current

THE JOURNAL OF MARINE EDUCATION

Volume 25 • Number 3 • 2009

special issue featuring

U.S. Regional Fishery Management Councils

Providing sound stewardship of our nation's fishery resources

NATIONAL MARINE EDUCATORS ASSOCIATION

"... to make known the world of water, both fresh and salt."

THE NATIONAL MARINE EDUCATORS ASSOCIATION brings together those interested in the study and enjoyment of the world of water. Affiliated with the National Science Teachers Association, NMEA includes professionals with backgrounds in education, science, business, government, museums, aquariums, and marine research, among others. Members receive *Current: The Journal of Marine Education, NMEA News,* and discounts at annual conferences. Membership information is available from: NMEA, P.O. Box 1470, Ocean Springs, MS 39566-1470; Phone: (228) 818-8893; Fax: (228) 818-8894; email: johnette.bosarge@usm.edu, or visit our website online at **www.marine-ed.org/.**

current
THE JOURNAL OF MARINE EDUCATION

Volume 25 • Number 3 • 2009

LISA M. TOOKER, MANAGING EDITOR
SYLVIA SPALDING, DAVID WITHERELL, AND JENNIFER GILDEN, ISSUE EDITORS
MEGAN GARZIANO, DESIGN

Current is published up to four times a year for members of the National Marine Educators Association. Library subscriptions to *Current* are available for $40 a year. Individual copies are available from the editors for $5 plus $1.25 postage.

Editorial and advertising offices: **NMEA**, c/o Johnette Bosarge, P.O. Box 1470, Ocean Springs, MS 39566-1470

Front Cover (starting at top and left to right by row): Pacific Fishery Management Council; South Atlantic Fishery Management Council; Peter Prybot; Western Pacific Fishery Management Council; North Pacific Fishery Management Council; Turtletrax; Alaska Seafood Marketing Institute; Western Pacific Fishery Management Council

current
THE JOURNAL OF MARINE EDUCATION
Volume 25 • Number 3 • 2009

CURRENT LOG *At a recent Honolulu meeting of President Obama's Ocean Policy Task Force, a former Hawaii state legislator quipped that he didn't fully comprehend the meaning of controversy until he became involved in fishery management issues. In this special edition of* Current, *the eight U.S. Regional Fishery Management Councils established by Congress to manage fisheries in the federal waters of the United States summarize some of the major fishery issues facing our nation and the tools used to address them. With America importing more than 85 percent of the seafood it consumes, understanding our domestic fisheries is not only an essential component of being ocean literate, it is a national security issue. We hope the information in this edition provides a sound appreciation of the ocean literacy principle that "the ocean and humans are inextricably interconnected" and inspires you to share it with those you educate in order to foster ocean-literate citizens who are "able to to make informed and responsible decisions regarding the ocean and its resources." For more on ocean literacy, go to www.coexploration.org/oceanliteracy.*

SYLVIA SPALDING *is the Western Pacific Fishery Management Council's communication officer and National Marine Educators Association (NMEA) Traditional Knowledge Committee co-chair. She is active in the International Pacific Marine Educators Network and received the NMEA 2009 James Centorino Award.*

DAVID WITHERELL *is the deputy director of the North Pacific Fishery Management Council. His background includes research on fish behavior and growth, fish stock assessments, and ecosystem-based management strategies for sustainable and viable fisheries. He has authored many peer-reviewed scientific papers on fisheries science, conservation, and management.*

JENNIFER GILDEN *is a staff officer for the Pacific Fishery Management Council in Portland, Oregon. She recently contributed to an analysis of community and social impacts for an environmental impact statement on a catch share program for the groundfish trawl fishery. She also develops outreach and educational materials, contributes to social science efforts, staffs the Pacific Council's Habitat Committee, and enhances the Pacific Council's communication with constituents.*

CONTENTS PART I: INTRODUCTION

CONTENTS PART II: FISHERY ISSUES

CONTENTS PART III: MANAGEMENT TOOLS

CONTENTS PART IV: LESSON PLANS

U.S. REGIONAL FISHERY MANAGEMENT COUNCIL CONTACTS

Commonly Used Fishery Management Terms and Acronyms

Acceptable biological catch (ABC): The range of allowable catch for a species or species group.

Accountability measures (AM): Management controls to prevent annual catch limits from being exceeded and to correct or mitigate catch limit overages if they occur.

Annual catch limit (ACL): The level of annual catch of a population or population complex that if met or exceeded triggers accountability measures, such as a seasonal closure or quota closure.

Bottom trawling: Fishing technique in which a vessel tows a funnel-shaped net to catch mid-water or bottom-dwelling species such as pollock, cod, shrimp, squid, and flatfish.

Bycatch: Fish harvested in a fishery that are not sold or kept for personal use, including economic discards and regulatory discards.

Bycatch reduction device: Devices that are installed in trawl nets to reduce incidental catch.

Catch share program: A program that allocates a specific portion of the annual catch limit of a fish stock to entities such as fishermen, cooperatives, and communities.

Derby fishery: A non-catch share program fishery limited by quotas, where commercial fisherman race to catch as many pounds as they can during the season.

Economic discards: Fish that are the target of a fishery but are not retained because they are of an undesirable size, sex, or quality or for other economic reasons.

Endangered Species Act (ESA): An Act signed in 1973 that restricts any federal or private action that may jeopardize the continued existence of a threatened or endangered species.

Essential fish habitat (EFH): Those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity.

Exclusive economic zone (EEZ): The area from the edge of a state's territorial sea (usually three miles off the coast) to 200 (321.87 km) miles offshore of the United States. Coastal states have United Nations granted rights and responsibilities to control, exploit, manage, and conserve the living and non-living resources of the EEZ.

Ex-vessel price: The amount paid to the fishermen for whole raw fish.

Fishery ecosystem plan (FEP): A fishery management plan that explicitly takes into account terrestrial and other non-fishery factors that affect the coastal zone and the marine environment.

Fishery management plan (FMP): A plan prepared by any of the U.S. Regional Fishery Management Councils, or by the Secretary of Commerce, that contains the conservation and management measures with respect to any fishery of the United States.

Habitat of particular concern (HAPC): Discrete subsets of "essential fish habitat" that provide extremely important ecological functions or are especially vulnerable to degradation.

High grade: The act of discarding lower-quality or lower value fish in favor of retaining better fish.

High seas: All parts of the sea not included in the territorial sea or in the internal waters of a state.

Highly migratory species (HMS): Tuna species, marlin, oceanic sharks, sailfishes, and swordfish.

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.

Limited access privilege program (LAPP): A catch share program whereby quotas (a portion of the total allowable catch of the fishery) may be received or held for exclusive use by a person, business, or other entity.

Magnuson-Stevens Fishery Conservation and Management Act (MSA): An Act by the U.S. Congress to provide for the conservation and management of U.S. fisheries. The MSA provided for the creation of, and guides the actions of, the eight Regional Fishery Management Councils.

Marine Mammal Protection Act (MMPA): An Act that sets annual limits for marine mammal mortality from commercial fishing and other activities in U.S. waters. Measures must be taken if limits are exceeded.

Marine protected area (MPA): Any area of the marine environment that has been reserved by federal, state, tribal, territorial, or local laws or regulations to provide lasting protection for part or all of the natural and cultural resources therein.

Marine spatial planning: Zoning areas of the ocean for specified activities to prevent user conflict and reduce impacts of the activities.

Maximum sustainable yield (MSY): The largest yield (or catch) that can be taken from a species' stock over an indefinite period. The maximum use a renewable resource can sustain without impairing its renewability through natural growth or replenishment.

Mortality: Death rate; ratio of total deaths to total population per unit time.

National Marine Fisheries Service (NMFS): Also known as NOAA Fisheries, NMFS is the NOAA division responsible for the management, conservation, and protection of living marine resources within the U.S. exclusive economic zone. Fishery management plans and amendments developed by the Regional Fishery Management Councils and approved by the Secretary of Commerce are implemented by the NMFS regional offices. NMFS Fisheries Science Centers provide scientific expertise to the Councils.

National Oceanic and Atmospheric Administration (NOAA): The agency within the U.S. Department of Commerce focused on the condition of the oceans and the atmosphere. It includes the National Marine Fisheries Service, National Weather Service, National Ocean Services (which includes the Office of National Marine Sanctuaries, etc.) and other divisions.

Nautical mile (nm): Nautical miles are used on ocean and coastal waters. Statute miles are used for inland areas such as the Intracoastal Waterway and the Great Lakes. A nautical mile is 1/60th of a degree or one minute of latitude. Roughly seven nautical miles equals eight statute miles.

Observer: Any person required or authorized to be carried on a vessel for conservation and management purposes by regulations or permits, e.g. to observe or prevent unnecessary discards or to monitor protected species interactions.

Optimum yield (OY): The amount of fish that will provide the greatest overall benefit to the nation—including economic, social, and biological considerations, particularly with respect to food production and recreational opportunities—while taking into account the protection of the ecosystem.

Overcapitalization: Too many boats and too much gear participating in a fishery.

Overfishing: When the rate at which fish are removed from the population (fish stock) jeopardizes the capacity of the stock to produce maximum sustainable yield (MSY) on a continuing basis, i.e. catching too many fish per year for the stock to provide sustainable fisheries, or harvesting at a rate equal to or greater than that which will meet the management goal.

Overfished: A stock is considered overfished when the population has declined below the minimum stock size threshold, triggering the implementation of a plan to rebuild the stock to sustainable levels.

Pelagics: Fish that live in the water column; open-water species.

Potential biological removal (PBR): Designated limit of fisheries interactions with a protected species allowed under the Endangered Species Act.

Recruitment: A measure of the number of fish that have grown to sufficient size or age to enter a fishery in a given year.

Regional fishery management organization (RFMO): An international organization dedicated to the sustainable management of fishery resources in a particular area of the high seas or highly migratory species that migrate through the waters of more than a single nation.

Regulatory discards: Fish harvested in a fishery that fishermen are required by regulation to discard.

Target catch: The species of fish or catch that is primarily targeted by a fishery.

Turtle excluder device (TED): Device on fishing gear to reduce the incidental catch and mortality of sea turtles.

Call for Papers

SHARE YOUR IDEAS, LESSONS, or RESEARCH in Marine Education!

The editors of *Current: The Journal of Marine Education* are seeking articles for upcoming general issues. We hope to review and publish articles on topics related to marine education. We seek original manuscripts that describe research, lessons, resources, or strategies for teaching marine and aquatic lessons to a variety of audiences. Please submit articles and/or activities by September 13, 2010 to Lisa Tooker at ltooker@sbcglobal.net for consideration.

current THE JOURNAL OF MARINE EDUCATION
Volume 25 • Number 3 • 2009

UNIQUE ENTITIES—U.S. REGIONAL FISHERY MANAGEMENT COUNCILS

BY SYLVIA SPALDING AND PAUL DALZELL

The eight U.S. Regional Fishery Management Councils are responsible for managing and conserving the fisheries of the United States. The Councils have their genesis in the "Cod Wars," a series of confrontations between Britain and Iceland in the 1950s and 1970s regarding fishing rights in the North Atlantic. In 1972, Iceland unilaterally declared an exclusive economic zone (EEZ) extending beyond its territorial waters before announcing plans to reduce overfishing. It policed its quota system with a coast guard. After a series of net-cutting incidents with British trawlers that fished the areas, Royal Naval warships and tug-boats were employed to act as a deterrent against any future harassment of British fishing crews by the Icelandic craft. In retaliation, Iceland threatened to close a major NATO base. In 1976, a compromise between the two nations was agreed upon that eventually allowed a limited number of British trawlers access to the disputed 200-nautical mile (nm) (370 km) limit. The 200-nm EEZs were finally agreed upon at the conference on the Third United Nations Convention on the Law of the Sea in 1982.

MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT

In 1976, in response to these geopolitical developments and the growing consensus of the primacy of 200-nm EEZs, the U.S.

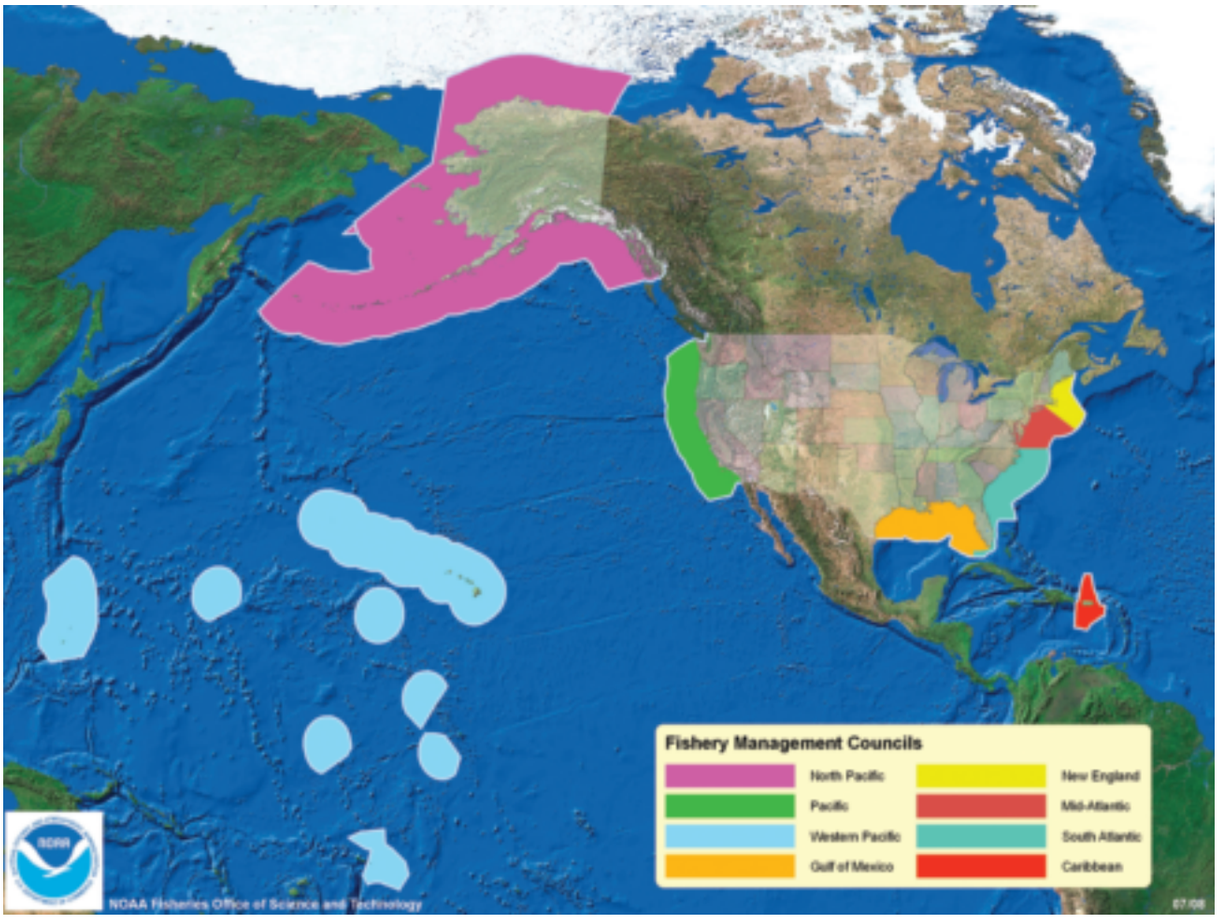


Figure 1. The U.S. EEZ is the largest in the world, containing 3.4 million square miles (11,351,000 km^2) of ocean and 90,000 miles of coastline; located not only along the eastern and western seaboards and Gulf of Mexico shoreline of the continental United States, but also in the Caribbean Sea, Pacific Ocean, and Arctic Ocean.

Congress passed the Fishery Conservation and Management Act (known today as the Magnuson-Stevens Act or MSA), which assumed U.S. authority over the 200-nm EEZ off U.S. coastlines and established the nation's eight Regional Fishery Management Councils. Five Councils were convened on the East Coast—New England, Mid-Atlantic, South Atlantic, Gulf, and Caribbean—incorporating members of their respective states and territories. On the West Coast, a single Council (the Pacific) included Washington, Oregon, and California, as well as Idaho, because of Pacific salmon migrations into Idaho streams and rivers. Another Council, the North Pacific, comprised the waters around Alaska. Lastly, in the far west, stretching from Hawaii across the dateline to Guam and the Northern Mariana Islands and south across the equator to American Samoa is the Western Pacific Council. Also included under the Western Pacific Council jurisdiction are eight central Pacific islands (Wake, Johnston, Midway, Howland, Baker, Jarvis, Palmyra, and Kingman Reef), which are either virtually uninhabited or under military control. The U.S. EEZ encompasses more than three million nm^2, of which about half is under the jurisdiction of the Western Pacific Council.

The advent of the MSA created opportunities for U.S. fishermen, since it pushed all foreign fishing vessels outside the EEZ. Between 1976 and the 1996 reauthorization of the MSA, U.S. fisheries expanded, driven by subsidies and discounted credit. This included the development of a U.S. purse-seine fleet in the Pacific Ocean. However, tuna was specifically excluded from the MSA because it was a highly migratory species, and the U.S. policy at that time did not allow any country to assume ownership and management of tuna stocks found within its EEZ. Several events led to Congress including tuna under the reauthorized MSA in 1992, including the arrest of a U.S. purse seiner in the mid 1980s by the Solomon Islands for fishing in its EEZ; Kiribati entering into a tuna-harvesting agreement with the then Soviet Union; and advice from organizations such as the Western Pacific Council.

The expansion phase of U.S. fisheries between the 1970s and 1990s led in some instances to concerns about overfishing of U.S. fishery resources and the impacts of fishing gear on the ecosystem. As such, the 1996 reauthorization of the MSA included a more stringent overfishing control rule based on measuring biomass and fishing mortality relative to maximum sustainable yield, as well as requirements for Councils to deal with and reduce bycatch where practicable and to describe and protect essential fish habitat. The 2006 reauthorization of the MSA has reaffirmed these standards and principles and requires Councils to set annual catch limits (ACL) to reduce the potential for overfishing. The MSA also allows Councils to implement limited access privilege programs (more commonly called catch share programs).

THE COUNCIL PROCESS

The Councils regulate commercial, recreational, and subsistence fisheries that are conducted in federal waters. States and territories typically manage fisheries from shore out to the limit of the territorial sea, generally, three miles from shore. Apart from national initiatives such as reauthorizations of the MSA, or other statutes that affect fishery management like the Endangered Species Act or National Environmental Policy Act, much of the Council decision-making is undertaken through a bottom-up process.

Each Council is unique in the way that it conducts business, but they all operate on the same basic bottom-up principle. They all have bodies comprised of fishermen, fish processors and dealers, and members of the public interested in fisheries management and conservation. Fishermen are often the first to identify management problems or other issues, since they are on the water and have a vested interest in how their fisheries are managed. While the advisory structures are not identical across all Councils, they broadly reflect the way the Councils learn about issues concerning fishermen and the public and about impacts to fisheries. For example, in the Western Pacific and Pacific Councils, the structures take the form of advisory panels or bodies. Many issues that lead to Council action are first brought before these advisory groups.

Several Councils, like the Western Pacific Council and North Pacific Council, have also developed, or are developing, fishery ecosystem plans (FEPs), which recognize that fishery management cannot be conducted in isolation from other factors that affect the coastal zone and marine environment. Some of the Councils have regional advisory groups to assist in the FEP process. For example, the Western Pacific Council has Regional Ecosystem Advisory Committees (REACs) for its three archipelagos. Each REAC includes representatives from the local and federal governments and non-government organizations focused on planning, agriculture and forestry, water supply, coastal development, tourism, and the military.

All Councils have teams that review stock assessments. In some of the Councils these are called plan teams, while in

The American Samoa Regional Ecosystem Advisory Committee provides input to the Western Pacific Council about land-based impacts to marine resources.

other Councils they are called stock assessment review panels or have another name. These bodies may monitor the performance of fisheries and compile annual stock assessment and fishery evaluation reports. Stock assessments are generally not conducted by these teams, but may be reviewed by them (or other bodies). The teams may also review fishery management issues brought up by other advisory bodies and may comment on these or endorse them for further consideration by the Council.

All Councils are required to have a Scientific and Statistical Committee (SSC), which may meet on a regular basis or on an as-needed-basis. SSCs are made up of federal and other scientists and are charged with reviewing the science aspects of fishery management and the recommendations emerging from Council advisory bodies. Under the most recent reauthorization of the MSA in 2006, the responsibilities of the SSCs have been greatly increased. They are now charged with reviewing all stock assessments and establish acceptable biological catches, from which Councils will set ACLs. The 2006 MSA also requires SSCs to develop five-year research priorities.

Figure 2. The U.S. Regional Fishery Management Council process is bottom-up. Recommendations from fishing communities and other members of the public are reviewed by scientists and managers and, if acceptable, transmitted to the Secretary of Commerce for final approval.

Councils may have other ad hoc committees or bodies to advise particular programs. Examples from the Western Pacific Council include: the Recreational Fisheries Data Task Force, Social Science Research Planning Committee, Marine Mammal Advisory Committee, and Sea Turtle Advisory Committee.

A common feature of all these various bodies is that their meetings are publicly announced in the U.S. *Federal Register*, Council websites, and in the local media. All such meetings are open to the public, and there are specific agenda items on which to take public comment. The same transparency principles apply to Council meetings, where public notification is usually extensive. In addition to *Federal Register* notices, website notices, and advertisements in local papers, fishermen and the public may receive regular mail notifications and summaries of issues for upcoming meetings.

COUNCIL MEMBERS

The Councils are comprised of designated state or territorial officials, National Marine Fisheries Service regional administrators, and representatives from other government departments such as the U.S. Fish and Wildlife Service, Department of State, and the U.S. Coast Guard. The remaining membership is nominated by the state or territorial governments and appointed by the Secretary of Commerce. It includes fishermen from all sectors, fish dealers and processors, indigenous representatives, community leaders, and members of environmental organizations.

