single authorized distributor, Northwest Food Strategies, successfully administers donations from almost 25 processors and numerous associated catcher vessels under the salmon donation program. The Council has adopted a similar donation program for Pacific halibut taken by trawl catcher vessels that deliver unsorted catch to shoreside processors.

Improved Retention and Utilization Program

The North Pacific Fishery Management Council has approved an improved retention and utilization program for the Alaska groundfish fisheries that would require 100% retention of pollock and Pacific cod caught in any groundfish fishery. Specified flatfish species-retention requirements would follow, but would be delayed for a period of five years to allow for development of markets and gear technology necessary for vessels to effectively comply with the requirements. The Council adopted a minimum utilization rate of 15% for pollock and Pacific

cod. NMFS is proceeding with rulemaking that, if approved by the Secretary of Commerce, would implement the Council's action by 1998.

Seabird Avoidance Program

Federal regulations require operators of vessels fishing for Alaska groundfish with hook-and-line gear to conduct fishing operations in a specified manner and to employ specified seabird-avoidance. Similar measures have been adopted by the North Pacific Fishery Management Council for the Pacific halibut hook-and-line gear fishery.

Regional Research Initiatives

Gear research to reduce bycatch in the Alaska fisheries has focused on changes in gear technology and fishing methods to improve gear selectivity. Some individual vessel operators and fishing companies experiment with equipment designed to avoid or reduce bycatch of nontarget species. The competitive nature of the open-access groundfish fisheries, however, generally is not conducive to voluntary adjustments in fishing gear to reduce bycatch, especially if changes necessary to achieve lower bycatch also result in lower catch rates of target species.

The Alaska Fisheries Development Foundation initiated a project supported by Saltonstall-Kennedy program funding to assess the effectiveness of experimental separator panels in trawl nets to reduce the bycatch of Pacific halibut in the Pacific cod fishery (Stone and Bublitz 1996). Although preliminary results were promising, the competitive nature of this open-access fishery reduces the incentive of individual fishermen to improve the selectivity of their fishing gear. Fishermen who experiment with new devices to reduce bycatch risk incurring operational costs and losing valuable fishing time, while other competing vessels continue to use nonselective nets.

Other research has been conducted on the behavior of fish encountering commercial trawl gear in the North Pacific (Rose 1996). Species-specific differences in fish behavior have been observed using underwater video cameras, some of which have applications for improving trawl selectivity. The information provided by video observations allows iterative development and testing of gear modifications and fishing techniques to find effective ways to reduce bycatch. An independent trawl vessel association recently was issued an experimental fishing permit by NMFS to expand upon this research to reduce the bycatch of groundfish (primarily pollock and Pacific cod) in flatfish fisheries off Alaska.

Industry members, as well as the NPFMC, have considered limiting the harvest of Alaska pollock to mid-water trawl operations to reduce halibut and crab bycatch. However, the open-access nature of the groundfish fishery again frustrates this approach by aggravating the trade-off between the gains associated with a reduction in bycatch and the increased allocation and operation costs that would ensue from restrictions on the use of nonpelagic trawl gear in the pollock fishery (Pereyra 1996).

A great deal of attention has been focused on the use of trawl mesh restrictions to reduce the catch of undersized fish in the Alaska groundfish trawl fisheries. Bublitz (1996) conducted research to provide a predictive capability to assess mesh-selectivity needs in the Alaska pollock fishery. Other researchers (Pikitch et al. 1996) pose a cautionary note on the effectiveness of trawl mesh restrictions, particularly in high-volume fisheries, where escape rates decrease as catch volume increases, regardless of mesh size or configuration. The deleterious result of "blocking" of codend meshes may be reduced or eliminated by using sorting devices that permit the escape of undersized fish before they reach the codend.

Other researchers have proposed an alternative type of codend with very small mesh size to reduce relative water velocity and enhance the ability of fish to escape through various bycatch reduction devices (Loverich 1996). The concept of codends made of very small mesh size or even impermeable material runs contrary to traditional thinking on codend selectivity and escapement associated with codends made of large-sized mesh.

Efforts also have been expanded to research ways to reduce bycatch in the crab fisheries or to reduce the unobserved mortality of crab associated with ghost fishing of "derelict" pots. The Alaska Department of Fish and Game has implemented minimum mesh size restrictions to encourage the escape of female and undersized male crabs, as well as mandatory use of cotton thread sewn into the bottom of all crab pots to minimize ghost fishing in lost pots. King crab excluder devices also are required to reduce tunnel height openings in the Tanner crab fisheries. Research is ongoing to address factors affecting crab entry into pots, improving the ability of small crabs to escape, reducing discard mortality due to damage while sorting unwanted catch, and reducing mortality associated with ghost fishing of lost pots (Stevens 1996, Wyman 1996).

With the exception of regulatory gear restrictions to reduce bycatch that may be applied fleetwide, little incentive exists for individual fishermen to voluntarily take action to change fishing gear or practices to reduce bycatch. As stated by Stone and Bublitz (1996), "Unless there becomes an economic advantage to fish cleanly, such as in the case of individual bycatch accountability, there is not likely to be any large-scale trend toward the use of improved fishing methods."

Regional Recommendations

Monitoring total catch, including discards, and decreasing bycatch mortality in the Alaska groundfish fisheries have been priorities of the North Pacific Fishery Management Council since it was established in 1976. An extensive at-sea observer program and a comprehensive catch reporting program generally are thought to provide adequate estimates of total catch by species for the groundfish fishery as a whole. However, the array of management measures that has been used in whole or in part to decrease or limit bycatch has not yet minimized bycatch to the extent practicable.

A more difficult task will be to assess the effectiveness of various bycatch reduction measures that have been implemented. The domestic Alaska groundfish fisheries are relatively new and dynamic. The evolving nature of these multispecies fisheries, together with the matrix

of different management programs governing them that may affect the spatial or temporal distribution of fishing effort and associated bycatch rates, creates a situation where impacts of specific management measures on bycatch rates may be cumulative and difficult to assess individually. An assessment of overall progress toward reducing bycatch can be attained through observer data on catch composition and discard.

The difficulty in adequately addressing the bycatch problem has resulted in an increasing awareness of the necessity for better information on which to base bycatch decisions by fishermen, fishery managers, and the public. This input requires better understanding of (1) the levels of bycatch; (2) the fishing practices and techniques that can decrease bycatch mortality; and (3) the population, ecosystem, social, and economic effects of bycatch and of bycatch management measures. In addition, improved decisions require increased efforts to ensure that fishermen, fishery managers, and the public more fully consider the impacts of their bycatch decisions. Following are specific recommendations for Alaska fisheries:

- Develop stable long-term funding for North Pacific groundfish observer programs. Funding is currently totally contingent on "pass-through" funding from several sources.

- Develop appropriate contractual arrangements for observer services that would reduce the potential for conflicts of interest, encourage the best observers to remain with the program, and improve operational control of the program by NMFS.

- Improve data collection and catch estimation procedures. A review of observer coverage levels as well as observer data collection methods and associated catch estimation procedures should be initiated to ensure that observer programs meet expectations of scientists, managers, and the industry cost-effectively.

- Improve the information concerning the population, ecosystem, social, and economic effects of bycatch and of bycatch management measures.

- Require that proposed bycatch management actions include clear statements of objectives and performance criteria.

- Develop models to assess the probable fleet response to alternative bycatch management measures.

- Support the establishment of international guidelines for managing bycatch.

- Increase involvement of the industry and academic communities in analyzing factors that affect bycatch rates by improving access to observer and oceanographic data.

- Conduct research on the survivability (acute and chronic mortality) and recovery of bycatch species from stresses imposed by capture.

- Increase industry's involvement in the development and testing of methods to reduce bycatch mortality.

- Improve technology transfer of bycatch reduction methods through reports, videos, and workshops.

- Establish a process for NMFS and the fishing industry to examine the bycatch incentives faced by fishermen and the degree to which bycatch is a consequence of current incentives and regulations. Identify regulatory changes that could be pursued to reduce regulatory discards.

- Improve individual accountability by developing programs that improve incentives to fishermen to consider the full costs and benefits of their bycatch decisions and that allow fishermen to use the most cost-effective methods for reducing bycatch.

- Conduct legal research to explore ways to overcome potential impediments to individual incentive programs and decrease the monitoring and enforcement costs of bycatch management programs that can provide catch and bycatch accountability for individual fishing operations.

- Develop improved estimates of catch and release mortalities, especially for chinook salmon, in both commercial and recreational fisheries.

- Increase knowledge of the type and magnitude of marine mammal bycatch, including ghost fishing by lost nets, in the salmon drift net and Southeast Alaska purse seine salmon fisheries.

Resource Material

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Glossary

Allowable biological catch (ABC)—The maximum allowable catch for a species or species group for a particular fishing year. It is set each year by a scientific group created by the management agency. It is developed by reducing the maximum optimum yield as necessary, based on stock assessments. The agency then takes the ABC estimate and sets the annual total allowable catch.

Bycatch reduction device (BRD)—Any of a number of implements that have been certified to reduce the likelihood of capturing nontarget species.

Catch per unit effort (CPUE)—The amount of fish that is caught by a given amount of effort. Typically, effort is a combination of gear type, gear size, and length of time gear is used.

Category I, II, and III fisheries—Categories of commercial fisheries under the Marine Mammal Protection Act:

Category I—A commercial fishery with frequent incidental mortality and serious injuries of marine mammals. A Category I fishery is by itself responsible for the annual removal of 50% or more of any stock's potential biological removals (PBRs).

Category II—A commercial fishery with occasional incidental mortality and serious injury of marine mammals. Collectively with other fisheries, a Category II fishery is responsible for the annual removal of more than 10% of any marine mammal stock's PBR. By itself is responsible for the annual removal of between 1% and 50%, exclusive of any stock's PBR.

Category III—A commercial fishery that has a remote likelihood of, or no known, incidental mortality and serious injury of marine mammals. Collectively with other fisheries, a Category III fishery is responsible for the annual removal of 10% or less of any marine mammal stock's PBR, or more than 10% of any marine mammal stock's PBR. By itself it is responsible for the annual removal of 1% or less of that stock's PBR.

Conservation engineering—The practice of determining the modification in gear design that will meet conservation objectives, such as decreasing bycatch and bycatch mortality by increasing the selectivity of gear and increasing the survival of fish and other living marine resources that fishing gear encounters inadvertently.

Demersal—Fish and animals that live near the bottom of an ocean.

Derby fishery—Generally, a fishery operated under conditions where each vessel has an incentive to catch the greatest number of fish in the least amount of time.

Endangered species—A species is considered "endangered" if it is in danger of extinction throughout a significant portion of its range; it is considered "threatened" if it is likely to become an endangered species.

Ex-vessel value— The amount paid to a vessel's owner or operator for its catch, excluding any value added by at-sea processing.

Exclusive economic zone (EEZ)—The zone contiguous to the territorial sea of the United States, the inner boundary of which is a line coterminous with the seaward boundary of each of the coastal states and the outer boundary of which is a line drawn in such a manner that each point on it is 200 nautical miles from the baseline from which the territorial sea is measured.

Fishery management plan—A plan developed by a regional fishery management council, or the Secretary of Commerce under certain circumstances, to manage a fishery resource in the U.S. EEZ pursuant to the Magnuson-Stevens Fishery Conservation and Management Act. It includes data, analyses, and management measures for a fishery.

Ghost fishing—The capture of fish or other living marine resources by lost or discarded fishing gear.

Groundfish—A species of fish, usually finfish, that lives on or near the sea bottom part of the time.

Haulback—The period in fishing operations during which the gear is hauled from the water back onto the fishing vessel.

Individual fishing quota (IFQ)—A federal permit under a limited-access system to harvest a quantity of fish, expressed by a unit or units representing a percentage of the total allowable catch of a fishery that may be received or held for exclusive use by a person.

Level of utilization—A comparison of existing fishing effort with that required to achieve long-term potential yield (LTPY).

Over-utilized—Fishing effort is in excess of that needed to achieve long-term potential yield.

Fully-utilized—Fishing effort is at a level that will support the achievement of long-term potential yield.

Under-utilized—Fishing effort is below the level at which long-term potential yield will be achieved.

Limited entry—A program that restricts the persons or vessels that can participate in a fishery. License limitation and individual fishing quota programs are two examples of limited entry.

Long-term potential yield—The maximum long-term average catch that can be achieved from the resource.

MARFIN (Marine Fisheries Initiative)—A program that brings together scientific, technical, industry, resource conservation, and management talents to conduct cooperative programs to facilitate and enhance the management of the marine fishery resources of the Gulf of Mexico and South Atlantic.

Maximum sustainable yield—The largest average catch that can be taken from a stock under existing environmental conditions.

Metric ton—2204.6 pounds

National standards—A set of 10 conservation and management standards included in the Magnuson-Stevens Fishery Conservation and Management Act. Each fishery management plan must be consistent with all 10 national standards. National Standard 9 requires that conservation and management measures shall, to the extent practicable (1) minimize bycatch and (2) to the extent that bycatch cannot be avoided, minimize the mortality of such bycatch.

Open-access fishery—A fishery in which any one can participate at any time.

Optimum yield (OY)—The amount of fish that (1) will provide the greatest overall benefit to the United States, with particular reference to food production and recreational opportunities; and (2) that is prescribed as such on the basis of maximum sustainable yield from such fishery as modified by any relevant ecosystem or social and economic factors.

Pelagic species—Fish and animals that live in the open sea.

Potential biological removal (PBR)—The maximum number of animals, not including natural mortalities, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population. The PBR level is the product of the following factors: (1) the minimum population estimate of the stock, (2) one-half the maximum theoretical or estimated net productivity rate of the stock at a small population size, and (3) a recovery factor of between 0.1 and 1.0.

Protected species—Living marine resources protected under the Marine Mammal Act, Endangered Species Act, or Migratory Bird Treaty Act.

Quota—The maximum amount of fish that can be legally landed in a time period. It can apply to the entire fishery, to an individual fisherman's share under an individual fishing quota (IFQ) system, or to the size of fish.

Recreational fishery—Harvesting fish for personal use, fun, and challenge.

Round (live) weight—The weight of fish, shellfish, or other aquatic plants and animals as taken from the water; the complete or full weight as caught.

Saltonstall-Kennedy (S-K) grant program—A competitive program that provides funds through grants or cooperative agreements for research and development projects to benefit the U.S. fishing industry. The S-K Act, as amended [15 U.S.C. 713 (c) (3)] is the program's statutory authority.

Stakeholder—One who is expected to receive economic or social benefits from the conservation and management of living marine resources.

Stock assessment—The biological assessment of the status of the resources. This analysis provides the official estimates of stock size, spawning stock size, fishing mortalities, recruitment, and other parameters.

Strategic stocks—Marine mammal stocks that have a level of human-caused mortality likely to reduce or keep the stock below its optimum sustainable population (e.g., short-finned pilot whale, Baird's beaked whale, mesoplodont beaked whales, Cuvier's beaked whales, pygmy sperm whale, sperm whale, and humpback whale).

Take-reduction plan—Plans to assist in the recovery or prevent the depletion of strategic marine mammal stocks by outlining strategies for reducing the number of marine mammals incidentally taken in the course of commercial fishing operations.

Take-reduction teams—Established by the 1994 amendments to the Marine Mammal Protection Act, these teams are made up of individuals who represent the span of interests affected by the strategies to reduce marine mammal takes, including commercial and recreational fishing industries, fishery management councils, interstate commissions, academic and scientific organizations, environmental groups, Native Alaskans or other Native American interests if appropriate, and NMFS representatives.

Threatened species—A species is considered "threatened" if it is likely to become an endangered species; it is considered "endangered" if it is in danger of extinction throughout a significant portion of its range.

Turtle excluder device (TED)—An implement that has been certified to reduce the likelihood of capturing turtles.

Appendices

Bycatch Matrix

The National Marine Fisheries Service Bycatch Team, consisting of representatives from the five science centers/regions and headquarters, conducted a survey of available information on bycatch and discards in the nation's fisheries, and efforts to understand and manage the issue. Throughout the assessment analyses were conducted only on the discard component of bycatch; information on the unobserved mortality component of bycatch is not quantified in most fisheries. It is intended that this type of assessment will be updated regularly as new information on bycatch becomes available and as data collection programs are expanded to include other sources of bycatch mortality.

The survey is intended to represent the latest (1996) information available for each fishery, defined by gear type and target species or species group. Estimates of discards are presented, where available, as well as landings levels in each fishery, and associated descriptive data. In many cases, assessments of variables described below are based upon subjective judgments by knowledgeable regional representatives of the National Marine Fisheries Service. The intent of this survey is to update information previously compiled elsewhere, and to serve as a benchmark from which to judge future efforts in data collection and management efforts to mitigate negative effects of bycatch. Regional matrices consisting of 28 variables assessed for each defined fishery are presented in this appendix for six regions: Northeast (Maine-North Carolina), Atlantic Highly Migratory Pelagic Species (large pelagic species); Southeast (North Carolina-Texas, and Caribbean); Western Pacific and Pelagics (Western Pacific); Pacific Coastal (Washington-California); and Alaska.

Major Categories for Fisheries Groups

Eleven major categories were addressed for each fishery group. Generally, within regions fisheries were grouped after the groupings in NMFS' Our Living Oceans (NMFS 1996a). Within these major groupings, fisheries were broken down by gear type. Target species and discard species, and the fishery management plans that manage them, are identified. Additionally, the matrix identifies each fishery's categorization under the Marine Mammal Protection Act. The volume of fish captured (metric tons), the value of the fishery (millions of dollars), and the number of vessels or permit holders are identified where available for target and discard species. The status of the stock is described by two factors—the stock's level of utilization and the stock's status relative to its long-term potential yield. These evaluations were based upon the 1995 Our Living Oceans publication (NMFS 1996a). Significance of the discards is a qualitative identification of the nature of the concern about bycatch (population, ecosystem, socio-economic) and the level of significance or seriousness of that concern. The matrix also identifies reasons for discards (regulatory, discretionary or prohibited species).

Matrix category	Information contained in category
OLO Fishery	Fishery category as identified in Our Living Oceans (NMFS 1996a)
MMPA Cat.	Fishery category under the Marine Mammal Protection Act
Gear	Primary gear used to capture target species
Retained species	Fish retained in the fishery
Discarded species	Fish discarded in the fishery
FMP (or other)	The management plan that applies to the retained and discarded species
Volume	The volume, in metric tons, of fish captured (retained and discard species) in a fishery. Figures are for 1995 except where noted.
Value	The ex-vessel value of the fishery
# Vessels	The number of vessels or permit holders in the fishery
Utilization	The level of utilization of the fishery resource [based upon Our Living Oceans (NMFS 1996a)]
Stock Size	The size of the stock relative to its long-term potential yield [based upon Our Living Oceans (NMFS 1996a)]
Level of Concern	The level of concern about the particular bycatch problems of that fishery
Nature of Concern	The nature of concern about bycatch in that fishery [population (p), socio-economic ($), or ecosystem (e)]
Reasons for Discards	The reasons that fish are discarded in that fishery [regulatory (REG); discretionary/economic/personal considerations (DIS); or prohibited species (PS)]

Seven Steps to Addressing Discards

Based upon the quantitative and qualitative information gathered in the first 11 major categories, each fishery was evaluated under "seven steps to addressing discards." The steps focus on determining the status of information on the amount and type of discards (Step 1); assessing the current state of knowledge about the population, ecosystem and socio-economic impacts of discards (Step 2); evaluating the effectiveness of current bycatch management measures (Step 3); identifying how extensively alternative management measures have been considered (Step 4); determining whether the population, ecosystem or socio-economic effects of those management measures have been identified (Step 5); determining whether alternative management measures have been implemented (Step 6); and assessing the capacity of the fishery to monitor the effectiveness of new bycatch management programs (Step 7). The criteria that determined each score in the seven steps are as follows.

Step 1: Information on Magnitude of Discards.

The quality of discard information was evaluated for each fishery using a 4-point scale where 0 = no information available; 1 = unverified harvester or incidental observer reports; 2 = isolated snapshots from observer programs, 3 = estimates of discards possible with limitations on precision and accuracy; and 4 = estimates available with adequate precision and accuracy.

Step 2: Impact Analyses of Discards.

The current status of impact analyses of discards was evaluated for populations, socio-economic considerations and ecosystems. Available impact analyses were scored as 0 = no evaluation made; 1 = qualitative information about impacts; 2 = some quantitative information mixed with qualitative information; 3 = quantitative information with limitations on precision and accuracy; and 4 = information on impacts with adequate precision and accuracy.

Step 3: Effectiveness of Current Measures.

This step evaluated the adequacy of current measures by 0 = current measures inadequate, identification of alternative management measures needed; x = no discard problem exists; and * = existing measures adequate to manage the fishery.

Step 4: Identification of Potential Alternatives.

Progress in identification of bycatch management alternatives was evaluated as 0 = no alternatives have been identified; 1 = factors affecting discard rates and mortality have been identified; 2 = input of constituency groups solicited; 3 = management measures have been identified; and 4 = practicality of proposed alternatives has been assessed in terms of industry acceptability and council policy.

Step 5: Evaluation of Impacts of Bycatch Mitigation Alternatives.

Impact analyses for mitigation alternatives were scored as 0 = no evaluation made; 1 = qualitative information about impacts; 2 = some quantitative information mixed with

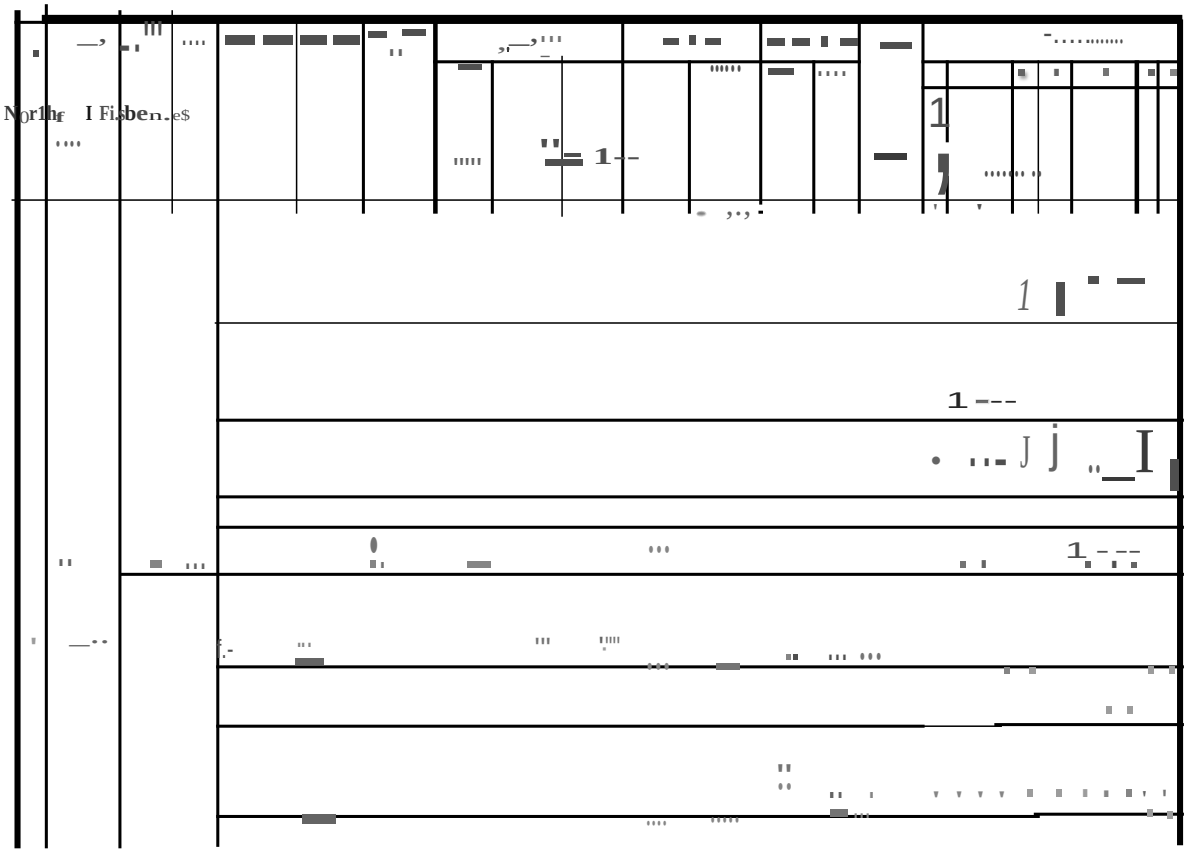
qualitative information; 3 = quantitative information with limitations on precision and accuracy; and 4 = information on impacts with adequate precision and accuracy.