The U.S. Regional Fishery Management Councils have been incorrectly described as dominated by fishing interests, especially by representatives from the commercial fishing sector. In the case of the Western Pacific Council, commercial fishing interests have never amounted to more than 30 percent of the voting representation. Similarly, voting representation by fishing sectors on other Councils is balanced by state, territorial and federal representation, and other voting Council members who represent other interests, such as recreational fishing, environmental concerns, community concerns, and indigenous rights.

CONCLUSION

The Councils represent a unique bottom-up approach to fishery management that balances two potentially antagonistic requirements of governance—namely the need for consistent federal fishery management across the United States and the recognition of the enormous size and diversity of our country, which extends from the Arctic to the South Pacific and from Plymouth Rock to the boundaries of Southeast Asia. U.S. fisheries include a diverse assortment of fishing activities, ranging from large-scale commercial fisheries catching millions of pounds of fish for mass consumption to traditional indigenous fisheries where harvests are for subsistence and cultural purposes.

While the Councils do not have an unblemished record of fishery management, they represent a transparent process

In the bottom-up decision-making process, recommendations from various stakeholders, advisory panels, and plan teams are reviewed by the appropriate Scientific and Statistical Committee (SSC) before moving to the region's Fishery Management Council. Pictured are members from the SSC for the Western Pacific Region.

where anyone can express their opinion on how fisheries should be managed. As a consequence, the United States has well-regulated fisheries, where 84 percent of the fish stocks in the nation are fished at sustainable harvest rates, and the situation is improving every year. Moreover, U.S. fisheries are already an exemplar to the world, ranking second behind only Norway's fisheries in their compliance with the United Nation's Code of Conduct for Responsible Fisheries.

Most recently, President Obama's administration has proposed new initiatives for U.S. ocean governance such as a National Ocean Council to coordinate all coastal and Great Lakes stewardship responsibilities and ensure accountability for all actions affecting ocean, coastal, and Great Lakes resources. It remains to be seen how this initiative will interface and operate with the Councils' bottom-up inclusive approach to fishery management.

SYLVIA SPALDING is the communications officer for the Western Pacific Fishery Management Council. She may be contacted at sylvia.spalding@noaa.gov.

PAUL DALZELL is the senior scientist for the Western Pacific Fishery Management Council and its lead for tuna and billfish fisheries. Dalzell has worked in the Pacific Islands and Southeast Asia for more than 30 years and has published extensively on marine fisheries assessment and management, including a landmark review of Pacific islands coastal fisheries. He may be reached at paul.dalzell@noaa.gov.

REFERENCES

Pitcher T. et al. (2000). Not honoring the code. *Nature* 457, 658-659.

White House Council on Environmental Quality. (2009). *Interim Report of the Interagency Ocean Policy Task Force*. Washington, DC: White House Council on Environmental Quality. 38 pp.

MORE RESOURCES

U.S. Regional Fishery Management Councils:
http://www.fisherycouncils.org/

PHOTO CREDITS

Figure 1: Courtesy of NOAA Fisheries Office of Science and Technology

Pages 5 and 7: Courtesy of Western Pacific Fishery Management Council

Figure 2: Courtesy of Western Pacific Fishery Management Council

The Western Pacific Fishery Management Council provides opportunities for fishermen to learn and voice their opinions about fishery management issues during Fishers Forums held regularly in Hawaii, American Samoa, Guam, and the Commonwealth of the Northern Mariana Islands.

current THE JOURNAL OF MARINE EDUCATION
Volume 25 • Number 3 • 2009

FISHERIES OF THE UNITED STATES

BY KIM IVERSON AND ANNA MARTIN

Let's go fishing! These words may bring to mind fond memories of family fishing trips to the coast or a recent charter trip offshore. For some, it signals the beginning of a multi-day trip on board a commercial fishing vessel in hopes of bringing home a profitable catch. In the United States, marine fisheries are as diverse as the people who live along the country's coastal shores and islands, and they constitute an important part of the social and economic viability of coastal communities and the national economy.

SOCIOECONOMIC IMPORTANCE

U.S. commercial and recreational fishing generated more than $185 billion in sales and supported more than two million jobs in 2006, the most recent year for which statistics are available. The U.S. commercial fishing industry—harvesters, seafood processors and dealers, seafood wholesalers, and seafood retailers—generated $103 billion in sales and $44 billion in income and supported 1.5 million jobs. Recreational fishing generated $82 billion in sales and $24 billion in income and supported 534,000 jobs in the United States.

Shrimp nets in the South Atlantic.

The economic value inherent in commercial fisheries throughout the country is on the rise. While landing totals within the commercial sector declined 11 percent between 2007 and 2008, the values of those landings rose by five percent. Finfish accounted for 87 percent of the total landings, but only 51 percent of the value. Species such as crabs, shrimp, scallops, and lobster remain an important part of U.S. fisheries.

During 2008, over 12 million anglers made approximately 85 million marine recreational fishing trips off of the Atlantic, Gulf, and Pacific coasts and caught an estimated 464 million fish. Of this catch, 58 percent were released alive. Nationally, most of the recreational catch was taken from state and inland waters with an estimated eight percent of total catches coming from federal waters. The Atlantic coast accounted for the majority of angler trips (more than 61 percent) and catch (54 percent). Along the Atlantic coast, black sea bass, Atlantic cod, dolphinfish, and summer flounder are commonly targeted offshore species.

REGIONAL FISHERIES

North Pacific

In 2008, commercial fishermen unloaded 612.7 million pounds of fish (mostly pollock) and shellfish at the port of Dutch Harbor-Unalaska, Alaska, making it the country's top commercial port for the amount of fish landed for the 20th consecutive year. The North Pacific Fishery Management Council is responsible for management of the commercial groundfish fisheries, including Pacific cod, pollock, flatfish, mackerel, sablefish, and rockfish species using trawl, hook and longlines, jig, and pot gear. The combined landings for the North Pacific fishery totaled four-billion pounds in 2008 and was valued at $815 million to the fishermen (ex-vessel revenue).

Recently made famous by the television show *Deadliest Catch*, Alaska's crab fisheries produce more than one-third of the total U.S. crab catches and include king, snow, and Dungeness crab. Collectively, U.S. landings of king crab and snow crab totaled more than $220 million dollars in 2008. Alaska is also a popular destination for recreational fishermen targeting halibut and salmon.

Pacific

Federal waters off the coasts of Washington, Oregon, and California are managed by the Pacific Fishery Management

Rank	Species	Pounds
1	Pollock	2,298,112
2	Menhaden	1,341,413
3	Flatfish	663,116
4	Salmon	658,342
5	Hakes	549,572
6	Cod	513,027
7	Crabs	325,184
8	Herring (sea)	259,597
9	Shrimp	256,597
10	Sardines	193,078

Rank	Species	Dollars
1	Crabs	562,267
2	Shrimp	441,818
3	Salmon	394,594
4	Scallops	371,641
5	Lobster	336,902
6	Pollock	334,477
7	Cod	304,895
8	Halibut	217,735
9	Clams	186,718
10	Flatfish	184,209

Table 1. Major U.S. Domestic Species Landed in 2008. Ranked by "Quantity" and "Value" (numbers in thousands).

Council where salmon, groundfish, coastal pelagic species, and highly migratory species such as tunas, sharks, and swordfish are the most common fisheries.

Salmon provide both spiritual and physical sustenance to Native American tribes in this region and have symbolic importance for the entire Northwest. The salmon fishery also includes recreational anglers and commercial fishermen (using troll and gillnet). Recently, low returns for Chinook and coho salmon have been recorded from the Klamath and Sacramento River systems, which have traditionally supported the fishery for a large part of the West Coast. The Pacific Council took the unprecedented action of closing all ocean Chinook salmon fisheries off California and most of Oregon in 2008 and 2009.

The groundfish fishery consists of over 90 species, a complex made up of rockfish, flatfish, roundfish, sharks, skates, and others. Commercial trawlers account for most groundfish landings, but these fish are also caught recreationally. The West Coast trawl groundfish fishery is currently being put under a catch share program.

Coastal pelagic species include northern anchovy, market squid, Pacific herring, sardines, and mackerel. They are targeted primarily with seines and nets. During the 1930s, Pacific sardines were the largest U.S. fishery in volume, with catches off the central California coast of over 200,000 metric tons. The fishery—which is the subject of John Steinbeck's famous novel *Cannery Row*—collapsed by the late 1940s. It has been a long held belief that the collapse was the result of overfishing. Recent evidence indicates that natural interdecadal fluctuations and the

Pacific coast trawler.

Traditional sailing canoe off Guam. According to archaeological research, pelagic fish accounted for a high proportion of the fish caught and eaten by the Chamorro people of Guam and Rota prior to Western contact.

sensitivity of sardines and anchovies to ocean temperature may have also played roles. The sardines have made a strong biological comeback over the past decade.

Western Pacific

The Western Pacific Region includes the State of Hawaii, U.S. Territories of American Samoa and Guam, Commonwealth of the Northern Mariana Islands, and eight U.S. Pacific remote island areas. Its inhabitants include: large Native Hawaiian, Samoan, Chamorro, and Refaluwasch populations with cultural ties to fishing that span millennia. All U.S. Pacific island communities are considered coastal, and the annual per capita consumption of seafood in Hawaii is 41 pounds, about three times the national average of 16.5 pounds.

The largest commercial fisheries target highly migratory pelagic fish within federal waters and on the high seas. Honolulu ranks among the nation's top five fishing ports in value of landings ($73.3 million in 2008) because of the quality of the high value, fresh (not frozen) tuna and swordfish harvested by the Hawaii-based longline fishery. The Kona charter fishery is the world's largest blue marlin targeting charter fishery. American Samoa is home to one of the world's largest tuna canneries, processing foreign and U.S. caught skipjack, albacore, bigeye, and yellowfin tuna.

The nearshore fisheries are socially and culturally important, with a high number of participants in the U.S. Pacific islands. In Hawaii, more than 25 percent of the households surveyed engage in non-commercial pole-and-line fishing (QMark 2005). Commercial and non-commercial fishermen regularly harvest several hundred species of bottomfish, crustacean, and coral-reef-related species. Additionally, the deepwater precious coral fishery has been sustainably managed for a half century. A significant commercial lobster fishery in the Northwestern Hawaiian Islands (NWHI) was permanently closed by Presidential executive orders that proclaimed a 1,200-mile chain of small islands and atolls as a reserve and then a marine national monument. The NWHI limited entry bottomfish fishery will close in 2011 for the same reason.

No purely domestic fishery managed by the Council is experiencing overfishing. Bigeye tuna, a pan-Pacific population, is experiencing overfishing and is managed under two tuna fishery management conventions, which have imposed bigeye catch limits. The only overfished fishery is the armorhead stock at Hancock Seamount, which was depleted prior to Council existence and has been under a series of moratoria since 1986. Most of the stock lies in the international waters of the Emperor Seamounts.

New England

For centuries, Atlantic groundfish stocks have supported a fishery that has served to shape the economy and culture of New England. Fishing for groundfish species, which often school together near the ocean bottom, was the first colonial industry in America. The fishing ports of Gloucester and New Bedford, Massachusetts became icons of U.S. commercial fishing, where ships loaded with Atlantic halibut, ocean perch, haddock, yellowtail flounder, and cod fish once fed millions of Americans. Foreign fleets in the 1960s and 1970s targeted these same stocks, removing millions of pounds of fish over a very short period of time. Development of advanced gear technologies, electronic navigation, fish-finding tools, and increased vessel power during the 20th century all greatly expanded this fishery and led to severe declines of almost all of New England's groundfish stocks.

With too many vessels chasing too few fish, the groundfish fishery reached an all-time low by 1994. Fishery managers began to implement seasonal and year-round area closures, gear restrictions, minimum size limits, limited access, and restrictions on the number of days a vessel is allowed to fish; and some of the 19 species in the management plan began to rebuild. Increases for several stocks are being observed for the first time in nearly a decade, including cod and haddock.

The sea scallop resource off of New England is at historic high levels, with landings in the last five years each in excess of 50 million pounds annually and a value of nearly $370 million dollars in 2008. Although the stock had experienced overfishing, the resource has recovered through effort controls, including a program that rotates access to harvest areas.

Mid-Atlantic

In the Mid-Atlantic region, measures were implemented to prevent overfishing on surfclams, ocean quahogs, Atlantic mackerel, scup, bluefish, monkfish, spiny dogfish, and tilefish. In 1990, individual transfer quota (ITQ) programs that allocated catch amounts to individual vessel owners were established for the surfclam and ocean quahog fisheries. This was the first time in the U.S. where this type of management strategy was implemented. The ITQ system was implemented because of economic issues.

Over four million recreational anglers in this region fish for bluefish, summer flounder, scup, mackerel, tilefish, croaker, striped bass, and black sea bass on a yearly basis. The black sea bass stock is rebuilt as a result of the measures put in place by the Mid-Atlantic Fishery Management Council, which began managing the stock in 1996.

Both commercial and recreational fishermen are involved in a Mid-Atlantic Research Set-Aside program. This unique program was created as a vehicle to fund research projects through the sale of research quota. Proceeds from the sale of research quota are used to pay for research costs and to compensate fishing vessels that harvest research quota. No direct federal funds are provided for research.

South Atlantic

From the Outer Banks of North Carolina to the tropical waters off the Florida Keys, the fisheries managed by the South Atlantic Fishery Management Council are as diverse as the creatures and habitats that stretch along more than 1,000 miles of coastline. The area includes Islamorada, Florida, boasting itself the "Sportfishing Capital of the World," and many historical fishing communities with diverse commercial fleets scattered along the coasts of the Carolinas, Georgia, and eastern Florida.

As the human population continues to grow in the southeast, so does pressure on the region's marine resources. The total number of anglers in the South Atlantic increased by 55 percent between 1997 and 2006, and this trend is expected to continue. Of the estimated 52 million marine recreational trips taken in the U.S. in 2008, almost 22 percent were made in east Florida, followed by nearly 14 percent in North Carolina. Species such as dolphinfish (mahimahi), wahoo, king and Spanish mackerel, sea bass, snappers, groupers, and spiny lobster are popular targets for both recreational and commercial fishermen.

Brightly colored dolphin (sometimes referred to as mahimahi or dorado) and wahoo are two popular sport fish caught in the Florida Keys, the "Sportfishing Capital of the World."

Seven of the eight fisheries managed by the South Atlantic Council are being fished at sustainable levels. Only the snapper and grouper fishery has species that are experiencing overfishing. With 73 species in the management complex, the mixed-species nature of the fishery offers the greatest challenge for successful management. Mandates to end overfishing are forcing the Council to consider closing large areas to all fishing for these popular reef-dwelling species, with severe economic and social consequences to both the commercial and recreational fisheries.

U.S. Caribbean

The crystal waters off the coasts of Puerto Rico and the U.S. Virgin Islands attract both commercial and recreational fishermen targeting spiny lobster, queen conch, and the numerous species associated with the area's tropical reefs. More than 230,000 recreational fishermen make more than 1.4 million fishing trips in this area each year. Regional species managed by the Caribbean Fishery Management Council know no jurisdictional boundaries and often move between waters surrounding the Caribbean and international waters, necessitating management coordination with other countries.

The Council's Shallow Water Reef Fish Management Plan, implemented in 1985, covers 140 species including popular snappers and groupers. Seasonal area closures have been used to protect spawning aggregations, but the complexity of the multispecies fishery, together with the high diversity of species caught on every trip, continues to present challenges to scientists and managers.

Despite management measures implemented since 1981, landings, catch rates, and abundance for spiny lobsters have continued to decline. The Council is working to increase enforcement and data collection to help improve the condition of the lobster resource in the region. Harvest of queen conch, targeted by both commercial and recreational divers for their meat and attractive shells, continues to increase. The Council has implemented minimum size limits in an effort to rebuild this species throughout its range.

Gulf of Mexico

The commercial shrimp fishery in the Gulf of Mexico is the nation's largest, comprising 73 percent of the nation's total landings of 256.6 million pounds valued at more than $440 million dollars in 2008. Louisiana alone contributed 89 million pounds, yet the overall Gulf harvest dropped 20 percent compared to 2007. Competition from cheaper foreign imports, increased operating costs, and other factors have led to an overall decrease over the past few years.

Councils manage non-commercial and commercial fisheries. Pictured are sashimi-quality tuna from the Hawaii longline fishery being sold at the Honolulu fish auction.

Reef fish, king and Spanish mackerel, spiny lobster, stone crab, and red drum are also economically important species managed by the Gulf of Mexico Fishery Management Council. The Council has used marine protected areas, gear restrictions, and seasonal closures as a tool for the conservation and management of the region's resources. In addition to managing traditional fisheries, the Council recently developed a plan to regulate offshore aquaculture in the region.

The mixed-species nature of the reef fish complex presents challenges for managers. To help address problems resulting from overcapacity and the derby nature of the fishery, the Gulf Council recently implemented a catch share program for the commercial harvest of red snapper. A similar type of management program for grouper and tilefish is expected to begin in 2010.

CONCLUSION

Marine fisheries in the United States are highly regulated, and fishery managers continue to work toward sustainable fisheries for all economically important stocks. While some stocks are threatened by overfishing or continue to be listed as overfished, the majority of domestically assessed fish stocks are either not subject to overfishing (84 percent) or not overfished (77 percent). New requirements to implement annual catch limits and end overfishing through the reauthorized Magnuson-Stevens Fishery Conservation and Management Act will help to reach the goal of sustainable fisheries.

REFERENCES

NOAA National Marine Fisheries Service. (2008). *Fisheries of the United States*. U.S. Department of Commerce.

NOAA National Marine Fisheries Service. (2009). *NOAA Fisheries Service: 2008 Business Report*. U.S. Department of Commerce.

Pacific Sardine Online, Oregon State University Seafood Laboratory: **http://osuseafoodlab.oregonstate.edu/seafoodlab/sardine.htm**

QMark Research and Polling. (2005). *Noneconomic Value of Hawaii's Coral Reef: Results from Telephone Survey and Focus Groups*. For the Hawaii Coral Reef Initiative Research Program.

KIM IVERSON has worked as the public information officer for the South Atlantic Fishery Management Council for the past 10 years. She is a National Marine Educators Association (NMEA) member and presented during the 2008 National NMEA Conference on outreach efforts in partnership with the Smithsonian Marine Station relative to the Oculina Bank deepwater coral protected area. She may be reached at kim.iverson@safmc.net.

ANNA MARTIN is the outreach assistant with the South Atlantic Fishery Management Council. She may be reached at anna.martin@safmc.net.

PHOTO CREDITS

Pages 8 and 11: Courtesy of South Atlantic Fishery Management Council

Table 1: Courtesy of Department of Commerce (Fisheries of the U.S. 2008)

Page 9: Courtesy of Pacific Fishery Management

Page 10: Courtesy of Lawrence Cunningham/TASI (Traditions About Seafaring Islands)

Page 12 (left): Courtesy of Western Pacific Fishery Management Council

Page 12 (right): Courtesy of Mid-Atlantic Fishery Management Council

Mid-Atlantic traps.

DEVELOPING ECOSYSTEM-BASED MANAGEMENT OF U.S. FISHERIES

BY DAVID WITHERELL

Management of marine fisheries in the United States is evolving from conservation and management of fish stocks (and management of fisheries for those stocks) to more holistic ecosystem-based management. Ecosystem-based management for fisheries seeks to use available scientific information to manage fisheries so as to prevent substantial adverse or irreversible harm to ecosystem structure or functioning.

The U.S. Regional Fishery Management Councils are making progress toward ecosystem-based approaches by 1) maintaining abundant fish stocks; 2) maintaining healthy habitats; 3) maintaining biodiversity and food webs; 4) minimizing the effects of fisheries on protected species; 5) incorporating variable environmental conditions, uncertainty, and ecosystem science into decision-making; and 6) coordinating with other government non-government agencies and communities to address non-fishery impacts on marine ecosystems.

Steller sea lions at Cape Izigan, Unalaska Island.

ECOSYSTEM-BASED MANAGEMENT

Until the late 1800s, most people believed fishery resources were inexhaustible and that conservation was unnecessary. But observed declines in populations of Atlantic salmon, trout, and other fish raised public concerns about pollution, the construction of dams, and other factors, prompting the U.S. Congress to establish a Commission on Fish and Fisheries in 1871 to investigate the conservation of food fish species in lakes and coastal areas. The Commission built fish hatcheries with stocking programs to boost production and initiated scientific studies of basic marine fish biology.

Over the next 50 years or so, it became apparent that fish population declines could be caused by over-harvesting by fishermen. By the mid 1930s, fishery scientists were measuring variations in abundance and production of year classes, growth rates, and natural mortality rates, as well as variations in fish catches and fishing effort. The objectives of fishery scientists had begun to change from understanding biology and hatching and stocking fish, to determining the maximum amount of a wild fish population (stock) that could be caught on a sustainable basis and implementing management measures to achieve that goal.

The prevailing law for managing marine fisheries in the United States, the Magnuson-Stevens Fishery Conservation and Management Act (MSA), is based on the maximum sustainable yield (MSY) principle. The Regional Fishery Management Councils, which were established by the Act, are required to develop management measures to prevent fishermen from catching too many fish per year (so-called "overfishing") and to prevent stocks from declining below threshold levels ("overfished"). By adjusting annual catch limits (ACLs) or limiting fishing mortality through more indirect means, the Councils strive to maintain fish populations—insofar as possible, given the dynamic marine environment—at a level of abundance that will produce MSY over the long term.

In addition to the direct impacts of fishing on fish stocks, however, climate change and human activities—including other target fisheries—can potentially have large, synergistic, and sometimes unexpected impacts on complex marine ecosystems (Jackson 2008). In turn, changes in marine ecosystems can have dramatic effects on the biomass, species composition, and productivity of fish species that are targeted by fisheries. These impacts can occur at local scales (such as habitat loss in estuaries), regional scales, or even worldwide scales (e.g., climate change causing ocean warming and acidification). To address these impacts, fishery management has begun to evolve once again, from a single species, sustainable yield approach to a broader ecosystem-based approach that recognizes connectivity among ecosystem components.