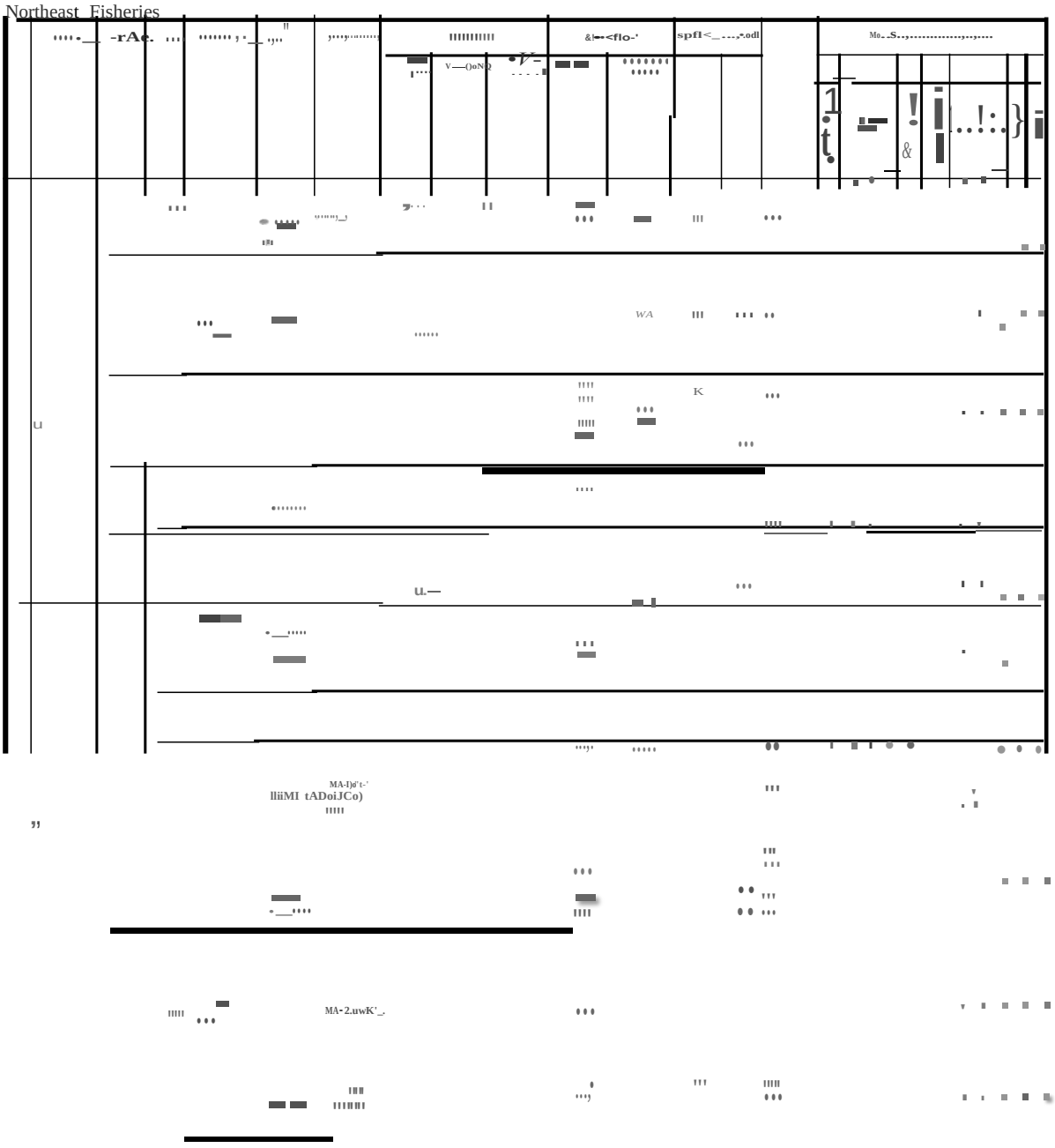
Step 6: Implementation of Alternative Management Measures.

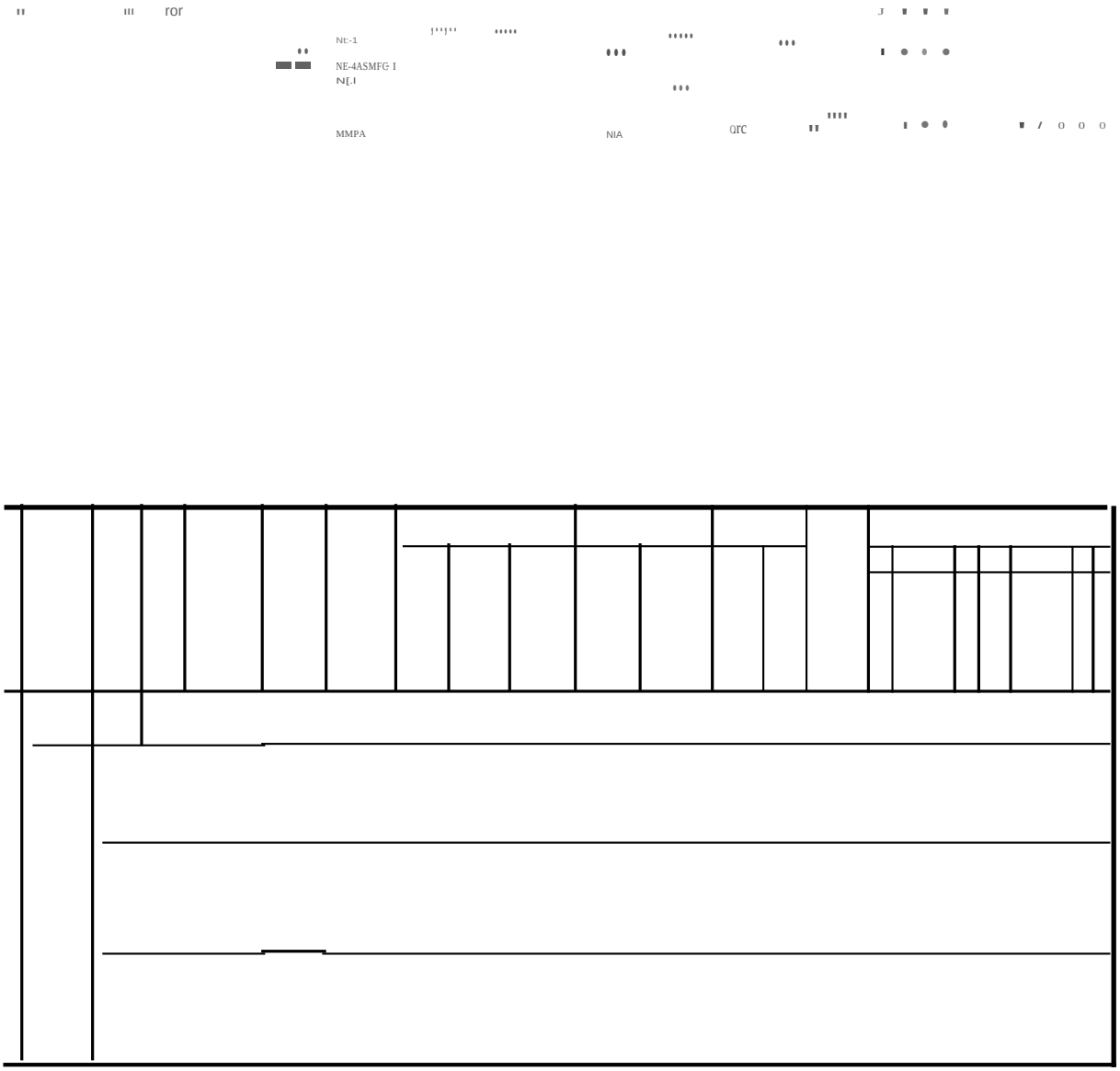
The implementation of alternative measures was quantified by 0 = none of the following; 1 = is there a fishery management plan or regulatory amendment for discard regulation?; 2 = is there a technology transfer program (if applicable)?; 3 = is there a discard reduction incentive program (if applicable)?; 4 = is enforcement ready to go?; and 5 = is a monitoring system ready to go?

Step 7: The Adequacy of Monitoring Programs.

The adequacy of monitoring programs for evaluating the effectiveness of selected and implemented management efforts was described by 0 = no capacity to monitor and evaluate effectiveness of implemented measures; 1 = demonstrated commitment to program; 2 = adequate pre- and postmitigation monitoring; 3 = monitoring sufficiently accurate and precise to quantify effects of mitigation measures; and 4 = effective communication program to ensure user-group buy-in to program.



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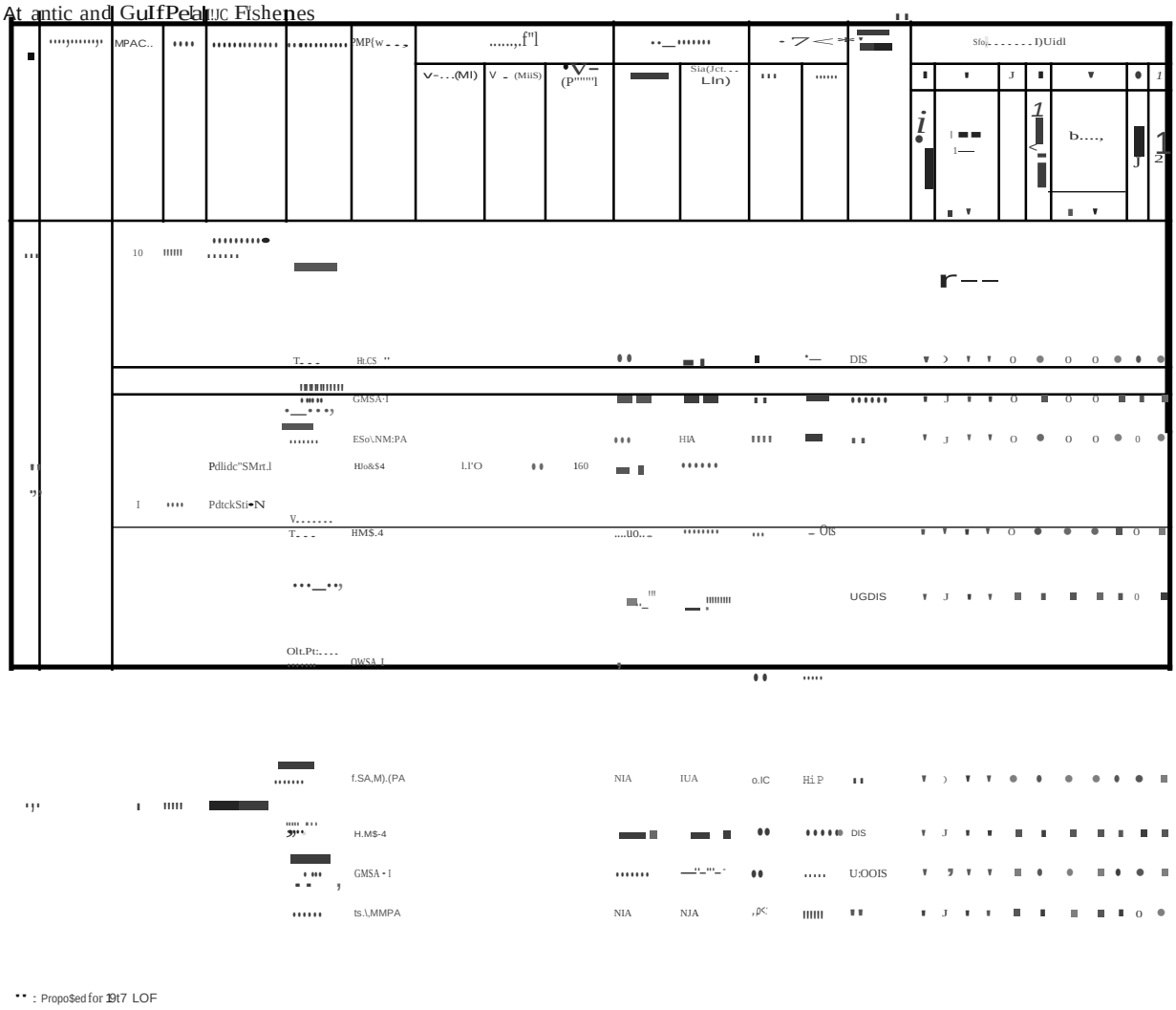

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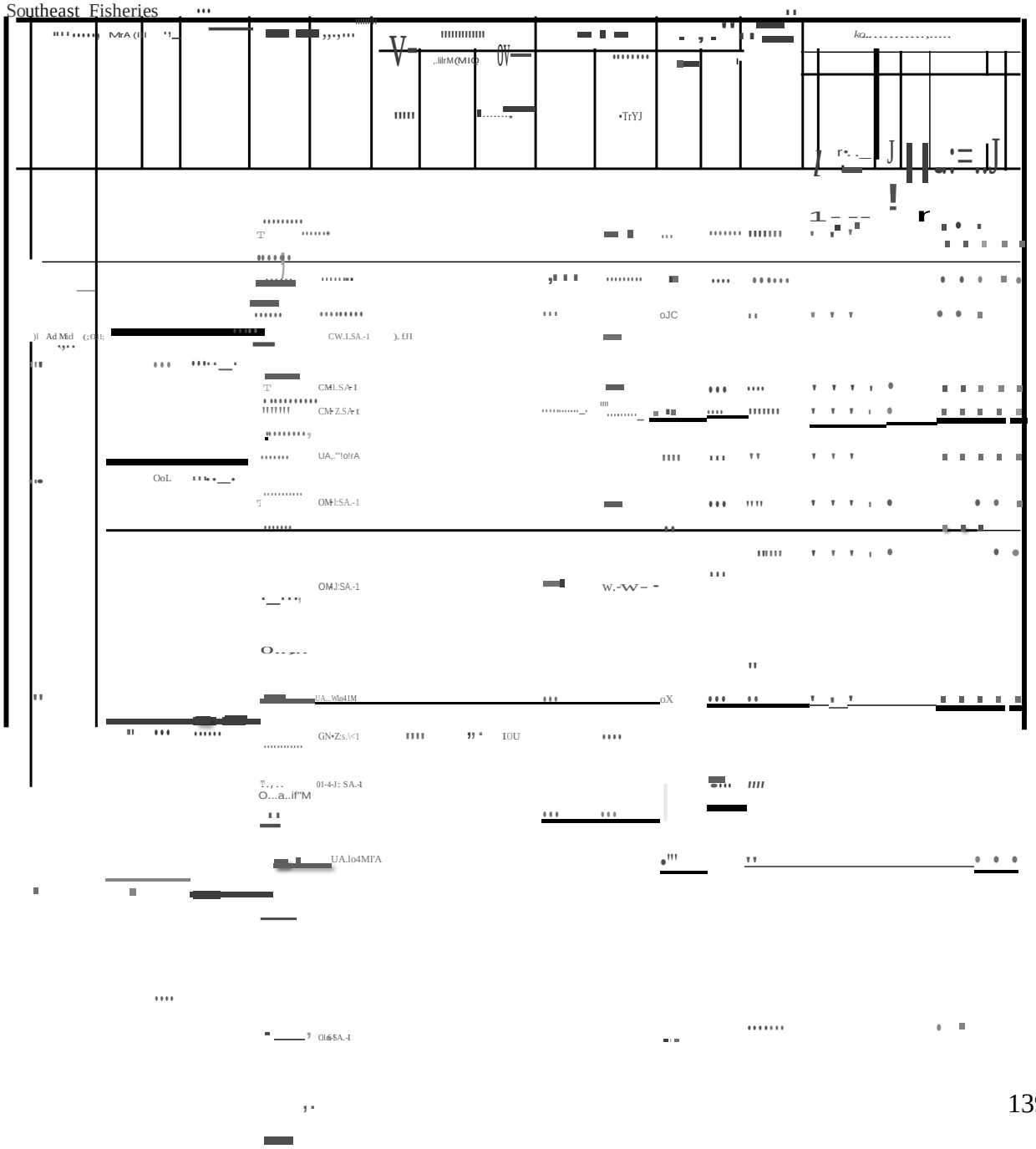
OLO Fishery	MMPA Cat.	Gear	Retained Species	Bycatch Species	FMP (or other)	Fishery ('95)			Status of Stock		Significance of Bycatch			Seven Steps to Addressing Bycatch
						Volume (MT)	Value (M$)	# Vessels (Permits)	Utilization	Size (rel. to LTPY)	Nature	Level		
					GMSA-1									
				Undersized Target	GMSA-1									
										N/A	a.PC			
					GMSA-1		1.7	900	full					
				Undersized Target	GMSA-1									
III	PGN	Gulf King Mackerel			GMSA-1									
				Undersized										
										N/A	a.PC			
					GMSA-1		1.2	1.136	full					
				Undersized Target	GMSA-1									
				Other Pelagic Species	GMSA-1					near/below	$a			
				Endangered / Protected Species	ESA, MMPA				N/A	N/A	a.PC			
III	PGN	Other Pelagic					3.2	1.136	unknown					



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						Fishery (*95)							Seven Steps to Addressing Bycatch
						Volume (MT)	Value (Mil $)	# Vessels (Permits)					
				ftolcla	DA..MWA								
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									below/unknown	Sp			
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				Sjorocioo									
III	OHL	Red Groupers		Undersized Target...	GM-2; SA-1								
				Other Reef Fish Species	GM-2; SA-1								
				Small Tropicjl					below/unknown	Sp			
					CM>LMol								
III	POT	Red Groupers											
				T.	cw.t..SA-1								
	al	IO											
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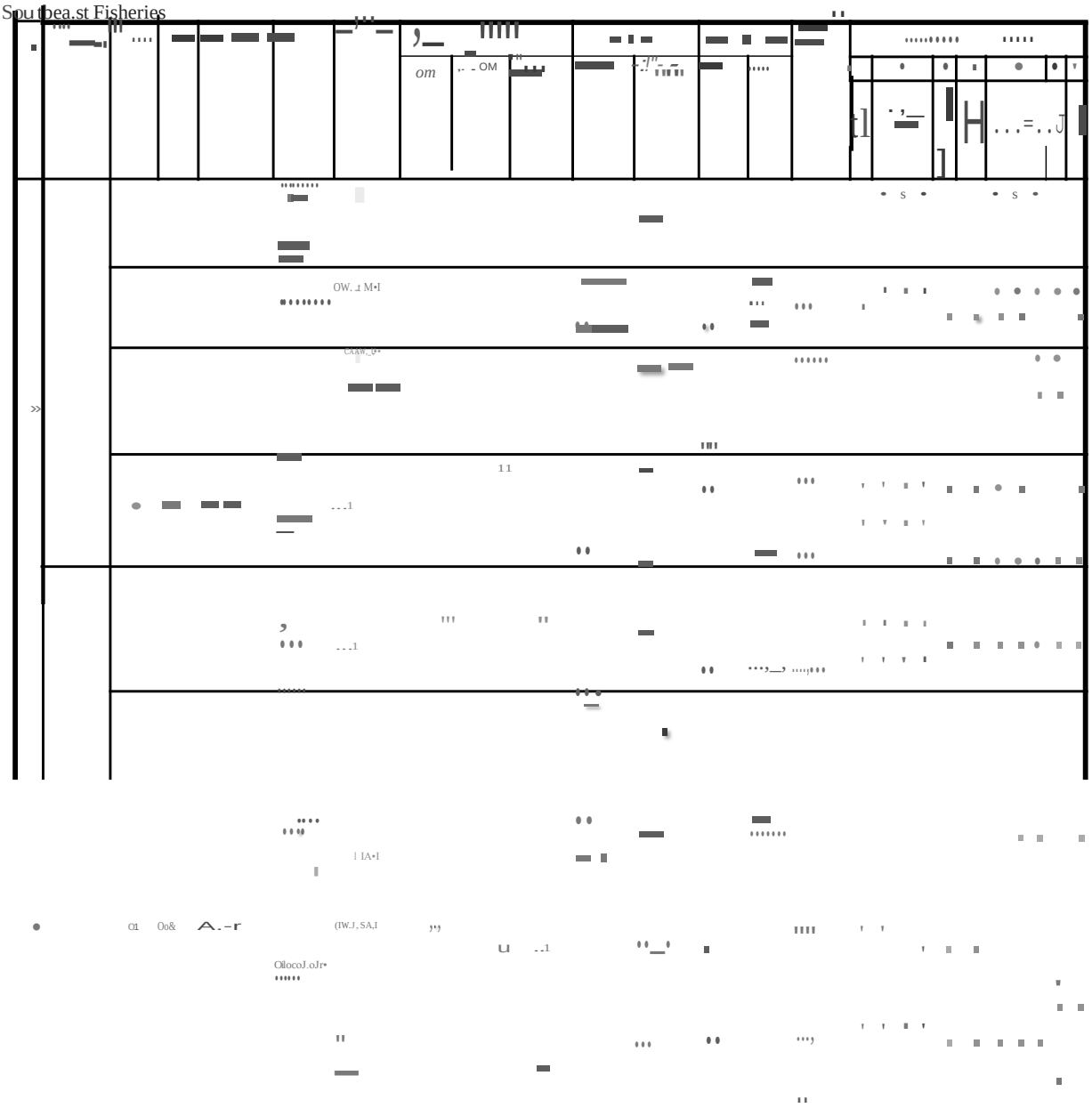
III	POT	Other Grouper Species											