The National Oceanic and Atmospheric Administration (NOAA) defines an ecosystem approach to management as one that is adaptive, geographically specific, takes into account ecosystem knowledge and uncertainties, considers multiple external influences, and strives to balance diverse social objectives. An ecosystem-based approach for fisheries goes beyond the traditional single species conservation approach by addressing how fishing activities affect biodiversity, food web interactions, and habitat (Fluharty 2005). The National Marine Fisheries Service's Ecosystem Principles Advisory Panel noted that "a comprehensive ecosystem-based fisheries management approach would require managers to consider all interactions that a target fish stock has with predators, competitors, and

prey species; the effects of weather and climate on fisheries biology and ecology; the complex interactions between fishes and their habitat; and the effects of fishing on fish stocks and their habitat" (NMFS 1999).

Although scientific information is not yet available to implement a fully comprehensive ecosystem approach in all coastal regions of the United States, fishery managers have been incorporating ecosystem considerations into their policies to address ecosystem concerns based on the best scientific information available (Murawski 2007). Currently, when a Council contemplates changes to fishing regulations, the potential effects of the proposed regulations on ecosystem structure and processes are frequently evaluated and considered in the policy decision-making. Additionally, the Councils also develop management measures to limit the effect of fisheries on marine ecosystems. Practical objectives to achieve ecosystem-based management of fisheries (modified from Francis et al. 2007 and Marasco et al. 2007) and how the Councils are meeting these objectives are discussed below.

MAINTAINING ABUNDANT FISH STOCKS

The MSA requires that fisheries be managed so that overfishing is prevented and optimum yield (OY) is achieved, while taking into account the protection of marine ecosystems. The most basic ecosystem consideration for fishery managers is to prevent over-harvesting of fish stocks. Because disproportionate removal of selected target species by fishing can alter predator-prey relationships, it is important that fish stocks not be exploited to such low levels that a species no longer fills its role (niche) in the ecosystem. Implementation of this principle provides long-term benefits to fishermen, fish stocks, and the ecosystem.

The U.S. Regional Fishery Management Councils are making progress with managing fish stocks at sustainable levels and rebuilding depleted stocks. A vast majority of U.S. fish stocks are considered to be at a healthy and abundant biomass and not subject to overfishing. As of 2008, of the 251 U.S. marine fish stocks assessed, only 16 percent were subject to overfishing. This situation will further improve with the implementation of ACLs for all fisheries in 2011, as required by the 2006 reauthorized MSA. It is anticipated that most stocks that had previously been depleted will rebuild to abundant levels.

MAINTAINING HEALTHY HABITATS FOR FISH

The MSA requires that fishery management plans (FMPs) describe and identify essential fish habitat (EFH), minimize to the extent practicable adverse effects on such habitat caused by fishing, and identify other actions to encourage the conservation and enhancement of such habitat. Benthic habitat can be adversely affected by fishing gears, particularly mobile gears such as bottom trawls. Habitat can also be adversely affected by non-fishing activities such as dredging, coastal development, and pollution.

Figure 1. Conceptual food web for the tropical Pacific marine ecosystem.

The Councils have identified EFH for fish species in their regions and have developed measures to protect that habitat from adverse impacts, when possible. In virtually every region, important habitats have been protected by the establishment of marine protected areas (MPAs), designed to minimize the effects of fishing on habitat. In fact, bottom trawling is currently prohibited in more than two-thirds of U.S. waters. Gear types used by fisheries have been closely regulated, or in some cases prohibited entirely, to protect fish habitats. Although Councils do not have the authority to regulate other activities besides fishing, they do provide input on federal permitted activities that potentially affect EFH.

MAINTAINING MARINE DIVERSITY AND FOOD WEBS

Fisheries can alter the biological diversity of a marine ecosystem by selectively removing predators, competitors, or prey, which in turn can affect the food web. Additionally, genetic diversity may be affected by traditional fishery management tools. For example, regulations that establish fishing seasons or allow only certain species or sizes of fish to be landed can selectively remove faster growing fish or spawning aggregations having different genetic characteristics.

The Regional Fishery Management Councils have been addressing biodiversity concerns by minimizing the bycatch of non-target species, setting limits on fishery removals of target species, preventing or minimizing fishing removals of key prey species, and implementing MPAs, including no-take marine reserves. In some regions, the Councils have prohibited fishing on ocean seamounts to protect endemic stocks and unique ecosystems. They have also closed vast areas to protect coral reefs, deep sea coral ecosystems, and, in some areas, long-lived spawning fish.

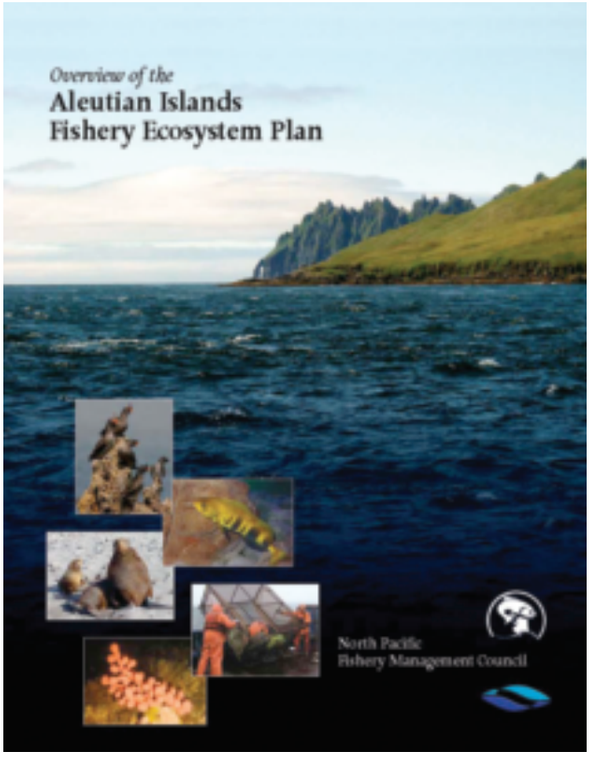
MINIMIZING EFFECTS OF FISHERIES ON PROTECTED SPECIES

Fisheries can impact marine mammals, seabirds, and sea turtles either directly (killed incidental to fishing operations) or indirectly

(e.g., through disturbance or removal of prey). The U.S. Regional Fishery Management Councils use several management tools to minimize these impacts. Area and seasonal closures mitigate both direct and indirect fishery interactions with protected species. Specifying what species may be caught and requiring others to be released also minimizes potential competition for prey. Modifications to fishing gear design and methods, as well as training in safe handling and release procedures, minimize mortality of protected species that are incidentally taken. (For more information on this topic, read the article *Protected Species Conservation and Fishery Management* in this issue.)

INCORPORATING ECOSYSTEM SCIENCE INTO DECISION-MAKING

Scientific information traditionally required by Regional Fishery Management Councils was species-specific and generally geared to determining a level of sustainable catches or measures to prevent overfishing. As management evolves toward an ecosystem-based approach, research will need to expand existing scientific information and to develop new surveys and data collection to measure variability in environmental conditions. Integrated ecosystem assessments and models that allow a better understanding of dynamic ecosystem processes are needed to convey complex ecosystem information to fishery decision-makers (NMFS 2009). The Councils rely on their Scientific and Statistical Committees to provide them with advice on the best available scientific information.



Interactions of ecosystem components are evaluated in the Aleutian Islands Fishery Ecosystem Plan risk assessment.

Many of the Councils have developed, or are in the process of developing, fishery ecosystem plans (FEPs) to provide comprehensive ecosystem information and serve as a foundation for FMPs within an ecosystem. For example, the Aleutian Islands FEP includes an assessment of potential risk associated with key ecosystem interactions. Scientists and managers from the North Pacific Council, National Marine Fisheries Service, and other agencies annually prepare an ecosystem considerations document that monitors ecosystem interactions through trends in a suite of ecosystem indicators. The report serves as an early warning system to managers, should trends signal that further adjustments be warranted.

The Pacific Council has initiated the development of an Ecosystem FMP as a first step in the evolutionary process of integrating management decisions across its four existing FMPs. Additionally, the Pacific Council has incorporated ecosystem-based concepts into current fishery management by banning the harvest of euphausiids (krill) in recognition of their important role in the food web and by integrating environmental indicators into harvest control policies for coho salmon and Pacific sardine.

INTEGRATING NON-FISHERY IMPACTS

An ecosystem-based approach to management requires more integrated governance than traditional fisheries management. The Regional Fishery Management Councils are only authorized to regulate fishing activities, yet fisheries are only one source of stress on populations and marine ecosystems. Other human activities—burning fossil fuels, coastal development, and non-point source pollution such as oil runoff, to name a few—are having large and potentially irreversible effects on ecosystems and fish stocks.

Some of the Councils are beginning to take an active role to address these problems by establishing and participating in regional interagency ecosystem management teams and panels. For example, the North Pacific Council brought together representatives of 15 state and federal agencies in the new Alaska Marine Ecosystem Forum to coordinate activities affecting the region's marine ecosystems. The Western Pacific Council has Regional Ecosystem Advisory Committees in each of the archipelagos under its jurisdiction that include representatives from local and federal government agencies, non-government organizations, and communities in the U.S. Pacific Islands, including indigenous communities with traditional knowledge about the local marine ecosystems.

The U.S. Regional Fishery Management Councils are making great strides toward implementing an ecosystem-based approach to fisheries. After 2011, when ACLs are established for all U.S. fisheries and removals are fully controlled, the Councils will have more opportunity to focus efforts on other aspects of the ecosystem approach, such as accounting for uncertainty,

FEPs, and emerging ecosystem governance structures. As fishery scientists increase their understanding of ecosystem components and indicators, they will be able to develop integrated ecosystem assessments and models to provide the Councils with ecosystem-based alternatives to a management system that has been based on MSY for target species.

DAVID WITHERELL is the deputy director of the North Pacific Fishery Management Council. He has authored many peer-reviewed scientific papers on fisheries science, conservation, and management. He can be reached at David.Witherell@noaa.gov.

REFERENCES

Francis, R.C., M.A. Hixon, M.E. Clarke, S.A. Murawski, and S. Ralston. (2007). Ten commandments for ecosystem-based fisheries scientists. *Fisheries* 32(5):217-233.

Fluharty, D. (2005). Evolving ecosystem approaches to management of fisheries in the USA. In Politics and socio-economics of ecosystem-based approaches to the management of marine resources, eds. Browman and Stergiou. *Marine Ecological Progress Series* 275:265-270.

Jackson, J.B.C. (2008). Ecological extinction and evolution in the brave new ocean. *Proceedings of the National Academy of Sciences* 105(1): 11458-11465.

Marasco, R.J., D. Goodman, C.B. Grimes, P.W. Lawson, A.E. Punt, and T.J. Quinn II. (2007). Ecosystem-based fisheries management: some practical suggestions. *Canadian Journal of Fisheries and Aquatic Sciences* 64:928-939.

Murawski, S.A. (2007). Ten myths concerning ecosystem approaches to marine resource management. *Marine Policy* 31:681-690.

National Marine Fisheries Service. (2009). *Report to Congress: The State of Science to Support an Ecosystem Approach to Regional Fishery Management*. NOAA Technical Memorandum NMFS-F/SPO-96. 24.

National Marine Fisheries Service. (1999). *Ecosystem-based Fishery Management: A Report to Congress by the Ecosystems Principle Advisory Panel*. 54.

PHOTO CREDITS

Page 13: Courtesy of Lowell Fritz

Figure 1: Courtesy of NMFS Pacific Islands Fisheries Science Center

Page 15: Courtesy of North Pacific Fishery Management Council

ENDING OVERFISHING AND REBUILDING STOCKS

BY KATHY COLLINS

Under the 2006 reauthorized Magnuson-Stevens Fishery Conservation and Management Act (MSA), the Regional Fishery Management Councils and the National Marine Fisheries Service (NMFS) are required to end overfishing of federally managed stocks through the establishment of annual catch limits (ACLs) by 2010 for all stocks experiencing overfishing and by 2011 for all others. They are also required to rebuild overfished fish stocks as soon as possible. The Councils are aggressively working to meet these deadlines.

During the past three decades, the U.S. Regional Fishery Management Councils have developed an array of fishery-specific management measures to prevent overfishing. The approach taken varies among the eight Councils, due in part to differences in their fisheries, data availability and monitoring programs, and enforcement capabilities. Widely used measures include commercial quotas, recreational harvest limits, minimum fish sizes, gear restrictions, limits on fishing effort, and open and closed seasons.

Overall, overfishing has been controlled in most federally managed U.S. fisheries. Of the 251 stocks assessed, 210 (84 percent) were not subject to overfishing, 41 stocks (16 percent) are subject to overfishing.

BALANCING ACT OF FISHERIES MANAGEMENT

Although the Councils' primary goal in preventing overfishing is to make sure stocks are sustainable in the long term, they must also consider the social and economic impacts of fishery management measures. The MSA imposes 10 National Standards for conservation and management of U.S. fisheries. National Standard 1 requires "conservation and management measures shall prevent overfishing while achieving, on a continuing basis, the optimum yield [OY] from each fishery for the United States fishing industry."

NEW RULES IN PLAY

On February 17, 2009, a National Standard 1 guideline was implemented by the NMFS on how to comply with new MSA requirements to address overfishing. As shown in Figure 1, the new acceptable biological catch (ABC) control rule requires implementation of ACLs and accountability measures (AMs) into all Council fishery management plans and allows annual catch targets (ACTs) as a type of AM. Additionally, ACLs and AMs must be specified for each federally managed fish stock. The AM's purposes are to ensure the ACL is not exceeded, to address causes of ACL overages, to ensure overages don't occur in subsequent fishing years, and to address any biological harm to a stock (NMFS 2008).

The Scientific and Statistical Committee (SSC) of the respective Councils is tasked with recommending the ABC for each federally managed fishery in its geographic region. National Standard 2 of the MSA states that "conservation and management measures shall be based upon the best scientific information available." In

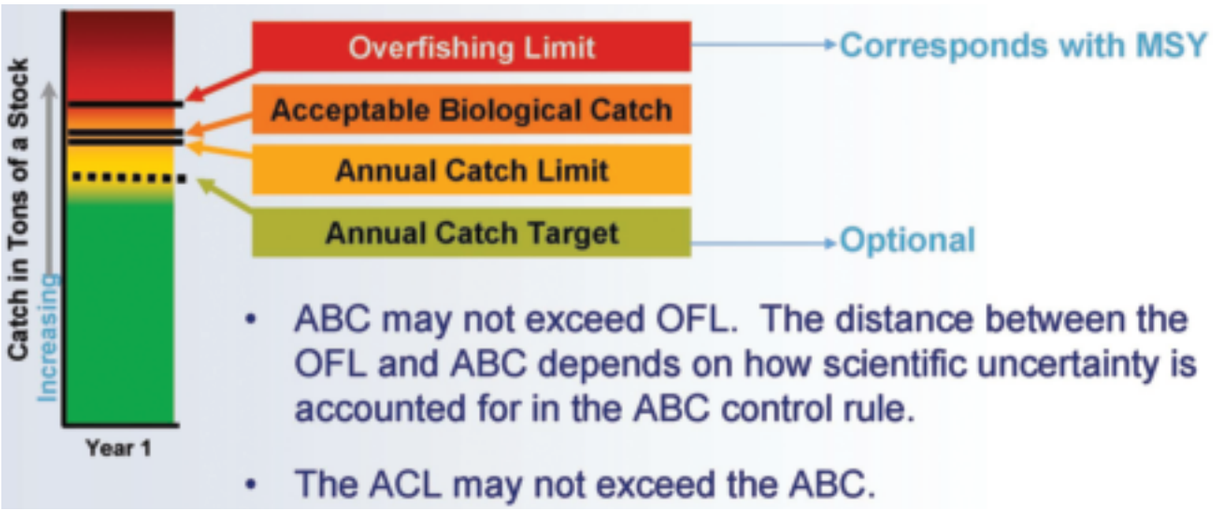


Figure 1. The new guideline for National Standard 1 of the Magnuson-Stevens Act incorporates control rules for overfishing that take into account scientific uncertainty.

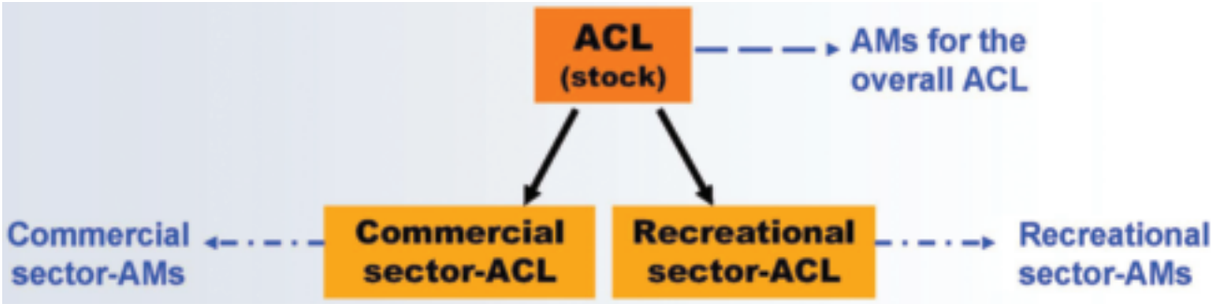


Figure 2. The Councils have the option of sub-dividing a stock's annual catch limit (ACL) and providing a portion to different fishing sectors.

some cases, the best available science may not be sufficient to accurately set ABCs. Scientific uncertainty includes the accuracy of a stock's estimated biomass, its MSY and level of overfishing. The SSCs must account for this scientific uncertainty when they propose ABCs.

The Councils are tasked with setting the ACLs, which cannot exceed the ABCs. The Councils, like the SSCs, must address uncertainties when setting the ACLs. Management uncertainties can be related to inadequate catch information due to errors or tardiness in reporting of landings and bycatch (*Federal Register* 2009). Management uncertainty can be addressed by comparing target catches and actual past catches to evaluate the differences. When developing ACLs, the Councils must also consider the risk of the stock, particularly to overfishing, and they may consider the stock's vulnerability, including its current status, gear used, habitat, and reproduction rates (Lenfest 2007).

The ACL should be specified for the entire stock and may have further divisions, for example, a federal ACL and a state ACL. The goal should be to develop collaborative conservation and management strategies with federal, state, tribal, and/or territorial fishery managers. The Councils have the option of also subdividing a stock's ACL into sectors, for example, a commercial sector-ACL and a recreational sector ACL.

CREATING REBUILDING PLANS

The reauthorized MSA specifies that, effective July 12, 2009, a Council shall prepare and implement a fishery management plan, a plan amendment, or proposed regulations to end overfishing immediately within two years of being notified that a fishery is overfished or approaching a condition of being overfished. It also calls for rebuilding of affected stocks of fish. The rebuilding time shall be "as short as possible" and "not exceed 10 years" unless biological or environmental circumstances or management under an international agreement dictates otherwise.

Rebuilding plans generally incorporate stringent management measures, which may include a prohibition on directed fishing or measures to reduce overall fishing mortality. A lower fishing mortality allows better survival and increased reproduction, which would be expected to result in increasing stock abundance. If a stock is in a rebuilding plan and its ACL is exceeded, the AMs should include overage adjustments that reduce the ACL in the next fishing year by the full amount of the overage, unless the best scientific information available shows that a reduced overage adjustment, or no adjustment, is needed to mitigate the effects of the overage. This AM increases the likelihood that the stock will continue to rebuild. In some cases, however, rebuilding plans have failed, and reduced fishing mortality has not been sufficient to allow for improved productivity and recruitment due to environmental or other conditions. Moreover, even though a stock may no longer be overfished, it may not necessarily be successfully rebuilt to target levels of abundance (Figure 3).

CONCLUSION

It is critical that management systems prevent marine stocks from becoming overfished and prevent overfishing from occurring. The Regional Fishery Management Councils are committed to using science-based ACLs and AMs to prevent overfishing of fish stocks and to rebuild overfished stocks.

KATHY COLLINS is the public affairs specialist at the Mid-Atlantic Fishery Management Council. She can be reached at Kcollins1@mafmc.org.

REFERENCES

Federal Register. (2009). Magnuson-Stevens Act Provisions; Annual Catch Limits; National Standards Guidelines; Final Rule. Vol. 74, No. 11.

Lenfest Working Group. (2007). *Setting Annual Catch Limits for U.S. Fisheries: An Expert Working Group Report.*

NOAA National Marine Fisheries Service. (2009). Fish Stock Sustainability Index (FSSI). Quarter 2 update through 6/30/09.

NOAA National Marine Fisheries Service. (2009). Revisions to the National Standard 1 Guidelines: Guidance on Annual Catch Limits and Other Requirements. Jan. **http://www.nmfs.noaa.gov/msa2007/docs/acl_final_ns1_rev_presentation_jan162009.pdf**

NOAA National Marine Fisheries Service. (2009). *2008 Report to Congress: The Status of U.S. Fisheries.*

NOAA National Marine Fisheries Service. (2008). Regulatory Impact Review and Regulatory Flexibility Act Analysis for Revisions to National Standard 1 Guidelines to Address Annual Catch Limit and Other Measures to End Overfishing and Rebuild Overfished Stocks.