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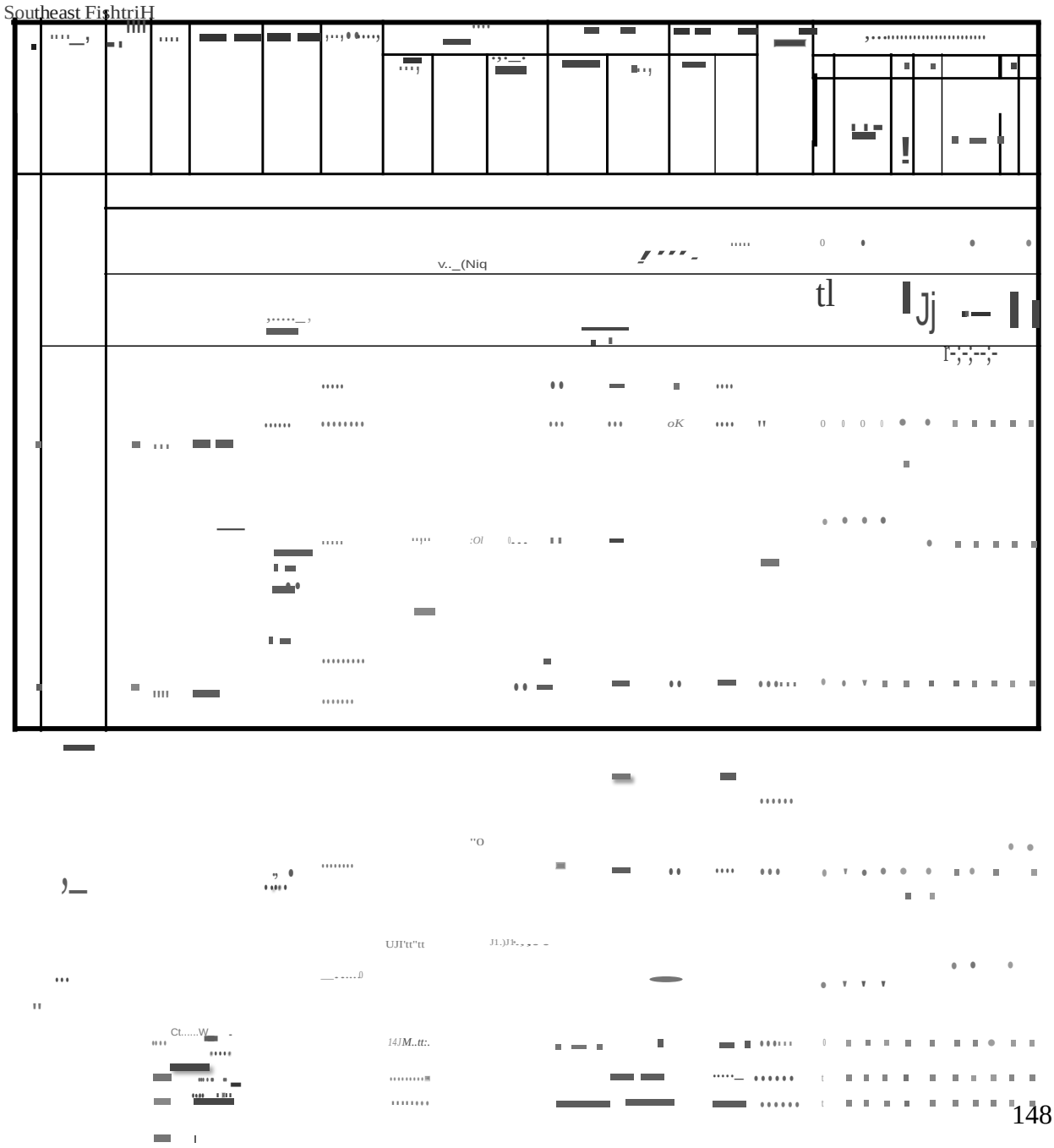
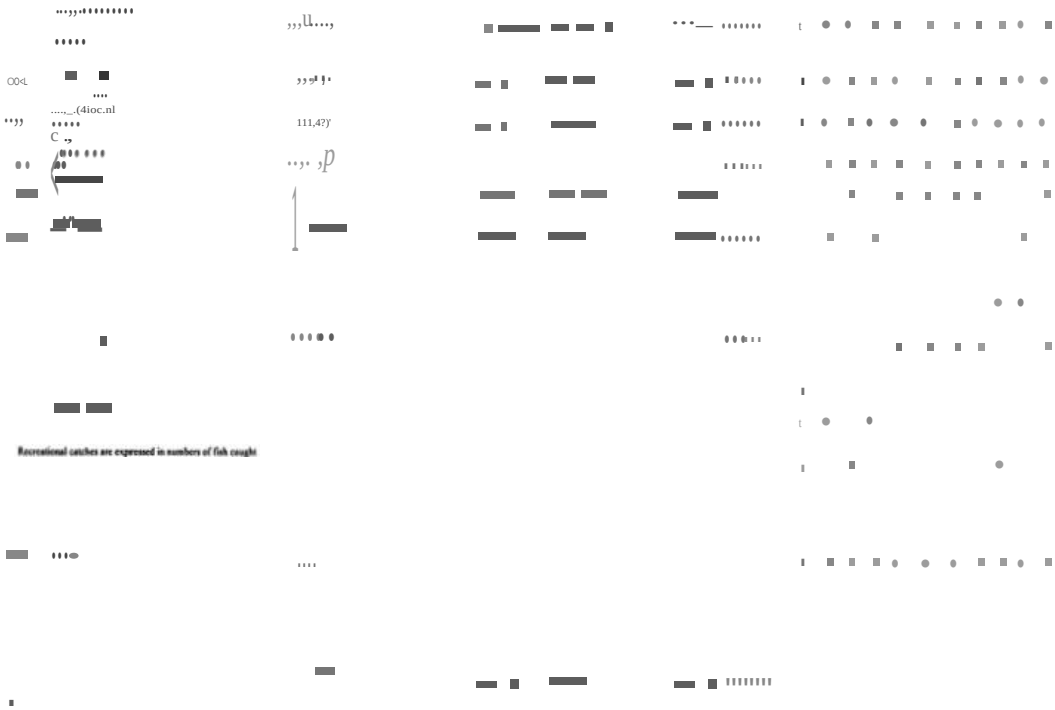
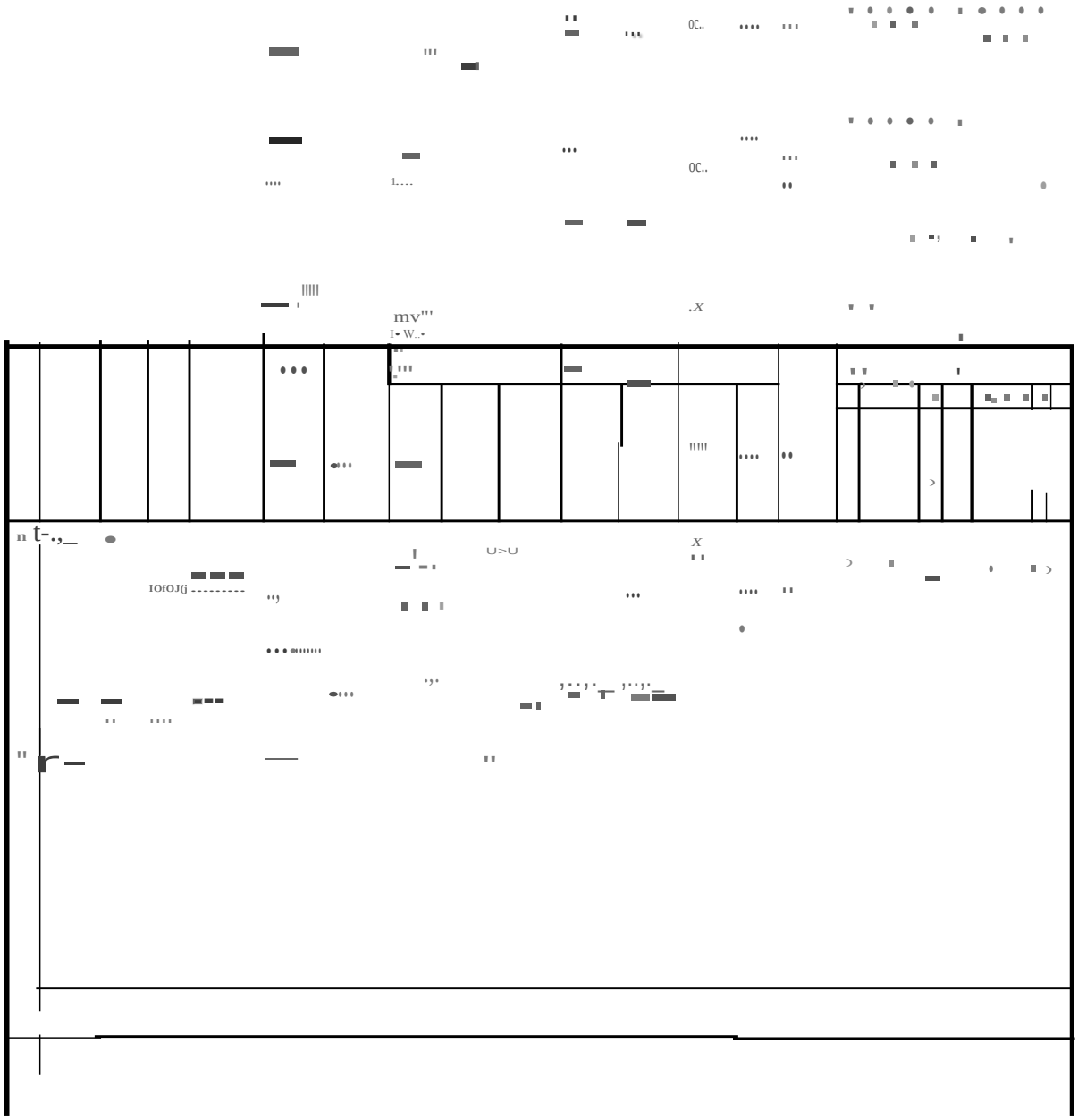
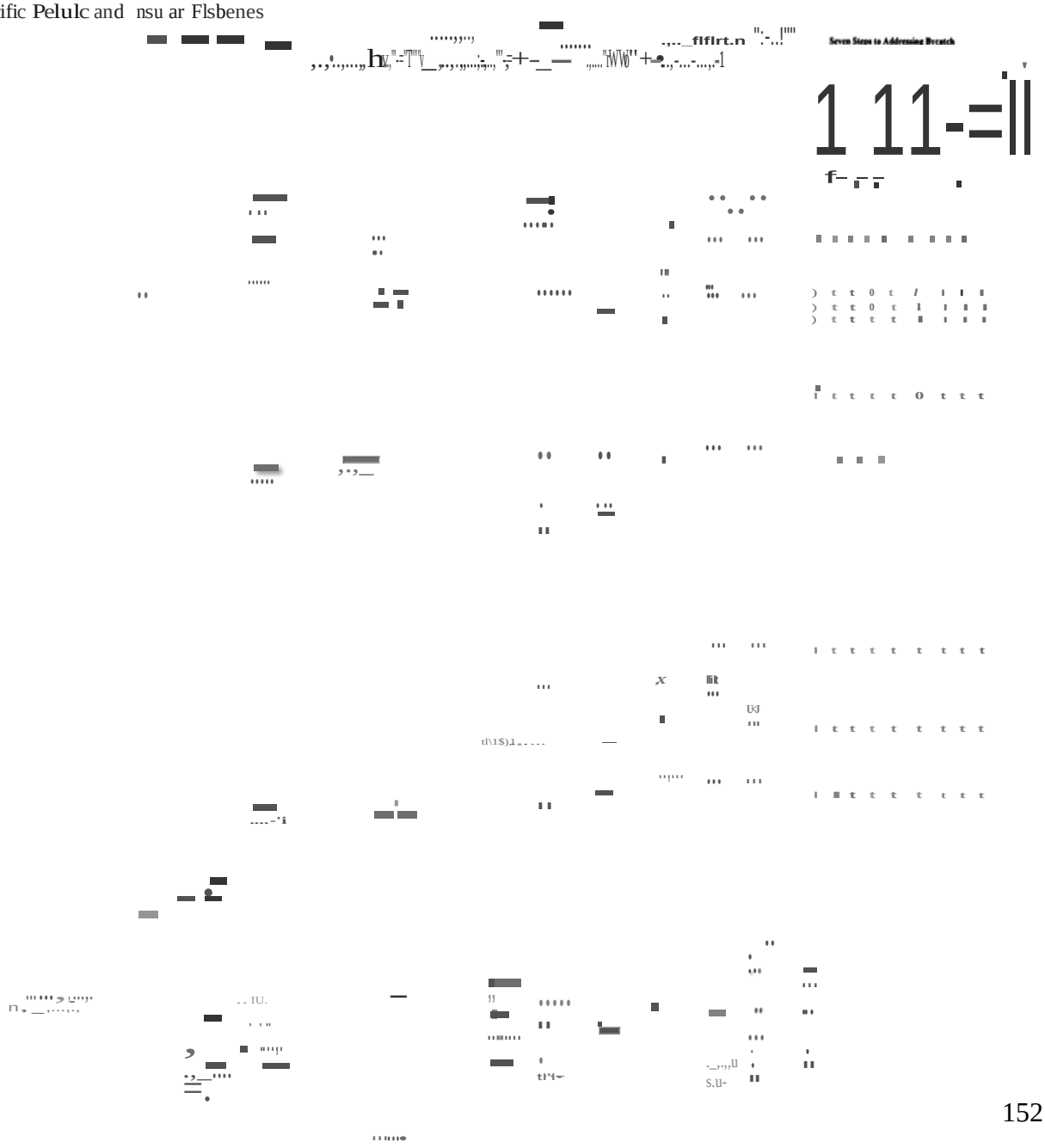
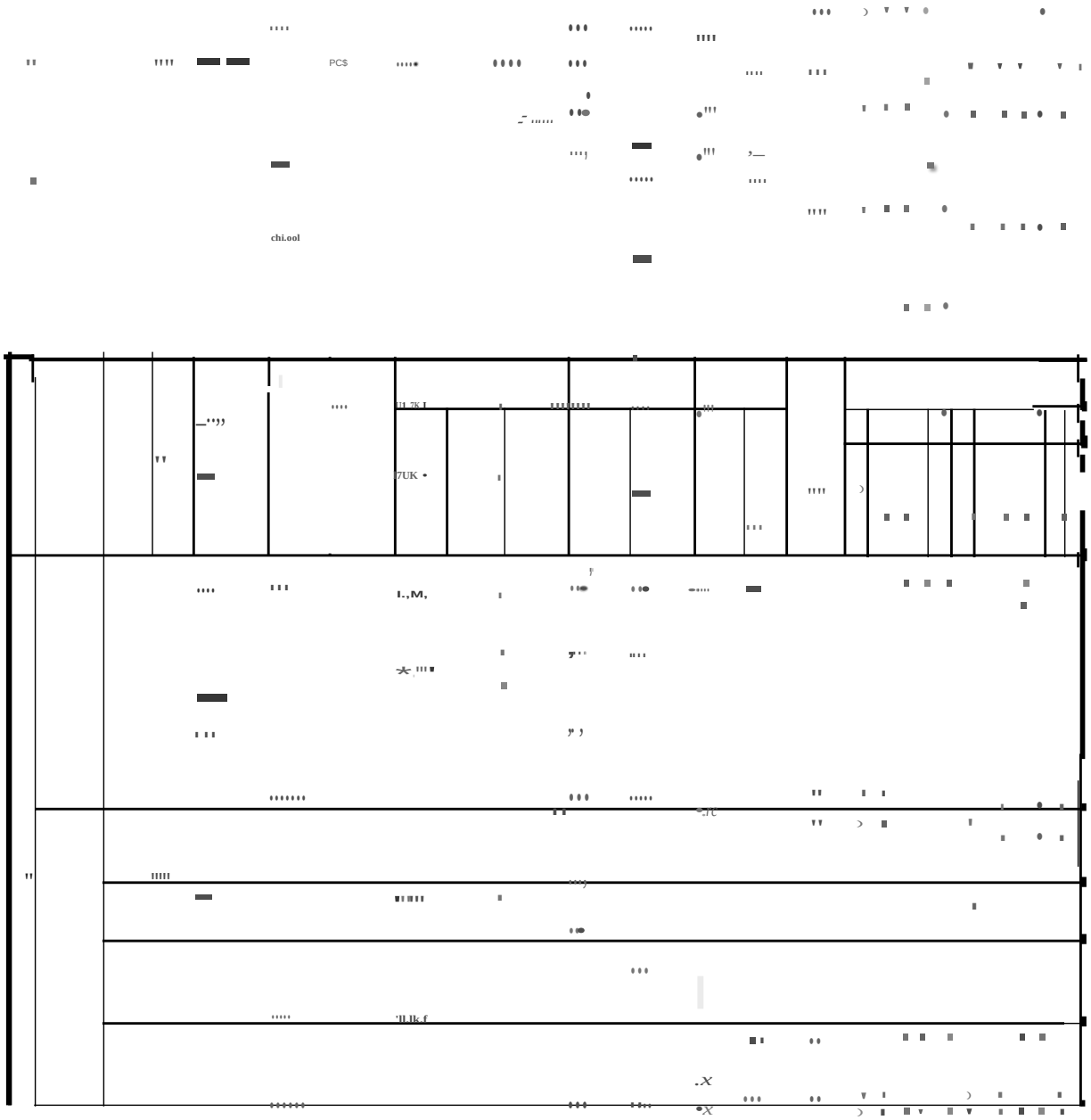



Recreational catches are expressed in numbers of fish caught



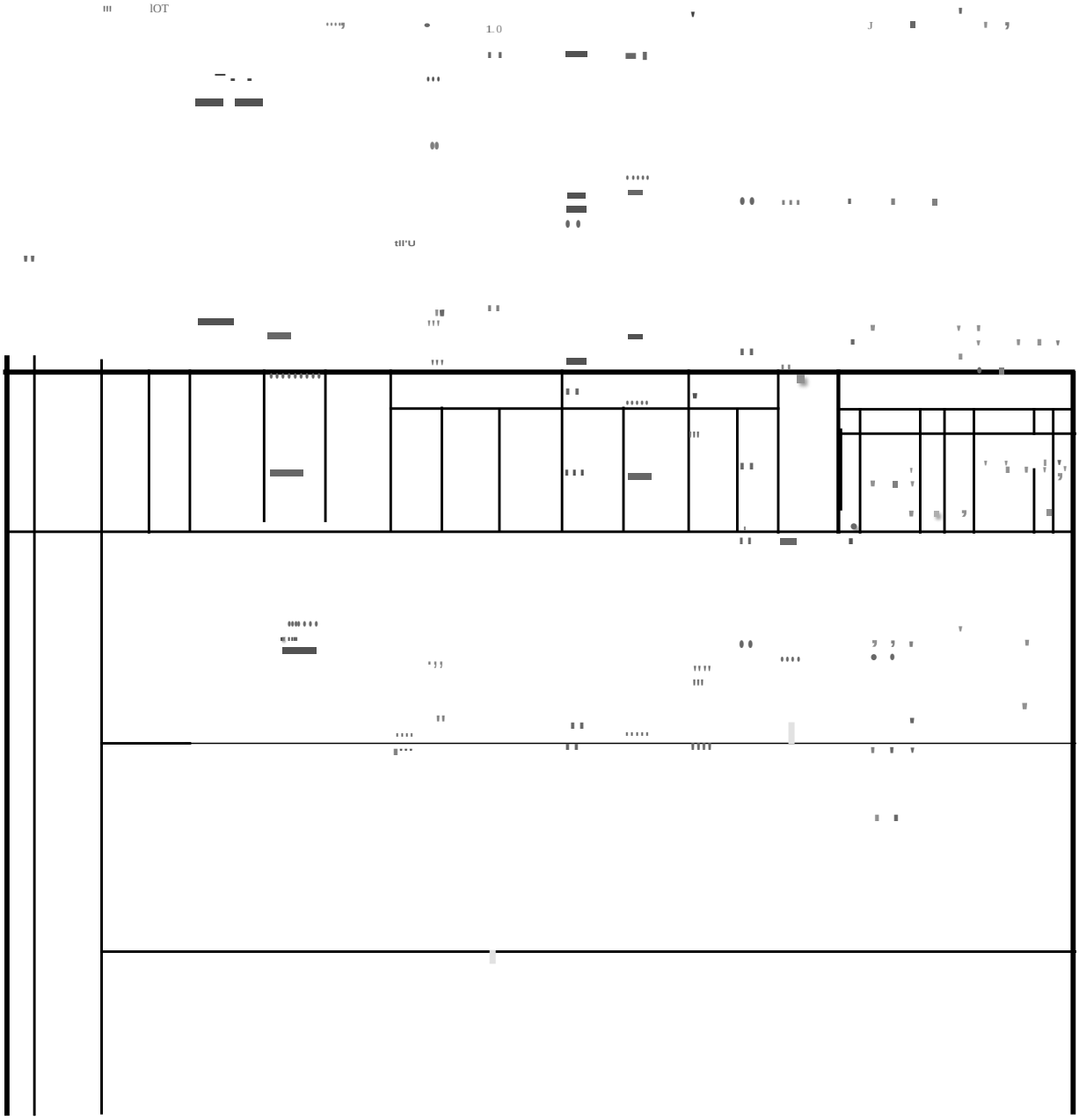


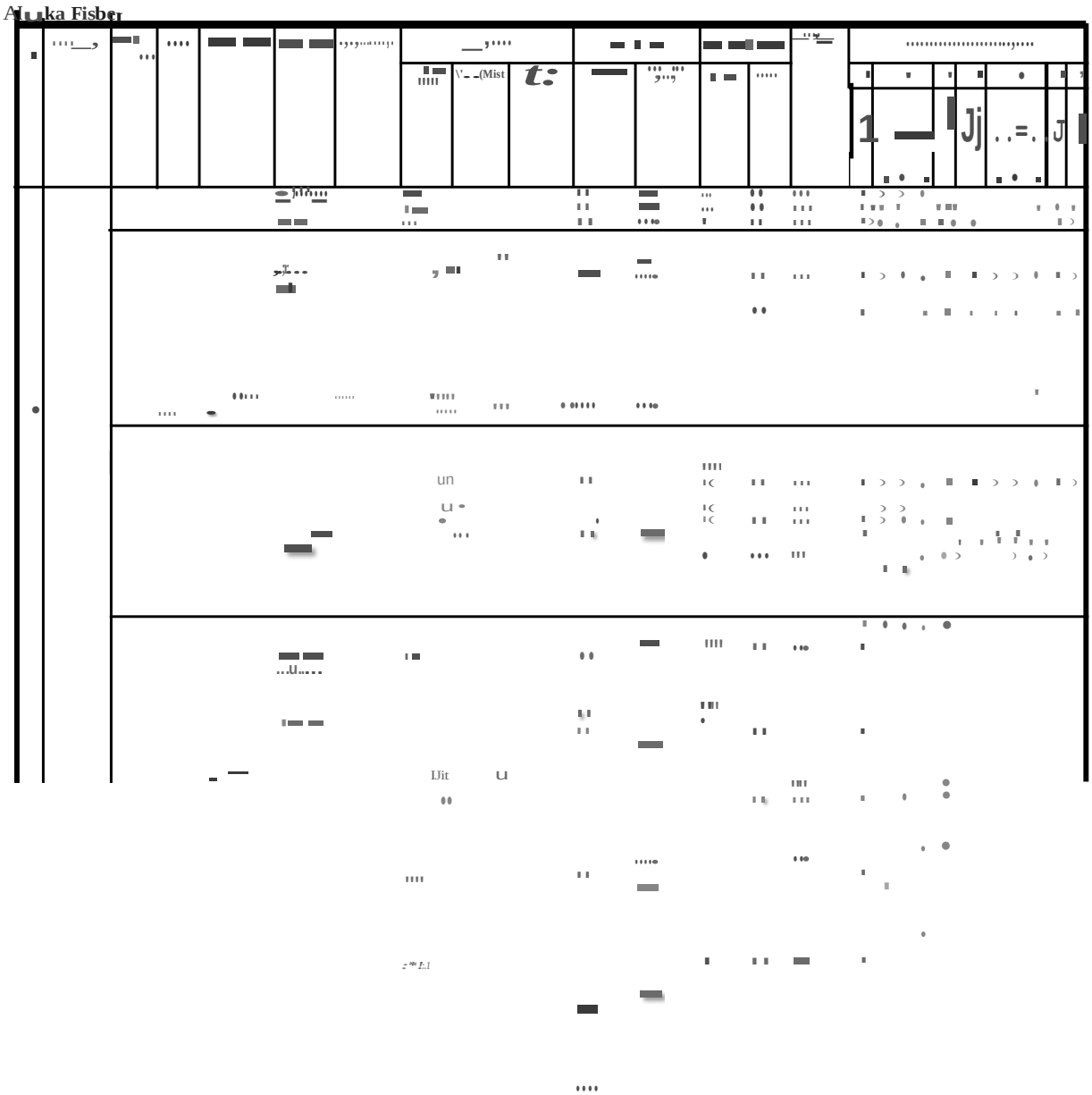
| | OLO Fishery | MMPA Cat. | | |



West Coast Fisberies

Species	u•um.tto:n	Siz.e relltive to LTPY
Rocklish		
Boau:cio	FuUy	Betow
Canary	Ov,er	Betow
OhiLipepper	Under	Above
PO:P	Over	Betow
Shonbelly	Under	Above
Thomyhead	fuUy	ear-
Y¢1lov.1ait	fuUy	Above
Widow	fuUy	car
01h Rckfsh	Fully	Unknown
Fhcfl!h		
Arrowtoolh	Under	Unknown
Do"'er	Fully	Below
English	Under	Above
Pettale	Fully	Ncar
Oth Fltfish	UnknDV'l'll	Unknown
RoundOsfl		
Pacific cod	Undtr	Unknown
Ling ood	Ov•r	Below
Sablefish	fully	Near
Pacific whiting (pt midwater)	fully	Below