NOAA National Marine Fisheries Service. (2007). Magnuson-Stevens Fishery Conservation and Management Act as amended through Jan. 12. **www.nmfs.noaa.gov/msa2007/index.html.**

PHOTO CREDITS

Figures 1 and 2: Courtesy of National Marine Fisheries Service

Figure 3 and 4: Courtesy of Mid-Atlantic Fishery Management Council

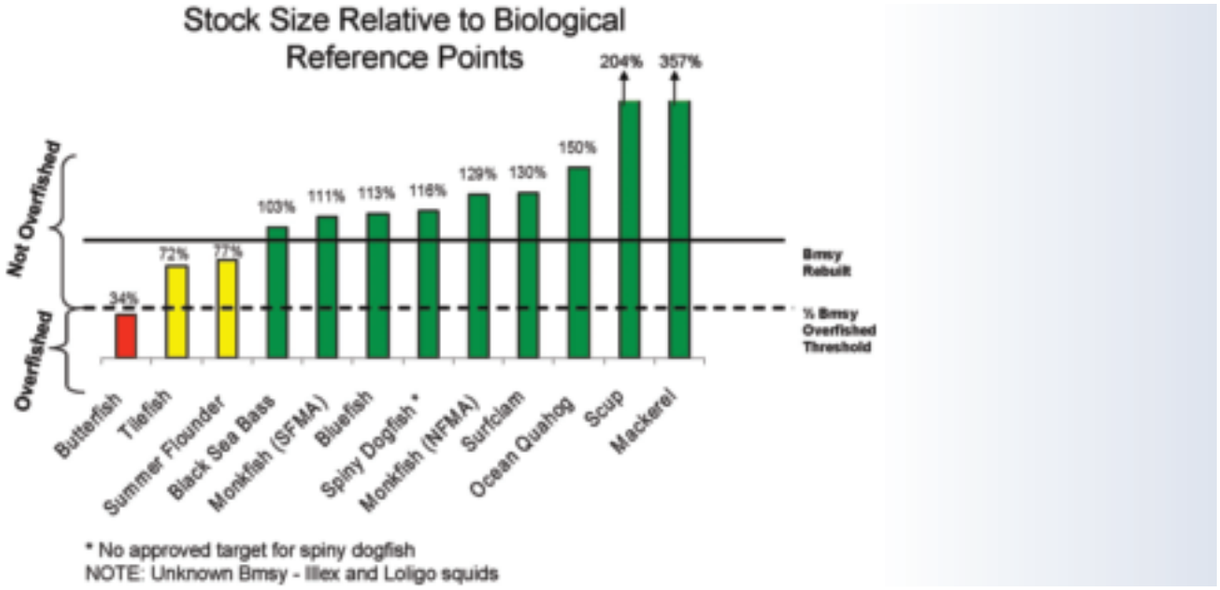


Figure 3. The Mid-Atlantic Council has successfully prevented overfishing in all of its managed stocks. One stock is overfished, and one stock, while not overfished, has not yet been rebuilt to target levels of abundance.

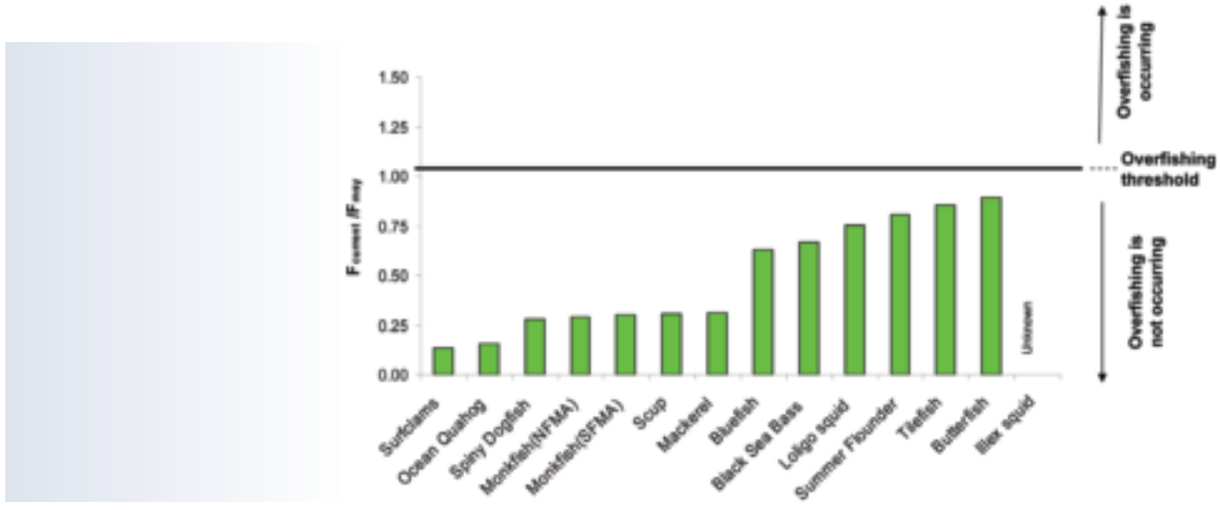


Figure 4. This graph of fishing mortality ratios for species managed by the Mid-Atlantic Fishery Management Council illustrates that overfishing is not occurring for any of the stocks.

Evolution of Habitat Protection in Federal Waters

By Patricia Fiorelli

Regional Fishery Management Council measures to protect marine habitats in the U.S. exclusive economic zone (EEZ) began in earnest with the 1996 reauthorization of the Magnuson-Stevens Fishery Conservation and Management Act (MSA). The legislation expanded the Councils' responsibilities by requiring greater stewardship of essential fish habitat (EFH) and specifying important tools to address the new challenges. During the intervening period, the eight Councils have taken action to protect thousands of miles of important marine habitat—from deepwater corals in the Western Pacific and South Atlantic, to shallow reefs in the Caribbean and Gulf of Mexico, including underwater canyons and seamounts off both the Atlantic and Pacific coasts.

The American public has long been aware that protecting marine habitats is critical to maintaining sustainable fish populations, as well as the health and general productivity of our oceans. Even so, the development of concrete measures to conserve and protect such important resources has been a lengthy process that continues to evolve. Prior to 1996, oversight of habitat-related issues involving the marine environment was the purview of various federal agencies, among them the Environmental Protection Agency (ocean dumping), the Army Corps of Engineers (dredging), and the Minerals Management Service (oil, gas, mineral exploration), as well as several branches within NOAA's National Marine Fisheries Service.

While the eight U.S. Regional Fishery Management Councils had managed and controlled federal fishing activities for two decades, they had little influence over the many non-fishing activities that affect the marine environment. In 1996, the U.S. Congress changed the patchwork approach by elevating marine habitat protection in amendments to the MSA. In their preface to the Act, legislators noted, "One of the greatest long-term threats to the viability of commercial and recreational fisheries is the continuing loss of marine, estuarine, and other aquatic habitats. Habitat considerations should receive increased attention for the conservation and management of fishery resources of the United States."

FISHERY COUNCIL INVOLVEMENT

The revised MSA enabled the Councils to become pro-active by arming them with a clear mandate to protect fish habitat from the growing threats of human activity, although its authors gave them limited authority to address threats caused by non-fishing impacts. The new provisions required that all of the Councils' fishery management plans (FMPs) identify and describe EFH, which is defined as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." The FMPs were also required to include actions to minimize any adverse effects from fishing, to the extent practicable, as long as there is evidence to demonstrate that fishing impacts are more than minimal and temporary. The FMPs also were to encourage the conservation and enhancement of EFH.

By 1998, the Councils had revised over 40 FMPs to address the EFH requirements. Council action on non-fishing impacts to EFH, however, was and continues to be limited to making comments on actions by federal agencies. Nor do the Councils have any authority to prevent non-fishing impacts to EFH.

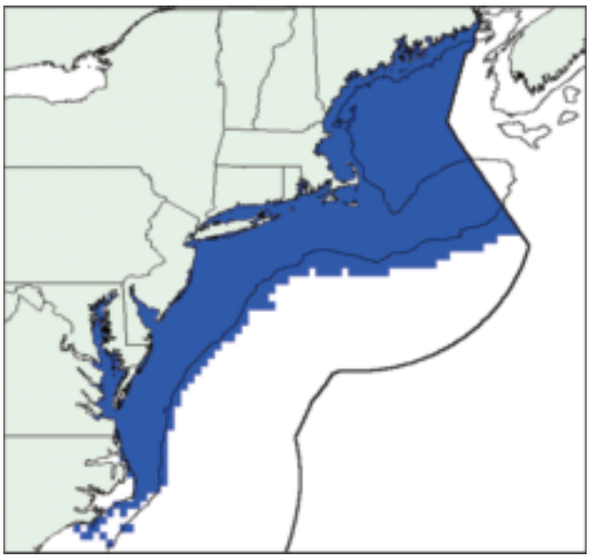


Figure 1. EFH identified by the New England Fishery Management Council in blue.

HABITAT AREAS OF PARTICULAR CONCERN

Identifying and describing EFH allowed the Councils to access another tool to protect EFH, the designation of discrete locations or habitat types as habitat areas of particular concern (HAPC). The selection of such areas must be based on one or more of the following considerations:

1. the importance of the ecological function provided by the habitat;
2. the extent to which the habitat is sensitive to human-induced environmental degradation;
3. whether, and to what extent, development activities are, or will be stressing the habitat type; or

4. the rarity of the habitat type.

COUNCIL ACTIONS TO PROTECT HABITAT

Council activities to address habitat concerns have moved dramatically forward since the early efforts described above. To fulfill their new responsibilities, the Councils looked at many of their traditional tools—area closures, gear restrictions and modifications, and harvest limits that control fishing effort—to provide benefits to EFH, but applied them for a different outcome besides fish conservation.

Western Pacific

Well ahead of its time and even before the habitat provisions in the MSA were adopted, the Western Pacific Fishery Management Council set the pace with its pioneering efforts to protect coral reef systems by banning bottom trawling and other potentially destructive and non-selective gear throughout the region's entire 1.5 million square nautical miles (nm^2) of U.S. EEZ waters. Moreover, in 2001, its members approved the first ecosystem plan for fisheries in the United States. In 2005, the Western Pacific Council voted to change all of its species-based FMPs to place-based Fishery Ecosystem Plans (FEPs). The notice of availability of the five FEPs was published in the *Federal Register* in October 2009.

North Pacific

In 2007, the North Pacific Fishery Management Council took action to conserve EFH in the Bering Sea by "freezing the footprint" of bottom-trawling activities, effectively limiting that gear type to areas where trawling already occurs. Potential new effects on habitat caused by bottom trawling were eliminated in a deep slope and basin area (47,000 nm^2) and in the northern Bering Sea region (85,000 nm^2). Within the northern Bering Sea region, the Council also established a Northern Bering Sea Research Area which, in the future and under a scientific research plan, could allow limited bottom trawling in designated areas to evaluate effects of the gear on habitat.

Pacific

In 2006, the Pacific Fishery Management Council adopted a complete ban on commercial fishing for all species of krill in West Coast federal waters. At the same time, the Council identified EFH for krill in order to make it easier to work with other federal agencies to protect krill. The precautionary step was taken because the tiny shrimp-like crustaceans are eaten by many species managed by the Pacific Council, as well as by whales and seabirds. When the ban was enacted, there was no fishery for krill in the Pacific region, although krill were (and are) harvested in other parts of the world.