	OLO Fishery	MMPA Cat.	Gear	Retained Species	Bycatch Species	FMP (or other)	Volume (MT)	V.....iMiU)			'Tn'l	Significance of Bycatch: Nature	Significance of Bycatch: Level	Reasons for Discards	Seven Steps to Addressing Bycatch: 1	2	3	4	5	6	7
												PC									
												PC									
												PC									
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												PC									
										WA		PC									
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					Dall's porpoise																
					killer whale								W								
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			POT	groundfish	harbor seal	MMPA															
102	Gulf of Alaska groundfish	III									WA										
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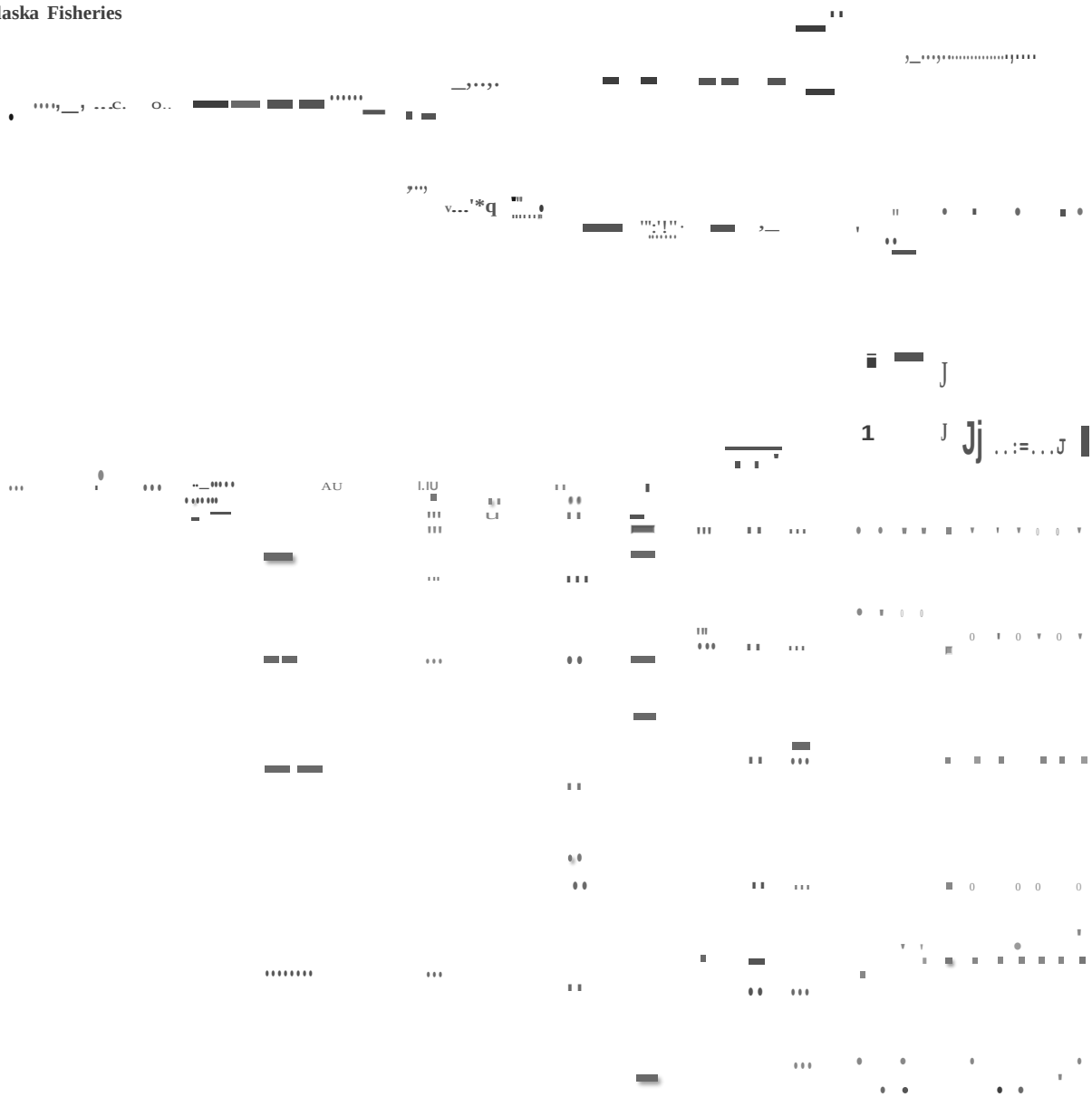

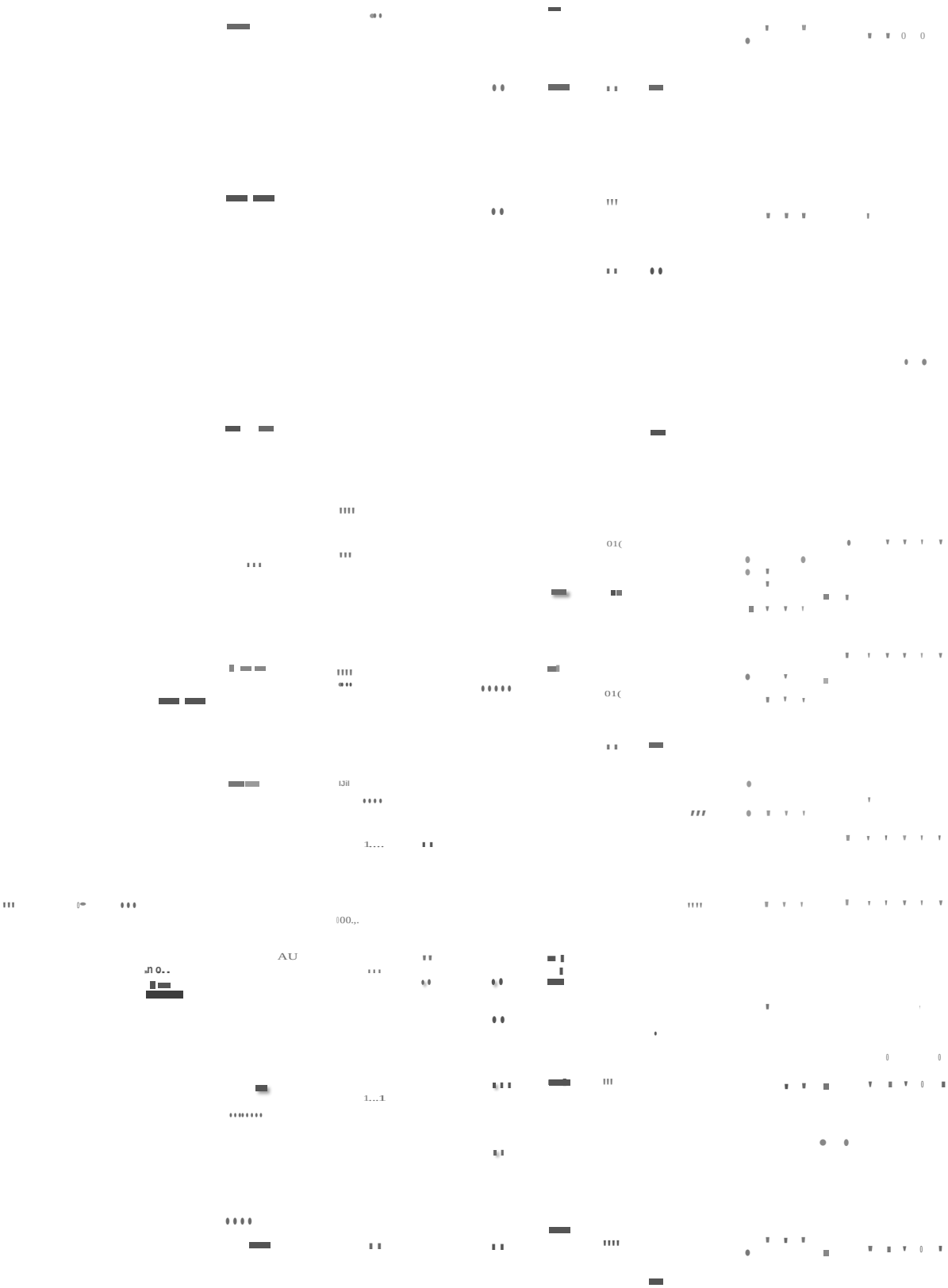

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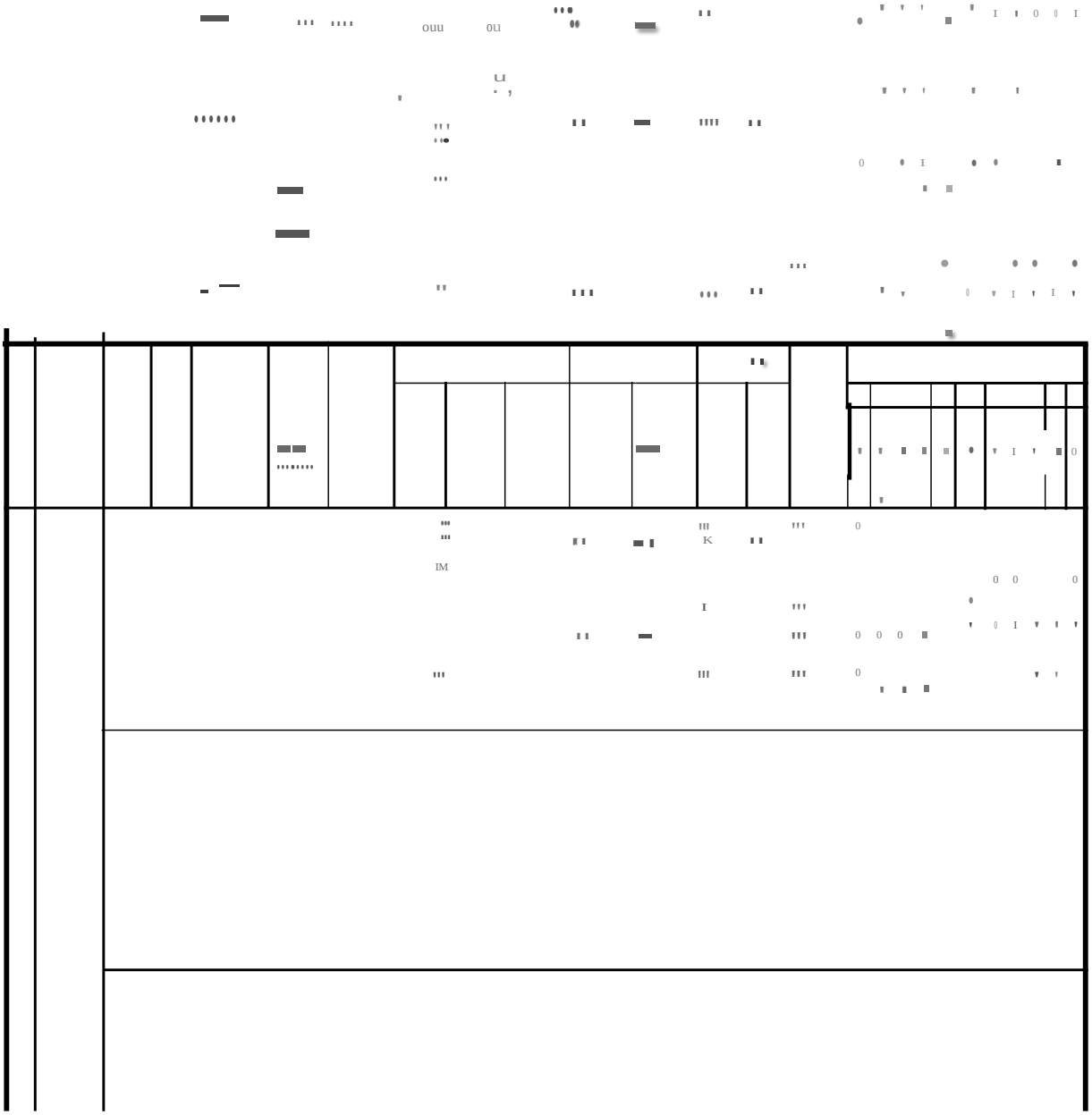

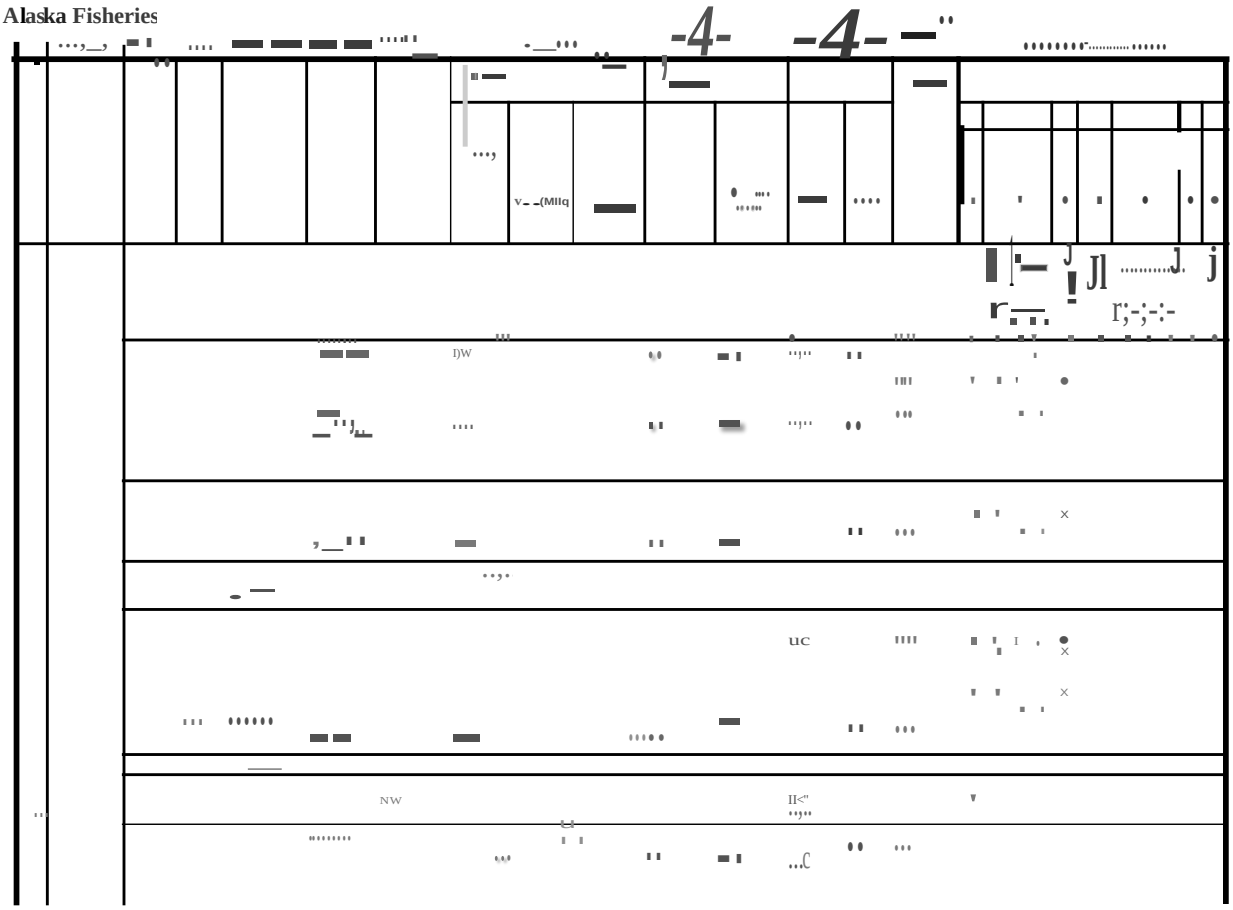

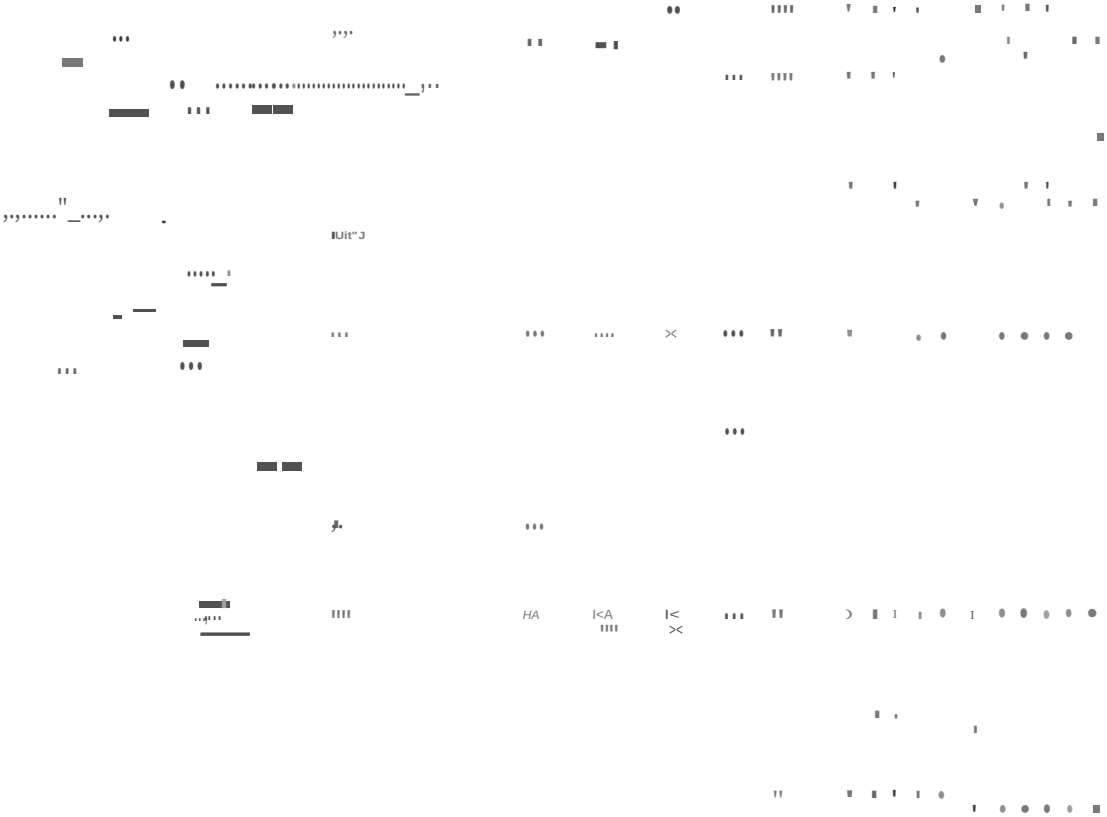

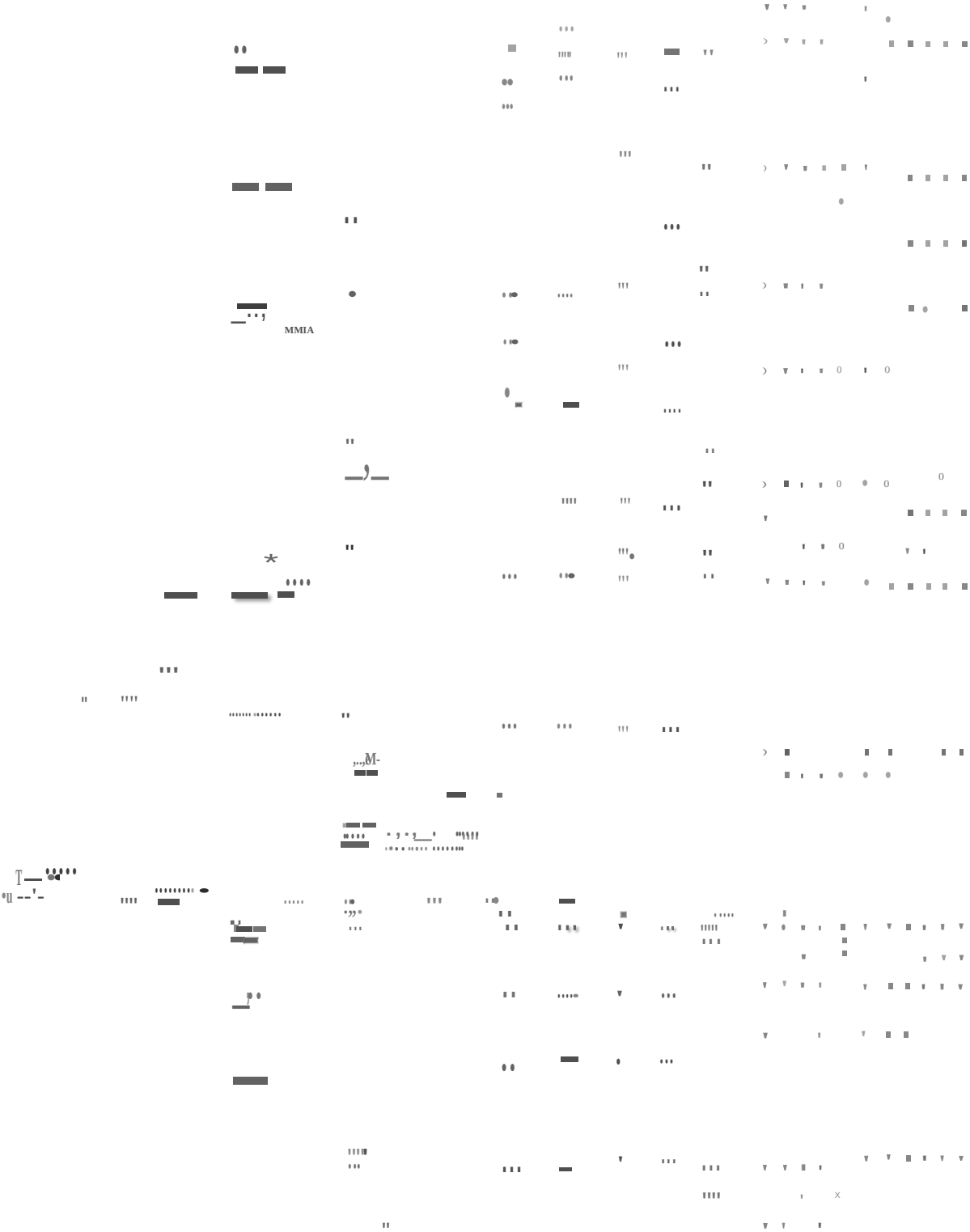
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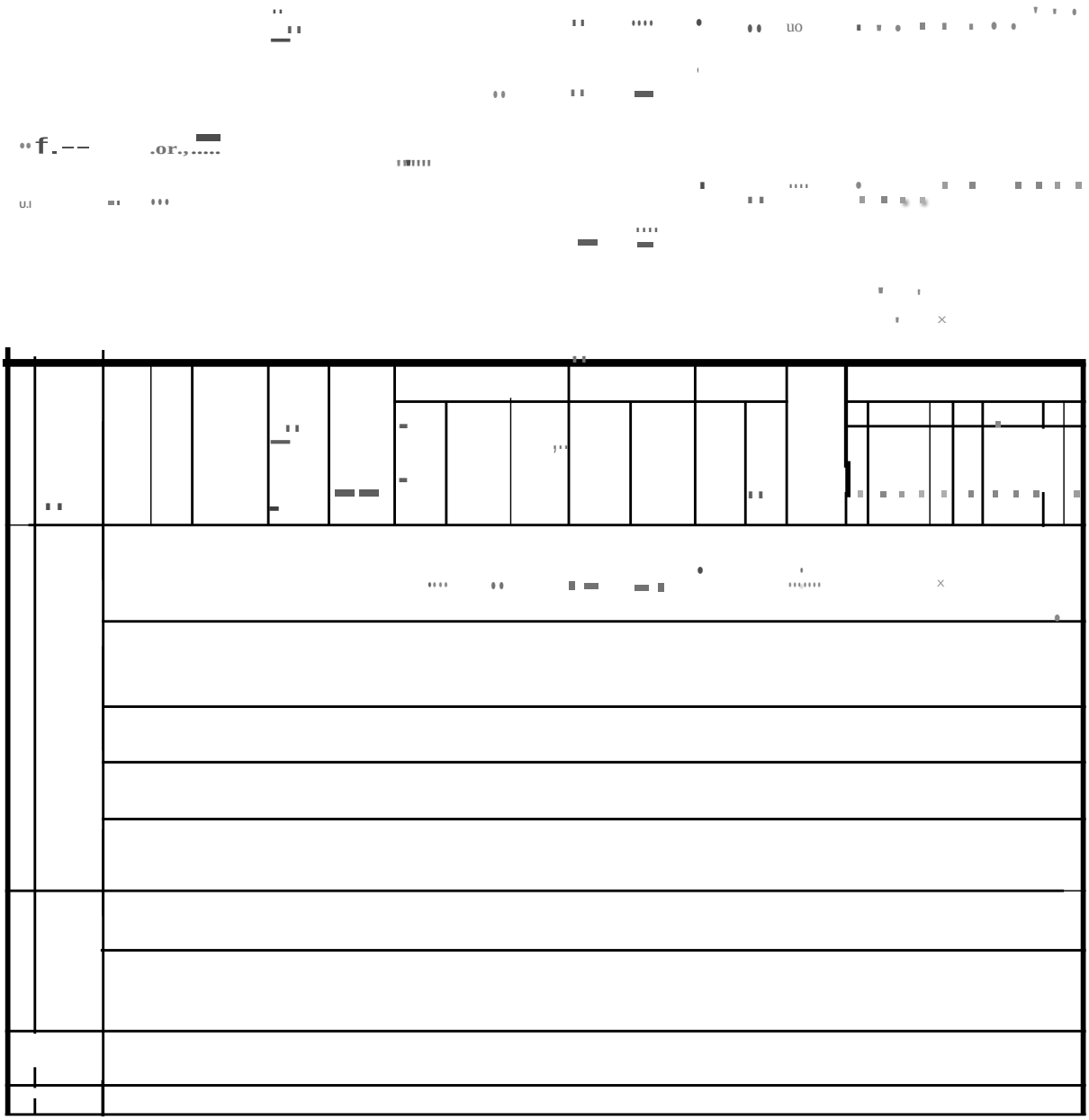

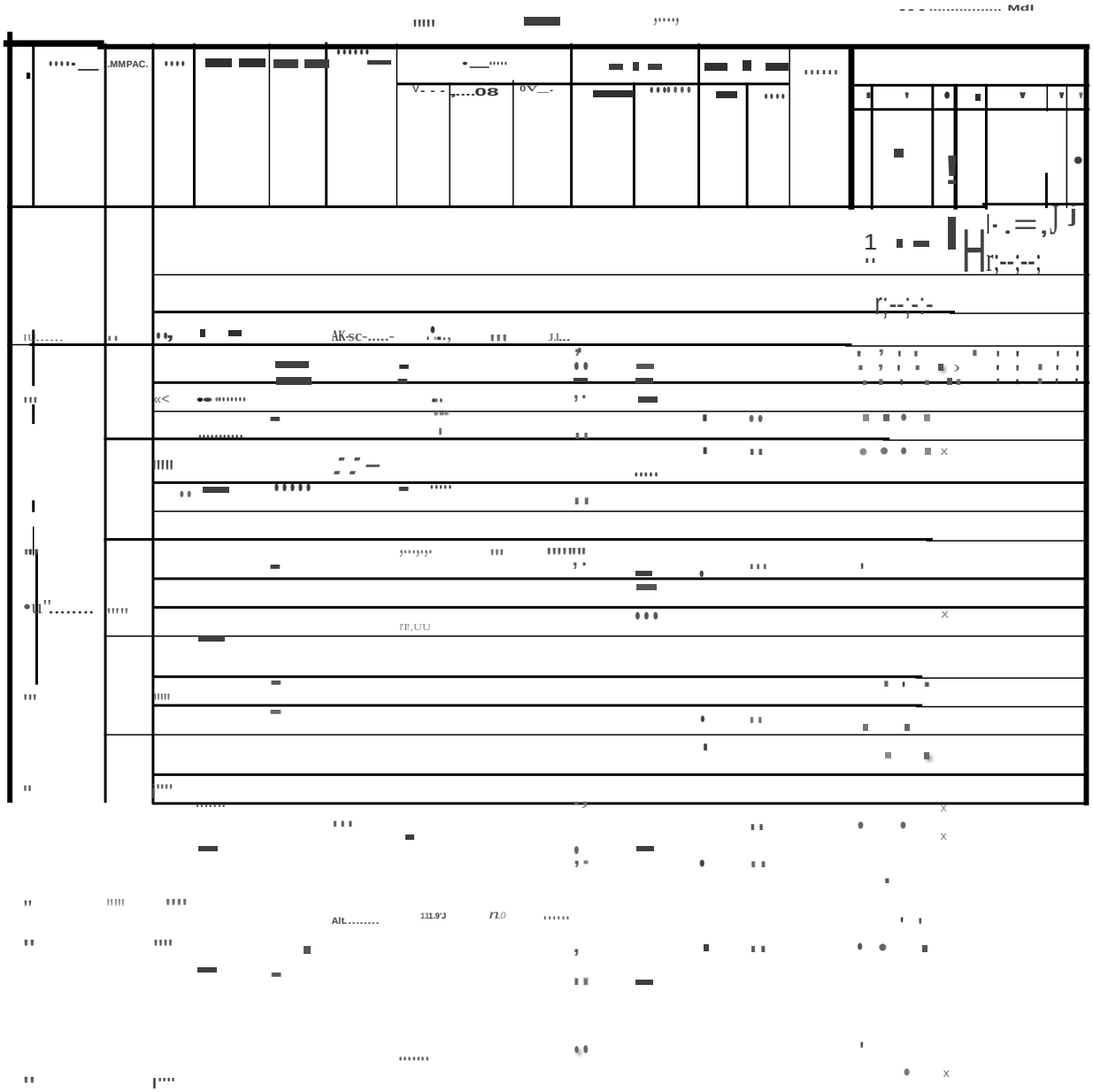

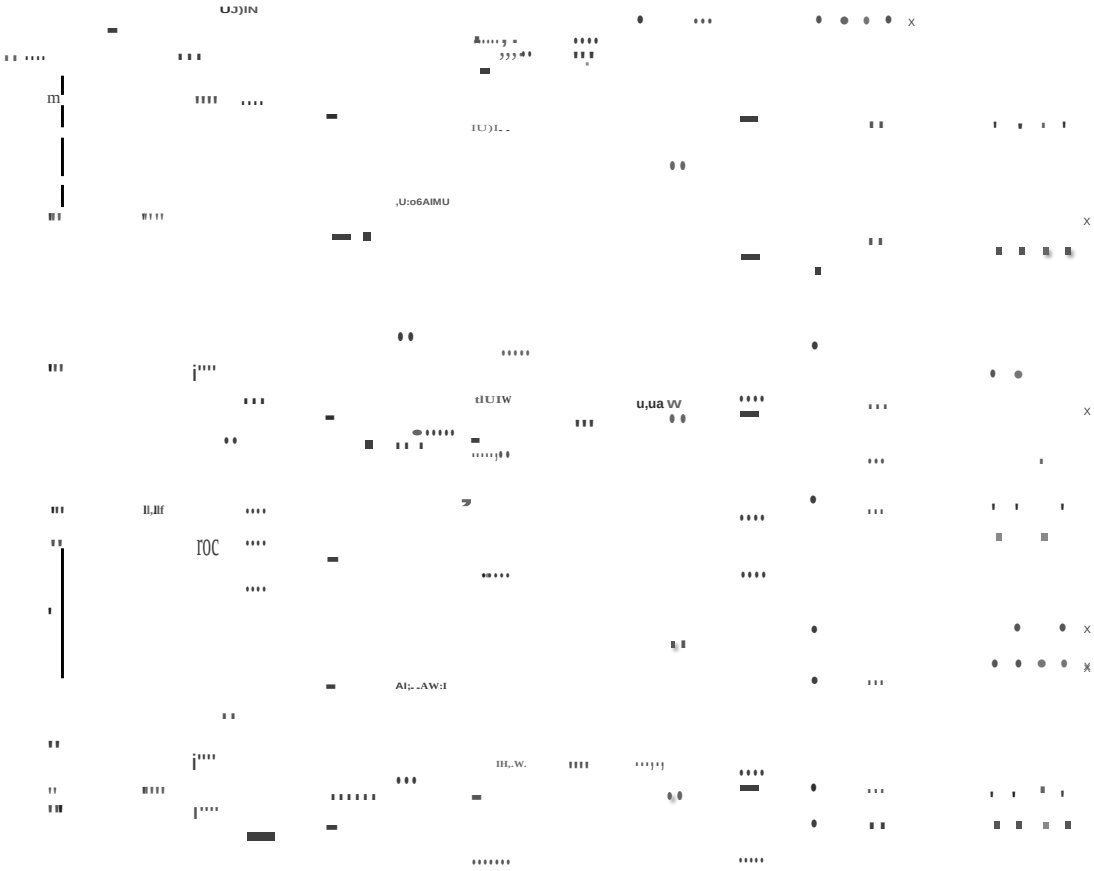

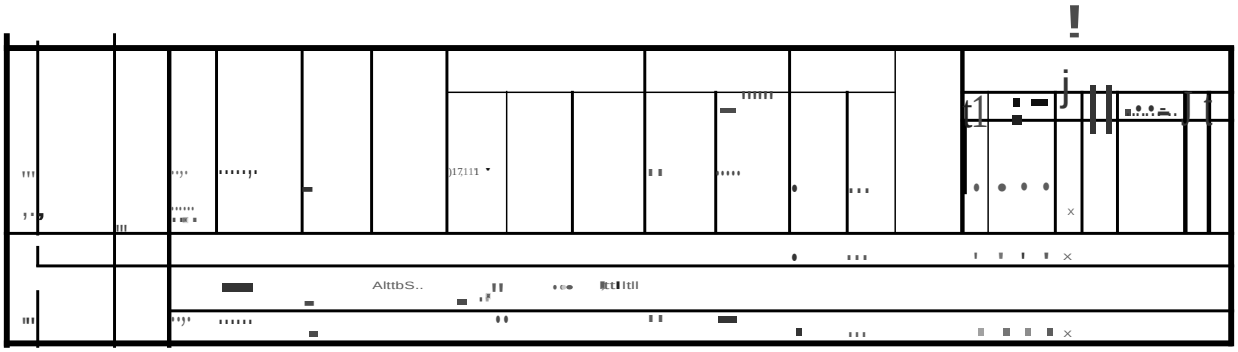

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Case Studies

A conceptual framework is used in Chapter 2 to explore the nature and source of the multidimensional bycatch problem. This appendix contains a more complete discussion of and conclusions from that exploration. In addition, empirical assessments, in the form of three case studies, are used to reinforce some of the conclusions from the conceptual framework and to identify some of the types of information required to address the bycatch issues.

Conceptual Framework

One way to frame the bycatch issue is to answer the following five questions. What is bycatch? Why does bycatch occur? When is bycatch a problem? What is the appropriate level of bycatch mortality? Why is there often excessive bycatch mortality?

What is bycatch?

For the purposes of this plan, bycatch is defined as fishery discards, retained incidental catches, and unobserved mortalities resulting from commercial, recreational and subsistence fishing. Bycatch mortality is bycatch net of the discards that survive the rigors of being caught and released.

Why does bycatch occur?

Bycatch occurs if the fishing method used is not perfectly selective. A fishing method is perfectly selective if it results in the catch of the desired size, sex, quality, and quantity of the target species, without causing other fishing-related mortality. Although bycatch rates often can be decreased by changing fishing methods, very few fishing methods are perfectly selective. In a commercial or subsistence fishery, bycatch mortality is a byproduct of catching fish that are retained. In a recreational fishery, bycatch mortality is a byproduct either of catching fish that are retained or of catching and releasing fish. Therefore, bycatch is a byproduct and a source of fishing mortality for the bycatch species.

When is bycatch a problem?

Bycatch mortality is a management problem if a lack of information on the level of bycatch mortality increases substantially the uncertainty concerning total fishing mortality, or if it precludes a use that would provide greater overall net benefit to the nation. The precluded uses include: 1) later harvest as target catch in the same or in a different commercial, recreational or subsistence fishery; 2) later harvest as bycatch in another fishery; 3) remaining in the sea to contribute to the ecosystem; and 4) being available for viewing or other nonconsumptive uses.

In the case of the bycatch of dolphins in the Eastern Tropical Pacific tuna fishery, Congress acted to ensure that dolphin bycatch mortality would be reduced to an insignificant level. This action reflects an implicit determination by Congress that the benefit of this reduction, principally in terms of ecosystem and nonconsumptive uses, would exceed the costs that it would impose on the U.S. tuna fleet, and U.S. tuna processors and consumers, and that the action would be beneficial to the nation.

Because bycatch mortality is a by-product of fishing, it usually cannot be reduced in a fishery without either reducing the amount and benefit of the catch or increasing operating and management costs in that fishery. For example, bycatch reduction devices may reduce catch per unit of effort and, therefore, may decrease the catch of the target species. This means that operating costs per unit of shrimp catch would increase due to the cost of the gear modifications as well as the decrease in catch per unit of effort. The net benefit of using fish and other living marine resources as bycatch in a fishery is determined by the reduction in the benefit of the harvest of that fishery and the increase in the cost of operating in that fishery that would be required to eliminate bycatch mortality. If bycatch mortality could be decreased without decreasing the difference between the benefit of the harvest and the cost of operating in a fishery, bycatch mortality would not be a contentious management problem, it would simply be eliminated.

What is the appropriate level of bycatch mortality?

From a National perspective, too much bycatch mortality exists in a fishery if a further reduction in bycatch mortality would increase the overall net benefit of that fishery to the nation through alternatives uses of the bycatch species. In that case, it is practicable to reduce bycatch mortality and the excess bycatch mortality is a wasteful use of living marine resources. Conversely, if a reduction in bycatch mortality would not increase the overall net benefit to the Nation, there is not too much bycatch mortality and bycatch mortality is not precluding better uses of resources. Reducing bycatch mortality in a cost-effective manner until a further reduction would not increase overall net benefit to the nation is equivalent to minimizing the cost to the nation of the bycatch problem, which is the sum of the cost of the bycatch itself and the cost of reducing bycatch. In many cases, it may be possible but not practicable to eliminate all bycatch and bycatch mortality in a fishery.

Bycatch mortality can be reduced by changing how, when, where, and how much fish are caught, what is discarded, and how fish and other bycatch species are handled before being discarded. Such changes can have desirable and undesirable effects for the individual fishermen who reduce their bycatch mortality and for the nation as a whole. Those effects determine if a further reduction in bycatch mortality would increase the overall net benefit of that fishery to the nation. The effects include the following: (1) changes in the bycatch mortality of the species for which a reduction is the objective; (2) resulting population effects for the bycatch species; (3) ecological effects due to changes in the bycatch of that or those species; (4) changes in the bycatch of other species of fish and the resulting population and ecosystem effects; (5) changes in

the incidental catches of marine mammals and birds and the resulting population and ecosystem effects; (6) changes in fishing, processing, disposal, and marketing costs; (7) changes in the economic, social, or cultural value of fishing activities and nonconsumptive uses of fishery resources; (8) changes in the effectiveness and cost of research, management, enforcement, and information exchange programs; and (9) the distributional effects of the preceding types of effects.

The probability that a further reduction in bycatch will increase net benefit to the nation is decreased if the methods used to reduce bycatch mortality are not cost-effective. The methods are not cost-effective if the cost of achieving a given reduction in bycatch mortality can be decreased by any of the following: (1) having a fisherman use a lower cost technique to attain a given reduction in its bycatch mortality; (2) changing the distribution of effort to decrease bycatch mortality among the vessels in a fishery; and (3) changing the distribution of effort to decrease bycatch mortality among fisheries.

Net Benefits to the Nation

Cost-benefit analysis (CBA) is the primary tool used to determine net benefits to the nation generated by the exploitation of domestic living marine resources and their distribution amongst different user groups. The economic theory of the firm and consumer theory are theoretical foundations for CBA. Using this scientific approach, the fishery manager is faced with the problem of maximizing net benefits from exploiting a stock or stocks of fish by different user groups—e.g., commercial, recreational, and subsidence fishermen as well as other consumptive and nonconsumptive users of the resource.

Net benefits received by the commercial harvesting sector consist of profits in excess of a normal return for fishing. Known as producer surplus, these net benefits are the remainder of the total revenue minus harvest costs and a fair return to the owner of the harvesting equipment.

Consumers of fishery products also receive benefits in the form of the difference between the purchase price of the fish and what they would be willing to pay for the fish—i.e. consumer surplus. For example, if the individual was willing to pay $10 for a pound of fish but the market price were $1, a net benefit of $9 per pound of fish in consumer surplus would exist.

Recreational fishermen receive satisfaction from taking a fishing trip and presumable catching fish on these trips. The value of this recreational fishing trip can be measured using nonmarket valuation techniques based on, for example, the costs of taking the trip. If the number of fish caught on a trip declines or the cost of taking the fishing trip increases, demand for fishing trips declines and the net benefits received by recreational fishermen from fishing decline. Similarly, subsistence fishermen receive satisfaction from consuming fish they have caught for their own use. Although not sold, the value of those fish can also be determined using nonmarket valuation techniques if the underlying objectives of the subsistence fishermen is understood—e.g. if the subsistence fishing is for traditional, cultural, or religious reasons.

Nonconsumptive users also value living marine resources because they know the resources exist or they enjoy or get satisfaction from viewing them. Scuba divers and snorkelers, for example, realize greater net benefits if reefs are heavily populated by fish species than if they are devoid of life. Even people who never see a reef environment in the sea can value the existence of fish species and will receive satisfaction just from knowing that the resource is being protected.

Cost-effective analysis is more restrictive than CBA, since it does not consider benefits to individuals or the nation generated by living marine resources. The value that may exist for a threatened or endangered species in terms of its contribution to biodiversity are presently unknown but possible future benefits to society have caused Congress to enact the Endangered Species Act to protect and improve the stock of that species.

The conservation and management measures that are used to reduce bycatch mortality as well as the overall management regimes of the fisheries in which bycatch occurs will determine whether cost-effective methods are used to reduce bycatch mortality. The management regimes for those fisheries and for other fisheries are critical in determining which alternative uses of living marine resources will increase when bycatch mortality is decreased and the net benefit to the nation of such increases.

Why is there often excessive bycatch mortality?

A widespread perception is that greed or lack of concern by fishermen results in excessive bycatch mortality. This line of reasoning ignores the decision environment in which individual commercial, recreational and subsistence fishermen work. Bycatch mortality results from the fishing practices employed by individuals that are in turn conditional on personal preferences and prevailing regulatory and economic circumstances. Thus, decisions made by individual fishermen and fishery managers are interdependent and jointly determine the levels of bycatch mortality.

The decisions of individual fishermen (or processors) tend to result in excess bycatch mortality if they do not consider fully the net benefit to the nation of reducing bycatch mortality. This can happen for two reasons. First, the information they have understates the overall net benefit to the nation of a further reduction in bycatch mortality. This could occur either if they are not aware of lower-cost techniques that are available to reduce bycatch mortality or if they are not aware of all of the benefits of reducing bycatch mortality. Second, they do not have sufficient incentives to consider fully the increase in overall net benefit to the nation of a reduction in bycatch mortality. For example, an individual fisherman is more likely to consider the costs and benefits that accrue to him than those that accrue to others; often a substantial part of the benefits of reducing bycatch mortality is not captured by the individual fisherman who reduces his bycatch mortality.

Most fishery management regimes do not create clearly defined and enforceable property rights for fish in the sea which would allow the market mechanism to be used to allocate fish

among fishermen and among competing uses. Instead, fish are allocated to fishermen on a first-come-first-served basis—that is, the "race for fish" is used as the allocation mechanism. This means that individual fishermen do not pay for the fish and other living marine resources they use. Therefore, fishermen have an incentive to use too much fish as bycatch, just as they each would have an incentive to use too much fuel if fuel were free to them or grossly under-priced. Other undesirable effects of this allocation mechanism often include overfished stocks, overcapitalization, boom-and-bust fisheries, and hazardous fishing practices. Management actions, that have been taken to address some of these other symptoms of a flawed allocation mechanism, often have increased further the incentive for fishermen to use fish as bycatch mortality. For example, bycatch mortality often has been increased by species specific trip limits in multispecies fisheries, inconsistent mesh size and minimum fish size regulations, pot limits, and TACs that decrease season lengths and increase the intensity of fisheries. Finally, the strategy of treating the symptoms of the bycatch problem and related management problems rather than eliminating the cause has resulted in a need to constantly change conservation and management measures. This has prevented more substantive progress in dealing with bycatch.

The level of bycatch and the methods used to reduce bycatch are determined by individual fishermen in response to a variety of incentives and constraints that reflect the economic, social, regulatory, biological, and physical environments in which they operate. The tendency for the decisions of individual fishermen to result in excessive levels of bycatch can be decreased by providing better information on the techniques to reduce bycatch mortality and on the benefits of decreasing bycatch. Ensuring that such information is used in making decisions can be done either by increasing incentives fishermen have to fully consider the information or by restricting the decisions they can make—that is, by making more decisions for them. With adequate information, either method can be used to improve bycatch management and therefore, increase the benefits the nation receives from fisheries. These methods differ in the types of information needed by fishery managers and fishermen, as well as the costs of obtaining the information. The information requirement differences are important factors in determining which method or mix of methods will be more effective in reducing the bycatch problem in a particulary fishery. For example, if the monitoring and enforcement cost of making individual fishing operations accountable for their bycatch is too high, that method is not viable, and restricting the decisions of fishermen is a more viable solution.

Compliance with regulations is an important factor in determining whether a set of regulations designed, at least in part, to reduce bycatch mortality will be effective in doing so. Involving fishermen in the development and implementation of fishery regulations can have a substantial positive effect on compliance. It does this by increasing the ownership fishermen have in the regulations and by having the regulations based more on the understandings of fishermen concerning the fishery and methods to reduce bycatch mortality.

The quality of decisions made by fishery policy makers and managers also depends on the information that is available to them and their decision making processes. Costs or benefits of a fishery that are not fully considered by policy makers and fishermen can lead to poor

management decisions. Information that would decrease the uncertainty concerning the biological productivity of stocks of fish, the impacts of fishing activities on living marine resources, and the economic and social impacts of alternative management policies would allow better decisions to be made by policy makers. Public review of the costs and benefits associated with a fishery and a clear identification of the objectives for a management policy will help improve the overall quality of management decisions. The increased involvement by the public also increases the need to ensure that public opinion is based on accurate information.

Conclusions

The Magnuson-Stevens Act defines the term optimum, with respect to the yield from a fishery, as the amount of fish which will provide the greatest overall benefit to the nation, particularly with respect to food production and recreational opportunities, and taking into account the protection of marine ecosystems. The amount of fish is the sum of target catch and bycatch; therefore, the optimum bycatch in a fishery is that which will provide the greatest overall benefit to the nation. Thus, if a reduction in bycatch mortality will increase overall net benefit to the nation, there is excessive bycatch mortality and it is practicable to reduce bycatch mortality. The term practicable is not synonymous with the term possible because not all reductions that are possible are practicable. In many fisheries, it probably is not practicable to eliminate all bycatch and bycatch mortality.

The extent to which it is practicable to reduce bycatch mortality is not static. Examples of changes that would tend to increase the extent to which it is practicable to reduce bycatch mortality include the following: (1) the development of lower cost methods either of avoiding bycatch or of increasing the survival rates of discarded catch; (2) changes in biological or oceanographic conditions that make it easier to avoid bycatch; (3) changes in market conditions, in population and ecosystem conditions, or in fishery regulations that increase the value of the uses of living marine resources made possible by a reduction in bycatch mortality; (4) changes in fishery regulations which encourage the development and use of lower cost methods to decrease bycatch mortality; and (5) a change in the open-access managed common property resource management paradigm to a rights-based management institution.

Because neither the extent to which it is practicable to reduce bycatch nor the best methods for reducing bycatch mortality are static, there is a periodic need to evaluate the merits of existing and alternative conservation and management measures to reduce bycatch. The evaluation should be in terms of the population, ecosystem, social, and economic effects which determine whether they have increased or are expected to increase net benefit to the nation. They should not be evaluated only in terms of their effects on the levels of bycatch. A mix of quantitative and qualitative analyses often will be appropriate for such evaluations. The cost of adequately monitoring the catch and bycatch of individual fishing operations is critical in determining which of the latter two methods is more likely to increase the overall net benefit to the nation. Similarly, the decisions of fishery policy makers and managers can be improved by improving

the information they have and by ensuring that they consider all the significant benefits and costs of reducing bycatch mortality.

The allocation of NMFS and Council resources will be critical in determining their success in increasing net benefits to the nation by decreasing bycatch mortality. In setting priorities to address the bycatch problems and other fishery management problems, it is important to do the following: (1) recognize that physical measures of bycatch are of limited use in comparing the magnitude of the bycatch problem among fisheries because the expected net benefit to the nation of reducing bycatch is not the same for all species or even for all fish of the same species; (2) recognize that typically it cannot be determined if a particular use of living marine resources is wise or wasteful compared to another use without considering all the costs and the benefits to the Nation for the two uses; (3) consider the expected net benefit to the nation of addressing a specific problem; (4) make a distinction between the sources and symptoms of a bycatch problem; (5) identify the principal concerns in terms of the population, ecosystem, social, or economic effects of bycatch; (6) recognize that rather than being a separable fishery management issue, bycatch management is an integral part of fishery management and that the ability to improve overall fishery management and bycatch management is limited by similar decision-making process flaws that include the same information gaps and faulty incentives for individual fishermen, fishery managers and other participants in the fisheries and fishery management process; (7) recognize that much of the information necessary to identify and quantify the effects of a specific set of changes in research, management, enforcement, and information exchange programs intended to decrease bycatch mortality is also necessary to address other management problems, such as determining the appropriate levels of exploitation for living marine resources and determining how to allocate the associated harvest levels among competing uses and users; (8) recognize that bycatch is a multispecies problem because actions to decrease the bycatch of one species can increase or decrease the bycatch of other species and because the bycatch of one species can affect the status of other species, through predator/prey or other biological interactions; and (9) determine if there are common solutions to multiple management problems that may only be feasible when the commonality is recognized.

The importance of identifying the principal concern about bycatch in a specific fishery is demonstrated by the following examples. Uncertainty about total fishing mortality can be decreased by improving the estimate of bycatch mortality or by decreasing bycatch mortality. If the current level of total fishing mortality for a species threatens either the population of that species or other components of the ecosystem and if that threat essentially could be eliminated by decreasing other sources of fishing mortality that a council and NMFS control, the bycatch itself is not a threat. In this case, bycatch results in an allocation problem, not a population or ecosystem problem. If the bycatch problem is principally that the bycatch by one group of fishermen decreases the retained catch and benefits of another group of fishermen, compensation from the former group to the latter group may be more beneficial to both groups than a reduction in bycatch mortality.

Information requirements and compliance with regulations are two important factors in determining whether a set of regulations designed, at least in part, to reduce bycatch mortality will be effective in doing so and will increase net benefit to the nation. The more uncertain fishery mangers are about what they know and the lower the compliance, the less likely it is that the objectives of the regulations will be met.

The overall management regimes for the fisheries in which a species is taken as bycatch and for the fisheries in which that species is taken as target catch are important in determining the extent to which it is practicable to reduce the bycatch of that species. For example, increased bycatch mortality is one of the effects of using the race for fish to allocate fish among competing fishermen.

Bycatch can be reduced by avoiding bycatch to begin with, by increasing the survival of discards, or by retaining fish that would normally be discarded. The optimum mix of these three methods depends on the desirable and undesirable effects of each method. The effects and, therefore, the optimum mixes are case-specific.

Empirical Assessments

There are three principal reasons why it can be very difficult to determine if a specific set of actions to reduce bycatch mortality will be beneficial to the nation. First, there can be significant uncertainty concerning the direction or magnitude of each type of effect. The uncertainty is generally the result of a limited understandings of the relevant biological, ecological, economic, and social relationships. Second, even when the effects can be quantified, not all of them can be measured in common units, such as discounted present value. For example, the distributional effects cannot be summarized in terms of discounted present value because the assessment of alternative distributions requires value judgements. Similarly, although the population and ecosystem effects are important due to their effects on net national benefits, the change in national benefits generated by a specific population or ecosystem change is difficult to identify.
Third, for the effects that can be measured in terms of discounted present value, the quality of the valuation techniques can differ substantially by type of effect. For example, better estimates of the change in value may be available for market goods than for non-market goods.

Some of the types of information required to estimate whether a change in bycatch management will tend to increase or decrease the net benefit to the nation are described in three case studies that were completed as part of the process for developing this plan. The case studies of the net benefit of bycatch reductions for the Alaska groundfish fishery, the Gulf of Mexico shrimp fishery, and Southern New England trawl fishery are intended to do the following.

- Provide examples of the types of information that are needed to estimate the net benefit of reducing bycatch in a specific fishery.

- Emphasize the need to consider the desirable and undesirable effects of reducing bycatch mortality and indicate that the result of decreasing bycatch can be an increase, decrease or no change in the net benefit to the nation.

- Note the importance of both the methods used to reduce bycatch and the overall management regime in determining the direction and magnitude of the change in the net benefit to the nation.

- Identify information gaps.

- Emphasize that rather than being a separable fishery management issue, bycatch management is an integral part of fishery management and that the ability to improve overall fishery management and bycatch management is limited by similar decision-making process flaws that include the same information gaps and faulty incentives.

Halibut Bycatch in the Alaska Groundfish Fishery

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Summary

Halibut bycatch mortality in the Alaska groundfish fishery has been a contentious issue for many years because it decreases the halibut fishery quota and because it cannot be decreased without imposing costs on groundfish fishermen. This case study compares the benefits of reducing halibut bycatch mortality in the Alaska groundfish fishery and the estimated cost to groundfish fisherment of three methods of decreasing groundfish catch and to reduce halibut bycatch mortality.

The most selective reduction in groundfish catch considered was the most likely to result in the benefits to the halibut fishermen exceeding the cost to the groundfish fishermen. With the most selective of the three methods considered, that happened if the ex-vessel value net of fishing costs is less than 44% of the ex-vessel value of groundfish. However, with the least selective method, that happened only if the ex-vessel value net of fishing costs is less than 3% of the ex-vessel value of groundfish. Generally as more selective methods are used to reduce halibut bycatch mortality, the cost to groundfish fishermen is decreased and larger reductions in bycatch mortality are practicable. Market-based solutions to the halibut bycatch problem that provide bycatch accountability by individual fishing operations, such as individual bycatch quotas, tend to result in the most selective methods being used. However, the monitoring and enforcement costs may be substantially greater for such programs. The existence of an extensive at-sea observer program for the groundfish fishery makes such a solution more feasible.

Background

Until recently, the bycatch issue in the Alaska groundfish fishery that received the most attention was the bycatch of halibut, salmon, crab and herring. These are relatively high-valued species for which the domestic fisheries had been fully developed well before the domestic groundfish fishery replaced the foreign and joint venture groundfish fisheries. This bycatch decreased the catch that was available to domestic halibut, salmon, crab and herring fishermen. Retention of these species is prohibited in the groundfish fishery (i.e., these are “prohibited species” in the groundfish fishery) and a variety of other measures have been used to control the bycatch of these species. This case study compares the benefit to the halibut fishery and the cost to the groundfish fishery of three methods of reducing halibut bycatch mortality by decreasing groundfish catch.

Benefit of Decreasing Halibut Bycatch Mortality

The use of halibut that would be increased by a decrease in halibut bycatch mortality in the groundfish fisheries has been made explicit by the International Pacific Halibut Commission (IPHC), which establishes the annual quotas for the halibut fisheries. In recent years, the IPHC has established quotas for total halibut removals in all fisheries combined and then subtracted expected bycatch removals and removals in all fisheries except the commercial halibut fishery and set the quota for that fishery equal to the residual. The expected halibut bycatch mortality in the groundfish fishery was set equal to the estimated bycatch mortality from the previous year. Therefore, for each metric ton (mt) of estimated bycatch mortality in the groundfish fishery one year, there was a one-metric-ton reduction in the halibut fishery quota the next year. This reduction in the halibut fishery quota was made in an attempt to prevent the bycatch from adversely affecting the long-term biological productivity of the halibut stocks.

In addition to this immediate adjustment to the halibut fishery quota, the IPHC estimated the long-term yield loss in the halibut fishery per metric ton of bycatch mortality in the groundfish fishery. The current estimate is 1.8 mt. That is, based on a population dynamics model and the current exploitation rate strategy, it is estimated that the cumulative effect of each metric ton of halibut bycatch mortality in the groundfish fishery is a 1.8-mt reduction in halibut fishery quotas over a 20-year period. Although new quota adjustment methods and yield loss estimates are being prepared by the IPHC, the current quota adjustment and yield loss estimate are used below in estimating the benefit of reducing halibut bycatch mortality in the groundfish fishery.

The IPHC estimates provide two important pieces of information concerning the benefit of reducing halibut bycatch mortality. They indicate what alternative use would increase and by how much. Specifically, catch in the halibut fishery would increase by 1 mt the next year and by 1.8 mt over the next 20 years. When a discount rate of 5% is used to account for the fact that a 1-mt increase in the halibut quota several years from now is not comparable to an immediate 1-mt increase, the discounted yield loss is about 1.5 mt per 1 mt of halibut bycatch mortality.

Since 1995, the halibut fishery off Alaska has been managed under an individual transferable quota program. The price that fishermen are willing to pay for 1 mt of halibut quota for one year provides an estimate of the net benefit to halibut fishermen of additional halibut quota. The quota price is about $1 per pound or about $2,205 per metric ton net weight, which is 75% of the round weight. The quota price is about half of the ex-vessel price of halibut, which suggests that the marginal harvesting cost is about half of the ex-vessel value of halibut. Therefore, using $2,205 as the net benefit per metric ton of net weight, the round- to net-weight conversion factor of 0.75, and a discounted yield loss of 1.5, the estimated increase in net benefit to halibut fishermen per 1-mt reduction in halibut bycatch mortality in the groundfish fishery is $2,481. Therefore, given that the halibut bycatch mortality in the Alaska groundfish fishery was about 6,720 mt in 1995, the potential benefit to halibut fishermen of the elimination of halibut bycatch in the groundfish fishery would have been about $16.7 million.

Developing this estimate of the potential benefit of eliminating halibut bycatch mortality in the Alaska groundfish fishery was greatly simplified by (1) the use of individual transferable quota management of the halibut fishery, which provides a market-based estimate of the net benefit of additional halibut quota; (2) a halibut allocation system, which makes it clear what the alternative use of halibut will be; (3) a halibut stock and management model that provides an estimate of the halibut fishery yield loss due to halibut bycatch mortality in the groundfish fishery; and (4) extensive at-sea observer and groundfish catch reporting systems, which provide a generally well-accepted estimate of halibut bycatch mortality.

This estimate tends to overstate the net benefit to commercial halibut fishermen because it does not allow for the downward ex-vessel price adjustment that would accompany an increase in halibut landings, but it tends to understate the benefits to the nation as a whole because it excludes any benefits beyond the ex-vessel level. An estimate of the ex-vessel demand for halibut could be used to account for the price effect and benefits beyond the ex-vessel level. In the absence of an estimate of the ex-vessel demand function, it is not known whether the estimate of $2,481 is higher or lower than the actual benefit to the nation of a 1-mt reduction in halibut bycatch mortality in the Alaska groundfish fishery.

Net Benefit of Decreasing Halibut Bycatch Mortality

Assuming that the benefit of reducing halibut bycatch mortality by 1 mt is $2,481, net benefits can be increased by decreasing bycatch as long as the cost of reducing bycatch is less than $2,481 per metric ton. Unfortunately, with the exception of the extreme case in which halibut bycatch mortality is reduced by decreasing groundfish catch, the cost of reducing bycatch is difficult to estimate. In the extreme case, halibut bycatch mortality can be decreased with a proportionate decrease in the catch of all groundfish species. Given the halibut bycatch mortality of 6,720 mt and a groundfish ex-vessel value of $585 million, this would result in about a $87,000 reduction in groundfish ex-vessel value per 1-mt reduction in halibut bycatch mortality. Therefore, if the ex-vessel value net of fishing costs is less than 3% of the ex-vessel value of groundfish, the benefit of the reduction in halibut bycatch mortality would exceed the cost through the ex-vessel level.

The cost of reducing halibut bycatch mortality can be decreased with a more selective reduction in groundfish catch. For example, the 1995 Bering Sea cod trawl fishery had an ex-vessel value of about $28 million and accounted for about 1,512 mt of halibut bycatch mortality. Therefore, with a proportionate decrease in the catch of all cod trawl fishing operations, there would be about a $18,500 reduction in ex-vessel value for each 1-mt reduction in halibut bycatch mortality. If the ex-vessel value net of fishing costs is less than 13% of the ex-vessel value of groundfish, the benefit of the reduction in halibut bycatch mortality would exceed the cost through the ex-vessel level.

An even more selective reduction in the catch in the Bering Sea cod trawl fishery would produce a greater reduction in the cost of decreasing halibut bycatch mortality. For example, if

halibut bycatch mortality is reduced by 20% by eliminating the catch of the fishing operations with the highest ratios of halibut bycatch mortality to retained cod catch, halibut bycatch mortality would be reduced by about 302 mt and the ex-vessel value of the cod fishery would be reduced by about $1.7 million or about $5,600 per 1-mt of reduction in halibut bycatch mortality. Therefore, if the ex-vessel value net of fishing costs is less than 44% of the ex-vessel value of groundfish, the benefit of the reduction in halibut bycatch mortality would be more than the cost through the ex-vessel level.

Conclusions

Among these three examples, the expectation that the benefit of reducing halibut bycatch mortality would exceed the cost increased as the method of reducing bycatch became more selective. Given this example in which the benefit of a 1-mt reduction in bycatch mortality is $2,481, the optimum situation is that in which each fishing operation reduces its halibut bycatch mortality to the point at which its cost to reduce bycatch mortality by another 1 mt is also $2,481. When that condition is met, the net benefits from the fishery cannot be increased by either changing the total level of bycatch or by changing the distribution of bycatch among fishing operations. This most selective method of reducing bycatch could be attained if each fishing operation had to pay $2,481 per metric ton of halibut bycatch mortality. Other mechanisms for inducing reductions in bycatch are generally less selective, will have higher costs to the groundfish fishery, but may have substantially lower monitoring and enforcement costs.

The preceding discussion of the benefits and costs of decreasing halibut bycatch mortality in the groundfish fishery excludes any discussion of the changes in the distribution of benefits and costs. Such changes are clearly important in determining if a reduction in halibut bycatch mortality will benefit the nation. If the use of halibut as bycatch is justified in terms of net benefits, but results in an undesirable change in the distribution of benefits and costs, the gain in net benefits must be weighed against the adverse change in their distribution. The determination of whether a specific change in the distribution of benefits and costs is in itself desirable or undesirable for the nation and the determination as to whether an increase in net benefits is more than offset by an undesirable distribution change require value judgements. The value judgements used are implicit in the decisions of those who determine whether a specific management measure will be implemented.

Economics of Bycatch: The Case of Shrimp and Red Snapper Fisheries in the U.S. Gulf of Mexico

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Summary

One of the more challenging fishery management issues in the Southeast concerns the incidental bycatch of juvenile red snapper by shrimp trawlers in the U.S. Gulf of Mexico. In the absence of bycatch reduction, directed red snapper catches will continue at their current small annual levels and the stock will not recover.

Analyses of potential economic outcomes of alternative ways to reduce the bycatch required information primarily on the current harvest sector costs for shrimp and red snapper and on the demand for the target and bycatch species. The analyses indicated that conservation of the red snapper resources via a reduction in bycatch will result in significant losses in producer surplus generated by shrimp trawling. Furthermore, while a reduction in red snapper bycatch could lead to recovery of the red snapper stock, the potential benefits would not be realized unless the commercial red snapper fishery was managed in an optimal fashion and unless the recreational catches could be constrained within their quotas.

An economic and technical evaluation of alternatives for reducing red snapper bycatch concluded that if bycatch reduction was to be accomplished, it would be via the use of bycatch reduction devices (BRDs) in shrimp trawls. Further analyses determined the particular BRD design that would meet the bycatch requirements at the lowest cost relative to other BRD designs. The outcome was that the cumulative discounted net value from shrimp harvesting would decrease by $117 million for the period from the inception of required BRD use until a new harvest equilibrium in the shrimp fishery was reached. The evaluation also concluded that benefits from red snapper stocks could approach the level of the estimated shrimp losses, but only if the red snapper stocks are managed under an individual transferable quota program or some other management regime that would produce the same results.

The case of red snapper and shrimp in the Gulf of Mexico provides an excellent illustration that bycatch reduction does not necessarily provide for increases in net economic benefits and also highlights the critical role that the management regimes for the target and bycatch species will play in the overall, long term economic changes that may result from reductions in bycatch for any fishery.

Economic Consequences

A major finding of the RIR was that although a reduction in red snapper bycatch had the potential to allow for recovery of the red snapper stock, the potential benefits would not be realized unless the commercial red snapper fishery was managed in an optimal fashion and unless the recreational catches could be controlled. Optimal management of the red snapper fishery was portrayed in the RIR as an ITQ management system and it is important to note that the Council developed, and the Secretary of Commerce approved, an ITQ system for red snapper. In addition, the Council has constrained future recreational catches by implementing an overall recreational quota.

While there was an a priori theoretical basis upon which to predict that benefits would not accrue to the red snapper fishery in the absence of an optimal management system for red snapper, and that the effects on the shrimp fishery would be negative, the RIR proceeded on the assumption that the ITQ system for red snapper would be implemented and that recreational catch would be controlled. Given these assumptions, the overall outcome of the RIR was dependent on empirical estimates that compared the level of shrimp losses to the potential gains to the red snapper fishery. While there may be instances where the economic outcome of bycatch reduction is so certain that declarations can be made as to whether net benefits will increase, decrease or even remain about the same, such is not the case for this example and this example is probably not particularly unique.

Impacts on Shrimp Fishery

Management alternatives considered under the amendment included area closures, seasonal closures and the use of bycatch reduction devices (BRDs) in shrimp trawls. Although the alternative ways to reduce bycatch have different cost and revenue implications for the shrimp harvest industry, they have roughly identical implications for the directed fisheries for the bycatch species because all the alternatives must reduce bycatch by 44%. It is important to note that this criterion was based strictly on biological grounds without knowledge of the magnitude of the economic consequences of a bycatch reduction of this level.

As a step toward determining whether to implement bycatch reduction, the Council conducted an economic and technical evaluation of alternatives. This process resulted in a decision that if bycatch reduction was to be accomplished, it would be via the use of BRDs in shrimp trawls. This outcome was based on a finding that the alternative of requiring BRDs was superior to the alternatives of area or seasonal closures in terms of the costs to shrimpers and the feasibility of meeting the 44% bycatch reduction criterion while the effects on the red snapper stocks would be similar to other alternatives. For this reason, the balance of the economic analysis focused on the BRD alternative.

Even though that alternative was chosen as the preferred alternative on the basis of being the least costly, a complicating factor is that several BRDs met the technical criteria of a bycatch reduction of 44%. Because it was known from the outset that they would perform differently in terms of the economics of shrimp harvesting, a separate economic analysis was conducted for all three BRDs that were deemed to meet the bycatch reduction technical requirement. The model results clearly indicated that the major factor providing for an economic differentiation among the BRDs is that they lose differing amounts of shrimp and hence have significantly different outcomes in terms of short term effects on shrimp harvest, on the resources used to harvest shrimp, on harvesting costs, and therefore, on profitability.

The long-term differences are more complex because the long term depends largely on the reaction of overall shrimp harvesting effort in response to the short term effects of management. Understanding that the shrimp harvesting industry is open access, and further understanding that the year to year variation in the shrimp resource is independent of previous harvesting effort, the models used indicate that overall long term effort reductions result in long term industry benefits that tend to offset part of the short term losses. It should be noted that this finding does not imply an absence of "losers" when shrimp effort declines. Indeed, the offsetting long-term benefits are attributed mainly to the exit of marginal firms.

The RIR determined that one particular BRD would meet the bycatch requirements at a minimal cost relative to other BRD designs. The outcome was that the cumulative discounted net value from shrimp harvesting would decrease by $117 million for the period from the inception of required BRD use until a new harvest equilibrium in the shrimp fishery was reached. There was an additional refinement in the BRD analysis could not be considered and that was the possible consideration of a number of BRDs being used by different fisherman or in different areas.

Although it is clear that the introduction of BRDs will result in varying outcomes according to which style of BRD is chosen, it is highly likely that several BRDs will be used. Since there is no information available to suggest which approved BRD device will be chosen by individual shrimpers (they will make individual choices according to their particular shrimping strategy and geographical area), the indicated refinements to the analysis are not possible. Using only one style of BRD as an example, the shrimp models indicated that a device called the "30-mesh fisheye" would reduce overall shrimp catches, and hence revenues, by 3% if all shrimpers used that style of BRD. Considering the costs of purchasing the BRDs, and the fact that profits as a percent of revenues are small for shrimp harvesting firms, it was fairly straightforward that the average shrimp vessel would incur an annual short term profit loss of significantly over 3%.

The economic models also considered the reaction of the effort response of the shrimp harvesting industry to the loss in short-term profits. This information came from an entry-exit model and a within season effort model that in combination described the expected change in shrimp harvesting behavior. The result was that total effort, in terms of overall fleet size, will decline in response to the decreased shrimp catches and increased costs of purchasing and

maintaining BRDs. The models indicated that when a new harvesting equilibrium was reached, then the overall reduction in effort tended to reduce overall costs and, hence, tended to produce long-term economic gains that offset, to some degree, the short term costs to shrimpers.

Impacts on Red Snapper Fishery

The RIR also concluded that benefits from red snapper stocks could approach the level of the estimated shrimp losses, but only if the red snapper stocks were managed under the approved ITQ program or some other management regime that would produce the same results. Since the Magnuson-Stevens Act has subsequently imposed a moratorium on ITQs until the year 2000, and since equally effective management regimes have not been discovered, the hypothesized benefits cannot be realized at this time. It is worth repeating that the case of red snapper and shrimp in the Gulf of Mexico provides an excellent illustration that bycatch reduction does not necessarily provide for increases in net economic benefits and also highlights the critical role that the management regimes for the target and bycatch species will play in the overall, long term economic changes that may result from reductions in bycatch for any fishery.

Given the result regarding potential losses to the shrimp harvesting industry, there would need to be a larger positive change in net benefits to the commercial and recreational users of the red snapper resource if the RIR test of benefits exceeding costs is to be met. A problematical issue on the benefits side is that the red snapper fishery is managed on a constant catch basis, versus a constant fishing mortality rate basis, so some of the gains cannot begin accruing until the year 2019, which is the projected stock recovery time. In the interim, the red snapper stock size will be increasing, so there may be a tendency for costs per unit of catch to fall somewhat and that would seem to signal an increase in benefits. However, as a counter situation, the fishery operates under a quasi license limitation program with an overall quota, trip limits and other restrictions. This management system produces the traditional derby fishery and as red snapper stocks increase, there will be expected decreases in revenues for a given level of TAC. The revenues decrease because TAC (quota) does not increase, but the season would become shorter due to increased catchability. The average annual red snapper price will be expected to fall as it has in other recent years when the derby fishery intensified. Hence, in the period preceding optimal management of the red snapper fishery, even the short term overall effect on benefits to the commercial users of the resource are uncertain or negative.

There is a quota in effect for the recreational users, and the recreational fishery is to be closed when the quota is reached. From an economics standpoint, the truncation of recreational fishing years would create losses in the red snapper recreational fishery and likely would create additional problems as the recreational effort moves to other species. Furthermore, red snapper are part of a mixed catch and a continuing mortality of red snapper from discarded recreational bycatch will be present for the balance of the fishing year. The possibility of a recreational closure would also likely create something like a derby recreational fishery, especially since red snapper are a highly sought species and are pursued in particular by the for-hire recreational sector. The Council could elect to reduce bag limits or take other actions in an attempt to ensure

that the fishery does not close during any given season, but such actions would also tend to decrease the values obtained from recreational fishing. Hence, short term benefits to recreational users will not exist.

For commercial and recreational users alike, the red snapper TAC would be increased to some sort of optimum yield level in the year 2019, the expected time when the fishery would be biologically recovered. Since the new, higher TAC level is not known at this time, and since the recovery period is 23 years in the future, the net present value of benefits to the commercial and recreational users that would accrue starting in 2019 cannot be forecast and in any event would be lower than many might suppose because of the influence of discounting a benefits stream that does not start for 23 years.

Importance of Management Regime

The case of red snapper and shrimp in the Gulf of Mexico strongly emphasizes that the management regime in place will have a dominant role to play in the overall, long term economic changes that will result from reductions in bycatch for any fishery. For example, theory and empirical evidence support the notion that if a fishery operates as a totally unmanaged fishery, then attempts to rebuild stocks via such devices as bycatch reduction, habitat restoration, or other means designed to enhance stocks will not be successful. This outcome is predicated on conditions whereby total effort will increase such that the fishery reaches a long term equilibrium that stabilizes catches at some level which is lower than maximum economic yield. This outcome will occur if the demand for the species under consideration is large enough to encourage the additional effort.

Under other scenarios, there can be an open access management regime that features quotas and a variety of other restrictions like trip and size limits, area closures and gear restrictions. This situation helps preserve the biological status of the stocks, but problems of bycatch mortality and inefficient production methods will still preclude the attainment of all the potential biological and economic benefits. Hence, the overall outcome under this situation is also subject to speculation.

A third class of management features market-driven effort controls such as individual transferrable quotas for the commercial sector. In this case there is a possibility to forecast an increase in overall benefits even without a great deal of information for management purposes.

The current and future management regime has particularly important consequences in the case of the red snapper and shrimp fisheries and indeed on a number of target/bycatch fishery combinations throughout the Southeast and the United States in general. As indicated earlier, at about the time it became clear that an amendment to reduce shrimp bycatch was imminent, Congress indicated the intent to impose a moratorium on new ITQ or similar management approaches until the year 2000. Subsequently, this intent was written into law in the form of the Magnuson Act as amended. As a direct result, the benefits that would have resulted from the

simultaneous implementation of bycatch reduction and effective management of the red snapper resource for commercial purposes have largely been put off at least until the year 2001. Under certain circumstances, benefits could still accrue to recreational fishermen, but such benefits are not guaranteed because the bycatch reduction is necessary merely to maintain recreational and commercial catches at current levels.

How Much Should Bycatch Be Reduced?

From an economic perspective, in those cases where it is economically rational to reduce bycatch to some degree, the optimum reduction in bycatch would be determined by comparing the marginal benefits and marginal costs of each additional reduction in bycatch and the bycatch should be reduced as long as the marginal benefit exceeds that marginal cost of doing so. In the case of shrimp and red snapper, the marginal costs refer to the extra cost that would be incurred by shrimpers and consumers from each additional reduction in bycatch, and includes the present value of current and future losses that would be incurred.

If it could be assumed that fishery managers and shrimpers are economically rational, the easiest, least-cost methods of reducing bycatch would be required and adopted first. Additional reductions in bycatch that could be achieved technically, but only with increasingly restrictive regulations on shrimping activity and concurrent increases in the cost of shrimping, would be adopted next.

At the same time when costs are being determined for the first units of bycatch reduction, the marginal benefits from the reduction should be determined. Marginal benefits refer to benefits that would be received by harvesters and consumers of red snapper that result from a reduction in bycatch by the shrimp fishery. These values include the present value of the extra current and future benefits that would be generated with each additional reduction in bycatch. It should be recognized that even if the first units of bycatch reduction are expected to increase marginal benefits to commercial and recreational red snapper fishermen, marginal benefits from successive increments of bycatch reduction would decline for several reasons. For example, each additional 10% reduction in bycatch probably would yield successively smaller additions to adult red snapper stocks due to the existence of other environmental factors that tend to limit stock growth. Additions to adult red snapper stocks also would probably yield successively smaller additions to profits of commercial fishermen as they increase their investments in fishing effort to harvest additional quantities, and would yield successively smaller additions to enjoyment of recreational fishermen due to the economic principle of diminishing marginal utility. For example, the first five fish caught per trip by recreational fishermen would yield more enjoyment than the second five if bag limits were less restrictive.

Epilogue

In summary, biologists have determined that the red snapper resource in the Gulf of Mexico is depleted for several reasons, including the application of too much fishing effort by

commercial and recreational red snapper fishermen and the incidental bycatch of juvenile red snapper by the shrimp trawl fleet. The ensuing debate about how best to restore the red snapper population to desirable levels involves numerous technological, political, biological and economic factors. Among them are: technological interaction in which shrimping gear inadvertently harvests juvenile red snapper; management interaction between the Reef Fish and Shrimp Fishery Management Plans; competition between commercial and recreational fishermen and among fishermen with different gear types within each group; economic trade-offs over time among various harvesting groups and between different groups of consumers; the current uncertainty regarding whether or not the commercial management structure for red snapper will shift to an ITQ-based system; a lack of current biological information to determine the desirable size of the red snapper stock and the size of future yields, and, the possibility of effort controls on the recreational fishery. For all these reasons, the interaction between the shrimp and red snapper fisheries of the U.S. Gulf of Mexico constitutes a management problem that is controversial, challenging, and, as yet, unresolved.

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Bycatch of Yellowtail Flounder in the Southern New England Trawl Fishery

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Summary

The Southern New England (SNE) stock of yellowtail flounder has been important to New England groundfish fisheries for several decades, but the stock has been depleted to a record low level. During 1988 to 1994, most of the catch, including the exceptionally large 1987 year class, was discarded by trawlers because the majority of fish were either too small for market or smaller than the legal size limit.

A comparison was made of the 1988-1994 outcome with simuations of other scenarios involving lower rates of fishing mortality and discarding. Analyses indicated that when compared to a fishing strategy that maximizes yield per recruit for this fishery, discarding cost the industry and consumers about $15 million in income (profit and crew share) and $11 million in consumer benefits that could have manifested in lower prices for more fish. It was not possible to identify the economically efficient optima for this fishery for two principal reasons. First, managers have not articulated a specific bycatch policy. Although zero discards would most likely be a prohibitively expensive option, not having a policy to evaluate makes it impossible to assess the costs of discard reduction. Second, the a single-species analysis fails to account for the benefits derived from additional species caught jointly with yellowtail flounder in the multispecies trawl fishery, including winter flounder, ocean pout, goosefish, and several others.

The study concluded that most of the variation in landings (and discards) was attributable to reductions in fishing mortality rates implying that to characterize the Southern New England yellowtail flounder trawl fishery as primarily a bycatch issue misidentifies the management problem. The consequences of problem misidentification may have broad implications for developing management strategies for the SNE yellowtail flounder trawl fishery in particular and other fisheries in general. In addition, while the economically optimum level of bycatch could not be determined, analyses indicated that, when compared to a fishing strategy that maximizes yield per recruit for this fishery, the economic optima is probably associated with a lower level of discard, a lower exploitation rate and a higher level of catch for the seven-year period as a whole.

Background

The Sustainable Fisheries Act amendment to the Magnuson-Stevens Fishery Conservation and Management Act requires fishery management plans (FMPs) and international agreements to

adopt regulations and measures that, to the extent practicable, minimize bycatch in U.S. waters. Congress defined bycatch as "fish which are harvested in a fishery, but which are not sold or kept for personal use," and distinguished between "economic discards" and "regulatory discards." Economic discards are "fish which are the target of a fishery, but which are not retained because they are of an undesirable size, sex, or quality, or for other economic reasons." In contrast, "fish harvested in a fishery which fishermen are required by regulation to discard whenever caught, or are required by regulation to retain but not sell" are known as regulatory discards.[1]

Both regulatory and economic discarding have historically occurred in the Southern New England (SNE) otter trawl fishery where the ratio of discards to landings has been estimated to be as high as 3-to-1 by weight.[2] This trawl fishery has been regulated by minimum size limits (12 and 13 inches) on yellowtail flounder (Pleuronectes ferrugineus), the principal target species, and by mesh size controls on the trawl net (4-6 inches). Of particular interest for this case study was the fate of the exceptionally large, 1987 year-class of which 60% was discarded, by weight, throughout the cohort's seven-year life span (Rago et al. 1993). Apart from the issues of why such discards occurred and the responses by industry and managers, we focus on the potential economic value of this fishery during 1988-1994.

Conceptual Framework

Before reporting our findings, it is important to characterize discarding in the SNE trawl fishery in more clear economic terms. First, discarding of undersized yellowtail in the SNE trawl fishery is a form of economic growth overfishing because fishing mortality occurs before optimum economic value is achieved. Not only are the sublegal fish prevented from growing larger and possibly reproducing (virtually all discards are dead), but the "large" market category of this flounder averages about 30 cents per pound more than "small" or "medium" fish.[3] Such premature harvest is a chronic feature of "non-exclusive," open-access fisheries, including fisheries regulated by total allowable catch (TAC) limits. Its extent in limited-access fisheries is being researched for Congress by the National Academy of Sciences.[4]

Second, the "single-species" management approach, which characterizes FMPs, including the New England Fishery Management Council's Multispecies Groundfish Fish Management Plan, does not accurately account for fishing practices in multi-product fisheries.[5] Yellowtail flounder is jointly targeted and harvested by trawl gear in SNE along with winter flounder (Pleuronectes dentatus) and Atlantic cod (Gadus morhua) in large mesh fisheries; whiting (Merluccius bilinearis) in small mesh fisheries; and spiny dogfish (Squalus acanthias), skates (Family Rajidae), and monkfish (Lophius americanus), which are not currently managed by a FMP, to name a few. The latter three species were, until recently, biologically "underutilized" because of weak market demand, but have gained in economic importance since the 1980s as either substitutes for depleted groundfish resources, including yellowtail, or because of foreign demand. In addition, scores of species captured by the trawl gear are not targeted (e.g., pelagic species such as long-finned squid (Loligo spp.) and Atlantic mackerel (Scomber scombrus), which are managed by the Mid-Atlantic Fishery Management Council's Squid, Mackerel and Butterfish

Fish Management Plan). Although not targeted, this incidental catch contributes nonetheless to the financial viability of trawlers.[6] Finally, in other cases, such as for the sea raven (Hemitripterus americanus), there is no market for the incidental catch. To base a bycatch reduction policy solely on the consequences for the SNE stock of yellowtail flounder would imply that other stocks have no value, that the yellowtail stock is by far most valuable, or that all parameters defining the biology (i.e., recruitment) and economics (i.e., prices) of the resource and fishery vary in direct and constant proportion to yellowtail. None of these implications is correct. However, an analysis of joint-production and of discarding of other species is beyond the scope of this inquiry.

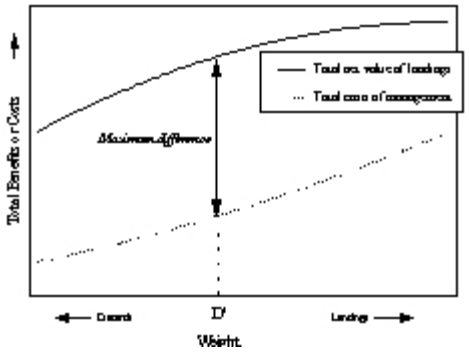

Figure 1a.
Total Net Value and Cost Discards are shown to vary in direct opposite proportion to landings (i.e., high levels of sustainable landings require low discarding, and high levels of discarding results in low sustainable landings). The (hypothetical) a mount of total net economic value is drawn to increase with landings, but at a decreasing rate due to consumer preferences. In contrast, the (hypothetical) total cost of managing sustainable fisheries, including discard management, is drawn to grow at an increasing rate (i.e., it would take increasing amounts of costly, "command-and-control" regulations to manage for low discards).

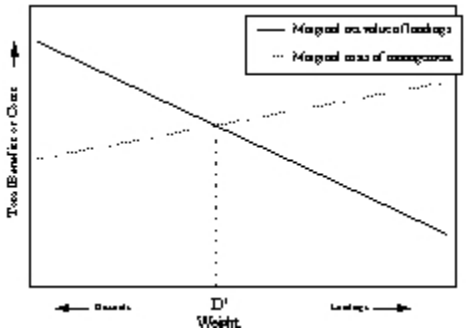

Figure 1b.
Marginal Net Value and Cost
Economic value (net of management and harvesting costs) is maximized at the point just before where the additional, marginal net value of landings (net of harvesting costs) is less than the additional, marginal costs of discard management that brought about the additional landings.

Having provided a broad economic context for the yellowtail flounder bycatch problem, it is time to impart an economic way of thinking about the efficiency of regulating fishermen. Put simply, society is better off from an efficiency standpoint whenever the economic value from the regulation outweighs the costs of imposing the regulation. This reasoning is illustrated in Figure 1a where the distance between the total net economic value of landings (net of fishing costs) and the total costs of management, including discard reduction, is greatest. (Notice that landings and discards vary inversely on the abscissa because high landings require low discards, but high discards cause low landings.) Put another way, discard reduction improves efficiency as long as the "marginal benefit" of the action is greater than the "marginal cost" (Figure 1b). Applying this decision rule, the economically optimal level of discards coincides with D^* on Figure 1b where marginal benefits equal marginal costs (i.e., where the curves intersect). To see the logic of this result, note that left of D^*, where discards are relatively high and landings are relatively low, the marginal benefits of reducing discards (moving left to right on the abscissa) exceed marginal costs. In contrast, continuing to reduce discards beyond D^* is perhaps too costly for society. That is, at discard levels less than D^*, the resources used to reduce bycatch (e.g., the labor, managerial skill, and physical capital used to implement, manage, and enforce discard reduction) are more valuable in the production of other goods and services that are valued by consumers than the gains from greater landings.

Findings

Discarding of SNE yellowtail flounder was investigated using a simulation model of stock dynamics and dockside pricing. The stock assessment model quantified resource conditions, by age, during the seven-year period, 1988-1994, while the 1987 year class was vulnerable to trawl gear (Rago et al. 1993). Other cohorts recruited to the fishery during this period were modeled similarly. Starting stocks (numbers at age) from Rago et al.'s (1993) most recent resource assessment were "fished" in a simulation model that varied the fishing mortality rate (F), proportions of the age-structured stock selected by trawl gear, and age-specific proportions of the catch that were retained or discarded, including all cohorts recruited to the fishery during 1988-1994. Fishing mortality, recruitment, and discard rates were varied at random within conceivable ranges in 1,000 iterations of the model, yielding 1,000 "observations" on landings and discards for the large and small market categories.[7]

The stock assessment model was complemented with price equations for the large and small market categories of yellowtail flounder. Prices were predicted from total yellowtail landings, including landings from Georges Bank, which were held constant at their reported levels during 1988-1994. Yellowtail flounder revenues were generated from the predicted market prices and SNE landings, and the price models were integrated for an estimate of value for consumers.[8] Consumers "profit" whenever market prices are lower than what they would be willing to pay for seafood, thereby leaving more income to spend on other goods and services. However, it is important to account for changes in consumption as prices vary. Together, dockside revenues and consumer "profit," or what economists prefer to call consumers "surplus," are an estimate of the total gross value of SNE yellowtail landings.[9] Revenues and consumer surplus were

standardized to constant 1994-dollars (an attempt to control for inflation), and then discounted to a present value in 1988 using the Office of Management and Budget (OMB) mandated rate of 7%. This procedure would be required of managers who, in 1988, might have asked "What impact would bycatch reduction on the 1987 and subsequent year classes have on dockside benefits during 1988-1994?"

Finally, the dearth of cost data on fisheries is a bane of regulatory impact analysis, but costs were roughly approximated from available information as follows. Vessel operating costs were set equal to 30% of baseline (i.e., observed) revenues and, therefore, held constant for each iteration. This assumes that total fishing effort measured in terms of days is constant regardless of policies to control discards. In contrast, shares paid to captain and crew were calculated as 40% of gross revenues.

Figure 2 compares dockside revenues from SNE yellowtail flounder under baseline ($F_{baseline}$ = 2.29), or observed, conditions to the biological optimum, which maximizes yield-per-recruit (F_{max} = 0.48). Annual dockside revenues drop sharply after reaching $15 million in three years in the baseline case. In contrast, revenues climb steadily to nearly $16 million in five years and level off under the F_{max} alternative. Throughout this arbitrarily short, seven-year period, revenues for the F_{max} scenario are nearly double those for the baseline case when simply summed across years ($71 million compared to $38 million, respectively) and nearly 70% greater when present values are compared ($54 million versus $32 million, respectively). Part of the reason for the superiority of the F_{max} bycatch scenario is that cumulative baseline landings were less during these years (37 million pounds versus 63 million pounds) and discards were correspondingly higher (50 million pounds versus 25 million pounds). However, landings of the higher-priced large yellowtail were also relatively greater for F_{max} (Figure 3). It is important not to overlook the added benefit of fish size.

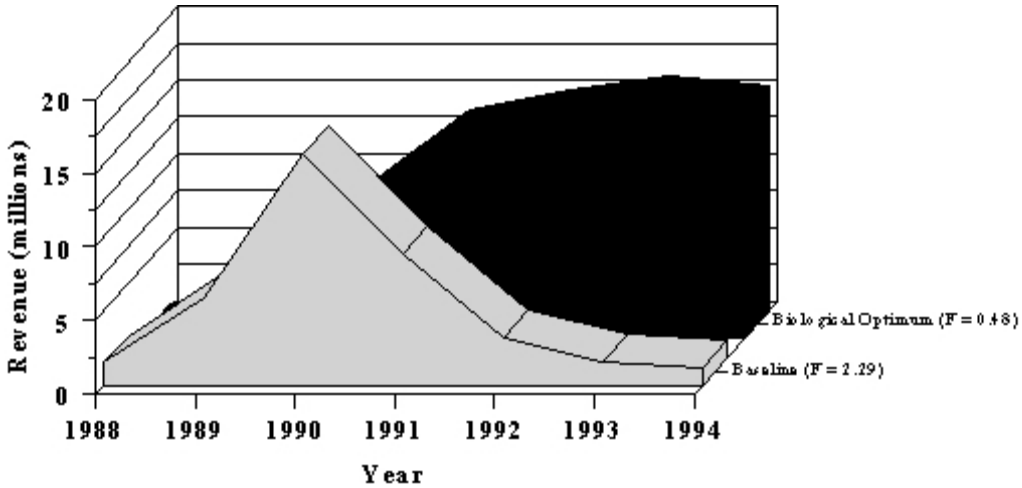

Figure 2. Comparison of Annual Southern New England Yellowtail Flounder Revenues, 1988-1994. The depleted, baseline case corresponds to actual conditions, including revenues obtained from landings of the exceptionally large 1987 year-class. In contrast, revenues that might have been earned from management at the biological optimum (F=0.48) are estimated to be considerably greater.

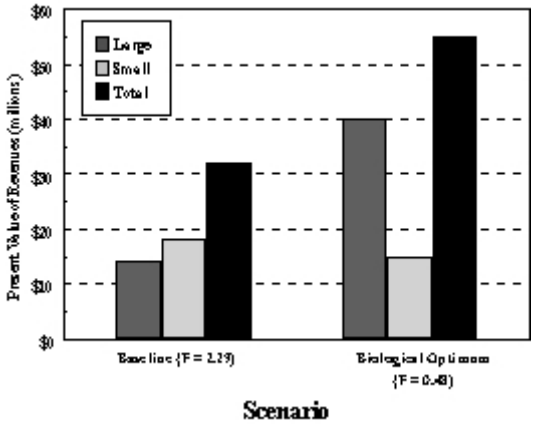

Figure 3. Comparison of Annual Southern New England Yellowtail Flounder Revenues, 1988-1994. Added across this period, revenues from landings of large, high-priced yellowtail flounder comprised the vast majority of total revenues in the scenario where biological yield was optimized. In contrast, revenues from this component of the catch comprised less than half of total revenues in the depleted, baseline case.

Next, turn your attention to the optimum amount of discard reduction from an economics perspective. This inquiry is compromised by not having a clearer understanding of the potential contribution of other species harvested with yellowtail in the SNE trawl fishery and by the absence of a specific policy or set of alternatives intended to reduce discarding. We also cannot identify the point of maximum net economic value because we do not understand the opportunity costs of trawl vessels, captains and crew. However, we can indicate the approximate neighborhood of an economic optimum and regions that are clearly losers.

Figures 4a and 4b each graph selected gross and net economic benefits as a function of landings (left to right) and discards (right to left). Going from top to bottom, we have gross value (revenues plus consumer surplus), net benefits (here, gross benefits net of vessel operating costs), revenues and profit. Profits and net benefits are upper estimates of their value counterparts, producer surplus and net economic value, respectively.[10] Specifically, net benefits are here comprised of consumer surplus, profit, and income to crew. To derive net economic value, however, the opportunity costs of the vessel and of labor should be subtracted from net benefit and the opportunity cost of the vessel should be subtracted from profit. Figure 4a reports totals, and Figure 4b reports marginals (i.e., first derivatives). In both cases, numerical values have been discounted to their present values as mentioned above. Due to the assumption of

constant vessel operating costs, the marginal gross and net benefits curves in Figure 4b are identical.

Looking first at Figure 4a, you see that cumulative total benefits during 1988 to 1994, measured in terms of the present value of the cumulative gross benefits, net benefits, revenues, or profits, climb from low amounts in the neighborhood of the overfished, baseline case of low landings and high discards, but taper and then decline at some point in excess of 70 million pounds and less than 17 million pounds of discards, depending on the curve. The decline results for two reasons. First, there is a point where further increases in landings fail to compensate for the resultant lower price. Second, greater cumulative landings are achieved over the seven-year period by reducing landings sharply early on. However, the benefits of future landings are being discounted to their present value to properly evaluate the economic investment in discard reduction.

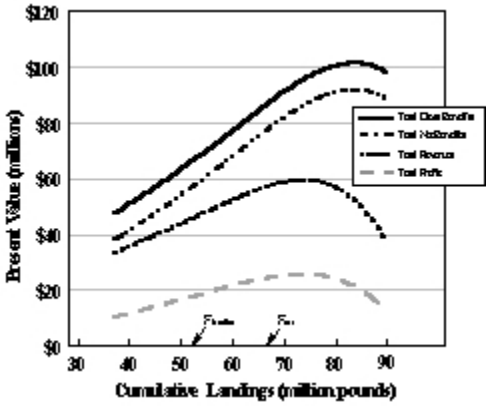

Figure 4a.
Total Benefits of Discard Reduction
(Cumlative Landings, 1988-1994) Annual values were discounted to single, present values. Benefits peak before landings are maximized because it would take too long to achieve higher landings (i.e., distant values are worth too little in present value). Values corresponding to the depleted and biological optimum are marked.

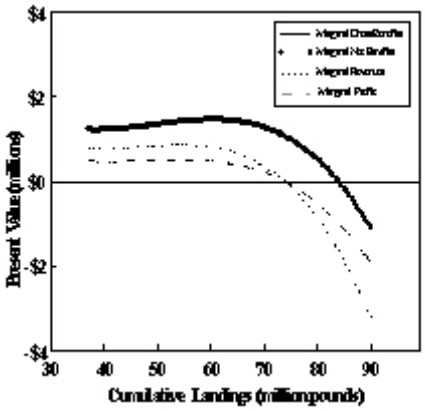

Figure 4b.
Marginal Benefits of Discard Reduction
(Cumulative Landings, 1988-1994) Annual values were discounted to single, present values. Marginal benefits become negative after peaks in the corresponding total benefits.

Also notice that by adding consumer surplus and crew incomes to profit, the economic case for discard reduction is bolstered. This is apparent on Figure 4b where the marginal benefits become zero (coincident with the peaks in total benefits on Figure 4a). Profit is maximized at about 74 million pounds of SNE yellowtail and 13 million pounds of discards. Here, profit is 50% greater than for the baseline where discards are 50 million pounds. The point of maximum profit practically coincides with F_{max}, but this is merely coincidental. However, by factoring in consumer surplus and income for crew, maximum net benefits coincide with about 84 million pounds of landings and negligible discards. Here, some profit and crew share is sacrificed to increase consumer surplus by a greater amount. Be aware, however, that if opportunity costs could be accounted for, net economic value probably would be maximized somewhere between these points.

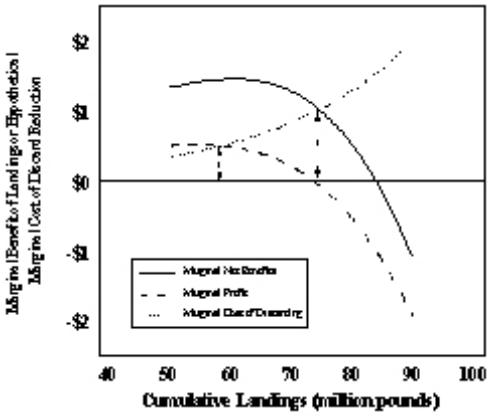

Figure 5.
Efficient Discarding of Southern New England Yellowtail Flounder
Marginal net benefits and marginal profit are from Figure 4b. The marginal cost of discard reduction (implicit in increasing landings) is hypothetical for illustrative purposes. Due to the effect of landings on prices, profits are maximized at lower cumulative landings than are net benefits which includes consumer surplus.

Discard reduction is not a costless policy, however. The regulatory process and regulations themselves typically involve costs that are paid by society and/or the fishing industry. To illustrate the point, the marginal cost of discard reduction is assumed to increase in the direction of lower discards (i.e., from left to right; Figure 5). Optimum discarding from an economic efficiency standpoint is found where the marginal benefit of discard reduction and the marginal cost of discard reduction curves intersect. Ignoring these costs would result in too little discarding. Some bycatch — along with fuel, crew, vessel insurance, etc. — is part of the cost of trawling for yellowtail.

Exactly where marginal benefit and cost curves intersect depends, of course, on which discard reduction policy is adopted and the costs of the resources used to reduce bycatch. The possibilities include (1) conservation engineering and input management, (2) area and/or time management, (3) effort reduction, and (4) property rights. These possibilities are not necessarily mutually exclusive, and each would involve a degree of costs for management, monitoring and enforcement.

Conservation engineering involves increased mesh size and new designs, such as the Nordmore grate now used in the Gulf of Maine shrimp fishery, which are intended to facilitate escapement of undersized yellowtail flounder and possibly other bycatch species from the trawl. To management, monitoring and enforcement, we should add the costs of research and development and production of new gear purchased by fishermen. The effectiveness of conservation engineering alone is suspect, however, because it is easy for fishermen to undermine its intended purpose without a complete and costly at-sea enforcement program, which heretofore has not been implemented.

Area and/or time management often involve closures of fishing grounds during times when undersized fish aggregate. In the yellowtail case, a closure in the SNE area was designed to coincide with where age-2 fish were historically discarded. Area/time management is a substitute for conservation engineering, the costs of which, measured in terms of foregone revenues from jointly-caught species, could be high. Figures 4a and 4b do not reflect this option because the "opportunity costs" of foregone revenues are not depicted.

By reducing the time that trawl gear is fished, effort reduction can be an important avenue to bycatch reduction in overcapitalized fisheries such as the SNE trawl fishery. Reducing effort via reductions in vessel numbers would also greatly reduce dissipation of resource rents.[11] However, resource rent would not result if vessel owners could not economize on fleet sizes. Allocations of days-at-sea (DAS) to individual vessels in the Northeast trawl fishery are scheduled for a reduction to 50% of pre-1994 levels in 1997, but at this time consolidation is not permitted.

Finally, there has not been sufficient discussion of the conservation benefits, including bycatch reduction, of property rights policies, including individual transferable effort quotas (ITEQs) or the more common individual transferable landings quotas (ITQs). Such property rights policies are potentially discard-friendly for at least two reasons. First, fishing effort and, therefore, discards will decline in ITQ fisheries as fishermen economize on the amount of capital they require to catch their quota. Second, and more controversial, by creating a valuable asset to yield in the fishery, fishermen have more incentive to fish in ways that are less damaging to the resource, depending on the degree that their fishing right is attenuated and their influence on management decisions. For example, mobile-gear fishermen in the Atlantic Canada ITQ fishery for cod have voluntarily increased their mesh size and have researched using grates to reduce bycatch.[12] Also, ITQ fishermen in New Zealand's Hoki fishery twice urged their government not to raise TACs as planned for 1993 and 1994.[13] Some researchers

have also highlighted stock enhancement projects funded by associations of New Zealand ITQ fishermen.[14] "Highgrading," which is a form of economic discarding, is often cited as problem for ITQ fisheries, but its extent might be exaggerated.[15] Congress has recently ordered a comprehensive review of ITQ fisheries throughout the world, including their possible conservation benefits.

Conclusions

Discarding of sublegal (regulatory discards) and, to an extent, unmarketable (economic discards) yellowtail flounder in the Southern New England trawl fishery during 1988 to 1994, including recruits from the exceptionally large 1987-year class, resulted because the overcapitalized trawl fishery used a mesh size which, in practice, captured too many small fish. Although the minimum fish size was increased from 12 inches to 13 inches, the trawl gear continued to capture sub-13-inch fish in large quantities.

Discarding SNE yellowtail was costly for the Northeast region. Compared to the biological optimum that maximizes yield-per-recruit, discarding cost the industry and consumers approximately $15 million in income (profit and crew share) and $11 million in consumer surplus (present value estimates). However, discard reduction is always an economically costly task. Therefore, the biological target does not necessarily coincide with what is economically optimal. Furthermore, a single-species approach to discard reduction ignores the contribution made by other jointly harvested species to benefits.

An economic optimum cannot be identified without data on the costs of discarding, including the management and enforcement costs of specific bycatch reduction policies. To completely eliminate discarding is clearly too costly (see Figure 5), but ignoring it is economically wasteful (see Figure 1a). Contrary to popular thinking, traditional notions of conservation and economic efficiency are allies.

Controlling yellowtail fishing mortality somewhere within the economically relevant range for bycatch reduction by correcting the mismatch between fish size and trawl selectivity, including use of time or area closures, could have been a win-win policy from traditional economic and conservation perspectives because of the greater industry incomes and consumer benefits just noted and because of less discarding (e.g., less than 13 million pounds where the marginal benefit and cost of discard reduction are equal compared to 50 million pounds for the baseline). Amendment 7 to the Multispecies Fishery Management Plan, which seeks to reduce DAS in Northeast groundfish trawl fisheries to 50% of pre-1994 levels in 1997, might contribute to bycatch reduction. However, additional necessary measures involving conservation engineering and incentive-compatible property rights are not part of Amendment 7.

The costs of various options to curtail discarding will place a lower bound on what is economically sensible to do. Unlike on fish farms where size-selectivity can be precisely practiced, at least some regulatory discarding of undersized yellowtail flounder will have to be

accepted as part of the cost of prosecuting wild fisheries. However, the task is not necessarily limited to searching for a least-cost alternative that minimizes yellowtail discards. That is, if ITQs are found to be bycatch-friendly and their use by regional fishery management councils is permitted and implemented, the fishing right will take on value in proportion to reductions in vessel numbers and growth of the demersal resources. In any case, reducing discards of juvenile yellowtail flounder in the SNE trawl fishery will frustrate managers until they devise a system whereby those who discard suffer the cost, and those who conserve reap the benefits.

Endnotes

1. Devising a mutually exclusive taxonomy for bycatch is a daunting task that is complicated by the behaviors of fishermen, managers, consumers and processors. For example, a 400-pound trip limit in the "general" permit category of the Atlantic sea scallop (Placopecten magellanicus), fishery can result in regulatory discards. However, by imposing a landings constraint, the trip limit might simultaneously cause fishermen to "highgrade" scallop catches due to the higher price per pound paid for larger scallop meats. Thus, a scalloper could simultaneously be engaged in regulatory and economic discarding. Another difficulty arises because markets are changeable. Therefore, what was an economic discard one year might only be partially discarded the following year after the market is fully supplied, and after several years become a regulatory discard after the resource is overfished and a management plan put in place. For example, incidental catches of monkfish (Lophius americanus) were considered a nuisance by groundfish and scallop fishermen until markets for tails and livers were discovered in Europe and Asia during the 1980s. Now they are overexploited and an amendment to the Multispecies Groundfish Plan proposes adding monkfish to the management unit and to impose minimum size and trip limits.

2. Rago et al. (1993) calculated this estimate using 1990 sea sampling data.

3. Gates and Norton (1974) examined growth overfishing in the SNE yellowtail fishery during the 1970s, and Gates (1976) estimated the influence of fish size on yellowtail dockside prices.

4. See Gordon's (1954) seminal work on overcapitalization that results from open access, but see Cheung (1970) for waste on the revenues side of the equation when resources are non-exclusive, including what has come to be called growth overfishing. Congress used the Magnuson-Stevens Act to call for an independent review of limited access systems, including whether ITQs create sufficient incentives for fishermen to minimize bycatch.

5. Although called the Multispecies Fishery Management Plan, overfishing definitions and practices reveal a single-species approach to groundfish management. Also, the effects of resource, market, or regulatory conditions on fishermen's behaviors and vice versa — e.g., fishing effort and input substitution (Squires and Kirkley 1991) — are not appropriately accounted for in management plans.

6. The FAO defines bycatch as the sum of discards and incidental catch (Alverson et al. 1994).

7. The simulation model was run using Microsoft Excel 5.0 and @RISK software. Fishing mortality (F) and partial recruitment (PR) and discard rates (DR) for age-1, age-2, and age-3 flounder were varied within uniform distribution functions as follows: (1) 0.000 to 3.000 for F ; (2) 0.000 to 0.050 for PR_{age-1}; (3) PR_{age-1} to 0.200 for PR_{age-2}; (4) PR_{age-2} to 1.000 for PR_{age-3}; (5) DR_{age-2} to 1.000 for DR_{age-1}; (6) DR_{age-3} to 0.900 for DR_{age-2}; (7) 0.300 to 1.000 for DR_{age-3}.

8. The average value of consumers surplus from total landings was used in these estimates because it would be arbitrary to assign SNE landings as being either the first or last supplies.

9. This is not the place to delve further into notions of economic value. See Edwards (1991) for a discussion related to fisheries and for more references.

10. See Copes (1972) for definitions and graphical relationships.

11. See Gordon (1954).

12. This information was reported by Jean Guy d'Entremont, a small-boat fishermen, at the New England Aquarium's forum on "Establishing an Agenda for Responsible Fishing," held in Boston on December 3, 1996.

13. Paper presented by Eric Barratt, then past president of the New Zealand Fishing Industry Association and General Manager of the Sanford South Island Limited fishing business, at the Fishery Council of Canada's 1994 Annual Convention on "Building a Fishery that Works: A Vision for the Atlantic Fisheries," held in Fredericton, New Brunswick.

14. Pearse and Walters (1992).

15. Arnason (1994).

Response to Comments

In March 1997 NMFS published a Notice of Availability in the Federal Register announcing the availability of the draft bycatch plan, Managing the Nation's Bycatch: Priorities, Programs and Actions for the National Marine Fisheries Service. Comments were received from 36 organizations or individuals representing a range of interests from conservation organizations to commercial and recreational fishing associations to the fisheries management councils and state management agencies. The comments were very helpful in revising the plan and preparing the final document. This appendix summarizes the comments and addresses each major comment. Many commenters also identified inconsistencies in the draft plan and suggested editorial or textual changes. These specific comments are not addressed here, however, the final plan document incorporated these suggestions as much as possible.

Inconsistent Definition of Bycatch
Comment: Several commenters stated that the definition of bycatch used in the bycatch plan is inconsistent with that in the Magnuson-Stevens Act. Specifically, commenters questioned the inclusion of retained incidental catch and unobserved mortality in the definition of bycatch. Several stated that the definition used in the plan deviated from the accepted definition of bycatch.

Response: The retained incidental component was removed from the definition of bycatch in the final version of this plan in order to make the NMFS national bycatch goal consistent with the MSFCMA and National Standard 9. The inclusion of unobserved mortality is essential to meeting NMFS' responsibility to assess total fishing mortality and to base management decisions on the best scientific information available.

The question of whether retained incidental catch should be included in the definition of bycatch is a difficult one. There are situations where suboptimal use of species as incidental catches in one fishery may adversely effect the catch and revenue to fisheries for which the same species is the primary target. In such instances the by-product (bycatch) of one fishery may have very great consequences on our ability to maximize the biological (yield or spawning) or economic potential of such shared resources, and may very well require their reduction or elimination in some fisheries.

However, inclusion of retained incidental catch is not consistent with the MSFCMA's definition of bycatch. The MSFCMA defines bycatch as "fish which are harvested in a fishery, but which are not sold or kept for personal use." The MSFCMA goes on to require that this bycatch be minimized to the extent practicable. Including retained incidental catch in the definition of bycatch would conflict with this mandate because, in many cases, retained incidental catch is a vital component of the overall economic activity generated by a fishery. Thus, it may be desirable to preserve this component of the catch, even as fishermen strive to eliminate or greatly reduce the discard and unobserved mortalities.

Adopting a broader operational definition of bycatch NMFS recognized that mortality associated with fisheries is greater than retained catch. Other components of fishing mortality, such as unobserved fishing mortality due to encounters with gear, may be critical elements affecting the sustainability of fisheries and marine ecosystems.

Unclear Prioritization of Minimization vs. Increased Utilization
Comment: Several commenters suggested that the bycatch plan does not clearly prioritize bycatch minimization over increased utilization of retained incidental catch. Commenters expressed concern that while the bycatch ?scorecard" could be improved by increasing utilization of catch that is currently discarded, this would not result in the decrease in bycatch mortality implicit in National Standard 9.

Response: In resolving bycatch issues first priority must be given to avoiding bycatch to the extent practicable. To the extent that it is not practicable, then priority must be given to minimizing bycatch mortality. The goal of the bycatch plan is to ?implement conservation and management measures for living marine resources that will minimize, to the extent practicable, bycatch and the mortality of bycatch that cannot be avoided." Inherent in this goal is the need to avoid bycatch over creating new ways to utilize bycatch. The practicability of reducing bycatch is not a static concept. It is expected that, over time, technological innovations and changing demands of fisheries may expand the practicability of reducing bycatch and bycatch mortality. In such cases, bycatch management, too, would respond by taking steps to further reduce bycatch as intended by National Standard 9.

Need for a Framework for Determining Priorities
Comment: Several commenters suggested that the bycatch plan include a framework for determining priorities among objectives and recommendations.

Response: Determining priorities for bycatch minimization is, in many cases, a regional- and Council-level issue and NMFS feels strongly that this is appropriate. For national and intra-regional objectives and recommendations the bycatch plan establishes a framework by which priorities can be determined. The framework is flexible yet consistent, designed to meet evolving needs of scientists and managers in a predictable, consistent fashion. This flexible approach is intended to encourage innovative approaches to bycatch management while establishing a deliberative framework by which management decisions are made.

The purpose of this plan is to assess what is known about bycatch in the nation's fisheries and what steps should be taken to address bycatch through science and management. Decisions regarding funding and allocation of the Agency's resources is outside the scope of this document.

More Detailed Discussion of Ecosystem Effects
Comment: Several commenters remarked that the discussion of ecosystem effects of bycatch lacked sufficient detail to be indicative of NMFS' ecosystem-related bycatch planning.

Response: The full range of ecosystem effects of all three components of bycatch (discarded catch, retained incidental catch and unobserved mortality) on living marine resource populations, predator/prey relationships, detrital food webs and essential fish habitat is not well understood. The inclusion of ecosystem level effects in all stages of bycatch planning as outlined in the document emphasizes its importance to research planning and management decision-making. While a body of literature has begun to develop on the effects of bycatch on the functioning of components of marine ecosystem, a detailed discussion of specific ecosystem effects of bycatch is not possible at this time.

Insufficient Attention to Recreational Fisheries
Comment: Commenters expressed concern that the draft bycatch plan focused on commercial fisheries bycatch to the exclusion of recreational fisheries.

Response: Bycatch is an issue that affects nearly every fishing operation, both commercial and recreational. The bycatch plan is intended to be used to guide NMFS' bycatch-related research and management, for commercial and recreational fisheries bycatch. As in many commercial fisheries, the magnitude of bycatch mortality in recreational fisheries is not fully documented and post-release survivability is of great interest. The discussion of bycatch has been expanded at several places in the document to more fully address bycatch issues in recreational fisheries.

Overemphasis of Economic Considerations
Comment: Several commenters stated that the bycatch plan overemphasized economic considerations related to bycatch management in relation to population, socio-economic and ecosystem considerations.

Response: Economic factors must be considered in bycatch management. However, they must be balanced with other concerns. Full consideration of economic incentives and disincentives can help managers determine how current management may contribute to total fishing mortality, including bycatch, and how management can be designed to most effectively minimize bycatch. However, these economic considerations should be viewed in context with considerations of bycatch as it effects ecosystems and populations of living marine resources as well as fishery participants and fishing-dependent communities. The bycatch plan attempts to give balanced consideration to each of these factors in order to meet the national goal of minimizing bycatch and bycatch mortality.

The economic consequences of dealing with bycatch is one of the factors that determines the extent to which it is practicable to reduce bycatch or bycatch mortality in a particular fishery. The determination must be based on the net benefit to the nation resulting from particular management measures. The net benefit to the nation includes, but is not limited to, reductions in negative impacts on affected stocks; short- and long-term incomes accruing to participants both in the fisheries in which the bycatch is taken and in the fisheries which target the bycatch species; environmental consequences; non-market values of bycatch species, including non-

consumptive uses of bycatch species and existence values; recreational values; and impacts on other marine organisms.

Inconsistent Use of Bycatch and Discards
Comment: Several commenters noted that the terms bycatch and discards are used interchangeably or inconsistently throughout the bycatch plan.

Response: Discards and unobserved mortality, are components of bycatch. There is currently very little quantitiative information available about unobserved mortality, and, by necessity, much of the bycatch plan's discussion about what is known about bycatch is based solely on discards. However, bycatch planning must acknowledge and incorporate unobserved mortality. Furthermore, while retained bycatch in not part of bycatch, estimates of this measure should be included in assessments of total fishing mortality and the total economic activity of a fishery. In the bycatch plan, discussion of long-term strategies and objectives generally focuses on bycatch, including improving current methods of estimating discards, developing new methods to estimate unobserved mortality, and developing management systems to address all three components of bycatch. Sections of the bycatch plan that discuss what is currently known about bycatch, such as the National Assessment, focus on discards since that is generally the only component of bycatch mortality for which quantitative information is available. Corrections have been made to various places in the text where the usage of bycatch and discards was unclear or inaccurate.

Insufficient Attention to Public Concerns
Comment: Several commenters stated that in parts of the bycatch plan NMFS appeared dismissive of public concerns about bycatch and assumed a condescending tone regarding bycatch management.

Response: Public concern about bycatch has been critical to establishing bycatch as a global fisheries concern. NMFS, with its partners in industry, the recreational and conservation communities, state fishery management agencies, the fishery management councils and tribal and international management organizations has listened to this public concern and is responding, in part, with iniatives like this bycatch plan. NMFS recognizes and appreciates the importance of two-way dialogue with all of its constituents, particularly in addressing an issue as complex as bycatch.

More Direct Discussion of the Waste Issue
Comment: Several commenters suggested that NMFS address the issue of waste more directly in the bycatch plan.

Response: Reports of large quantities of fishery resources being dumped at sea or of large numbers of marine mammals being taken in fishing operations have resulted in a mounting public concern that valuable marine resources are being wasted or needlessly killed. In part, the inclusion of National Standard 9 in the Magnuson-Stevens Act is the most recent response to

this growing public concern. As NMFS, working in cooperation with regional fishery management councils and constituents, implements measures to minimize bycatch and the mortality of bycatch that cannot be avoided, a concerted effort must be made to consider measures that result in real reductions of bycatch, rather then new ways to use existing bycatch.

Objection to the Term Adequacy of Current Measures
Comment: Several commenters objected to the use of the term adequacy of current measures to describe current management programs.

Response: The determination of adequacy of current measures was made in the context of developing the Bycatch Information Matrix found in Appendix A. This determination was solely part of an exercise to determine what is known about the magnitude and type of bycatch in the nation's fisheries and to identify those fisheries that have some bycatch management measures in place. Adequacy in this context is not meant to serve as a justification to fail to explore other management options nor was the determination made in view of National Standard 9 criteria.