The same year, the Pacific Council redefined EFH and HAPCs for groundfish. The Council identified groundfish EFH as all waters from the high tide line (and parts of estuaries) to 3,500 meters (1,914 fathoms) in depth. Current HAPC types include estuaries, canopy kelp, sea grass, rocky reefs, and "areas of interest" (a variety of submarine features, such as banks, seamounts, and canyons, along with Washington State waters).

The Pacific Council also created three types of closed areas to protect sensitive groundfish habitats from the adverse impacts of fishing: bottom-trawl closed areas, bottom-contact closed areas, and a bottom-trawl footprint closure. Thirty-four bottom-trawl closed areas restrict all types of bottom-trawl fishing gear. Seventeen bottom-contact closed areas prohibit all types of bottom-contact gear. The bottom-trawl footprint closures encompass EEZ waters between 1,280 meters (700 fathoms) and 3,500 meters (1,094 fathoms), or the outer extent of groundfish EFH.

New England

The New England Fishery Management Council indefinitely closed about 3,000 nm^2 in the Gulf of Maine, Georges Bank, and southern New England to bottom-tending mobile fishing gear to reduce the effects of fishing on EFH. The New England Council minimized the effects of fishing gear on sensitive deepwater coral habitat by supporting the closure of two offshore canyons located southeast of Nantucket in 2005 to vessels targeting monkfish.

Building on that effort, the New England Council has adopted 18 new HAPCs, adding seamounts, steep-walled offshore canyons on George's Bank and in the Mid-Atlantic, and areas of the Great South Channel and the inshore Gulf of Maine that are important to juvenile cod growth and development to its list of areas that may merit further protection.

Mid-Atlantic

Very recently, the Mid-Atlantic Fishery Management Council adopted the New England Council's earlier protection of two offshore canyon areas by prohibiting all bottom trawls and dredges, and not simply monkfish gear, from the areas. Through Amendment 1 to the Tilefish FMP, the Mid-Atlantic Council closed four canyons: Lydonia, Veatch, Norfolk, and Oceanographer.

South Atlantic

The South Atlantic Fishery Management Council has focused on deepwater coral conservation by proposing the designation of over 23,000 nm^2 of deepwater habitat as Coral HAPCs. Potential threats to the deep ocean, including damage from fishing gear and from energy exploration and development, create a time-sensitive need to map and characterize these habitats. Continued pressure for extraction of fossil fuels and liquefied natural gas and their associated pipelines and offshore facilities could directly impact local deepwater coral ecosystems. (See pages 28-29 for more.)

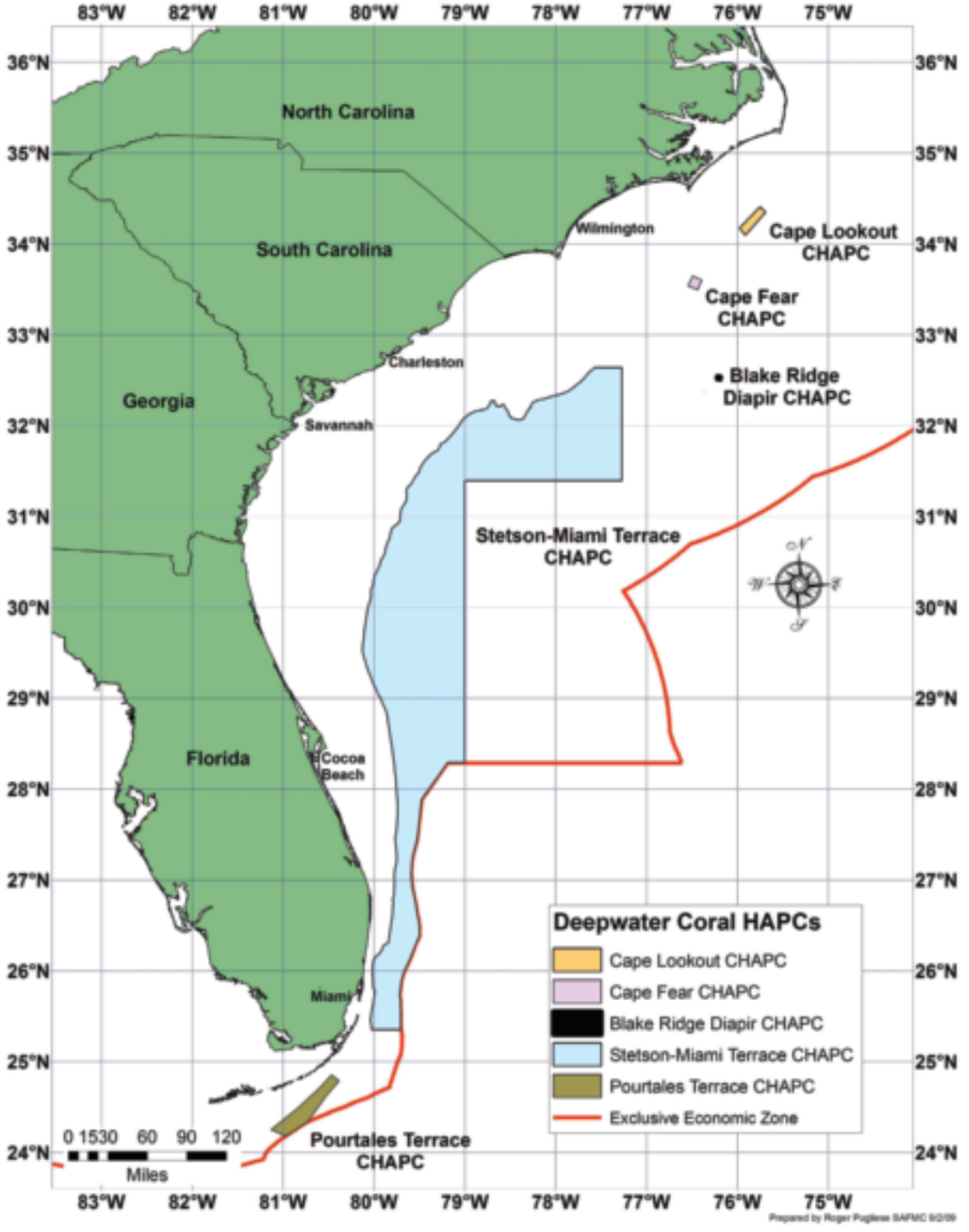


Figure 2. Over 23,000 square miles of deepwater corals (approximately the size of the State of West Virginia) will be protected from damaging fishing activities through the designation of these areas as HAPCs by the South Atlantic Fishery Management Council. The area may be the largest contiguous distribution of deepwater coral in the world.

Invasive sea squirts smothering prime gravel/cobble habitat on George's Bank.

U.S. Caribbean

Reef fisheries and their habitats remain a challenge for the Caribbean Fishery Management Council. Coral and other hard-bottom areas, as well as sea grasses and mangroves, are heavily impacted by coastal development, runoff, marine debris, tropical storms, and coral bleaching events. Proposals for year-round fishery closures or closed seasons may protect both fish and the environments in which they live, but cultural and dire economic circumstances in local communities frequently complicate efforts toward greater stewardship.

Gulf of Mexico

The Gulf of Mexico Fishery Management Council has used marine protected areas as an important tool for conservation and management of the region's resources, protecting thousands of square miles of vulnerable habitat types, as well as nursery areas, from fishing activities. Measures in the Coral Reef Management Plan prohibit the harvest of stony coral and sea fans except by scientific permit. The plan also established HAPCs in the Gulf and Atlantic where the use of any fishing gear interfacing with the bottom is prohibited.

Additionally, the Gulf Council has regulated the use of chemicals by fish collectors near coral reefs and established a data reporting system for permit holders. Certain gear types also have been prohibited over large areas to reduce fishing mortality on juvenile fish and shrimp. Other areas containing sensitive benthic habitat have been identified as HAPC, and fishing is severely restricted. Some areas containing corals and coral reefs were considered so sensitive that the Gulf Council declared them marine reserves and prohibited all types of fishing in them.

NON-FISHING IMPACTS

Despite limited authority in this area, many of the U.S. Regional Fishery Management Councils have increasingly focused on activities that are termed non-fishing impacts on EFH. Councils have called for the removal of dams and supported efforts to clean rivers and harbors and conserve wetlands. They have opposed offshore drilling on productive fishing grounds and become involved in the siting of alternative energy and pipeline projects in nearly all federal waters surrounding the United States.

LOOKING AHEAD

While efforts to define and protect EFH help conserve fish habitat, a number of challenges remains. The U.S. Regional Fishery Management Councils face the very real effects of climate change, including changes in water temperature, ocean acidification, sea level rise, and threats posed by invasive species. The list of science and research needs continues to grow while funds to support such activities remain limited. In addition, Councils lack the authority to impact non-fishing activities in Council waters. Although outstanding progress toward habitat conservation and protection has already occurred, the Councils and the public have a great deal of work ahead of them to ensure healthy oceans and fisheries for future generations.

PATRICIA FIORELLI is the public affairs officer for the New England Fishery Management Council and currently staffs the New England Council's Scientific and Statistical and Research Steering Committees. She also has worked on habitat and marine mammal issues for the New England Council. She can be reached at pfiorelli@nefmc.org or (978) 465-0492.

REFERENCES

Essential Fish Habitat Final Rule (50 CFR 600).

State of deep coral ecosystems of the U.S. northeast U.S. region. (2007). In *The State of Deep Coral Ecosystems of the United States: Maine to Cape Hatteras*, eds. S.E. Lumsden, T.F. Hourigan, A.W. Bruckner, and G. Dorr. NOAA Technical Memorandum CRCP-3. Silver Spring, MD.

Essential Fish Habitat: **http://www.nmfs.noaa.gov/habitat/habitatprotection/efh/index.htm**

PHOTO CREDITS

Figure 1: Courtesy of New England Fishery Management Council

Figure 2: Courtesy of South Atlantic Fishery Management Council

Page 23: Courtesy of Dann Blackwood, USGS

MANAGING TO MINIMIZE BYCATCH AND OTHER INCIDENTAL CATCH

BY CHARLENE PONCE

Bycatch is the term used to describe caught fish that are not retained for sale or personal use. Examples are sea turtles caught in shrimp trawls in the Gulf of Mexico, salmon caught in pollock trawls in Alaska, and undersized cod caught in New England. Bycatch includes species that are targeted in other fisheries, species that have no economic value but that may be important to the functioning of marine ecosystems, and fish that are too small to be retained. This latter category includes juveniles of species that would be valuable if caught as adults. Bycatch presents a problem because it is wasteful and can decrease the sustainability and efficiency of a fishery, as well as affect protected and endangered species (like sea turtles) and other non-targeted species.

Shrimp bycatch

The prevailing law governing marine fisheries management in the United States, the Magnuson-Stevens Fishery Conservation and Management Act (MSA), defines bycatch as "fish which are harvested in a fishery, but which are not sold or kept for personal use, and includes economic discards and regulatory discards. Such term does not include fish released alive under a recreational catch and release fishery management program." National Standard 9 of the MSA requires that conservation and management measures shall, to the extent practicable, minimize bycatch and, to the extent bycatch cannot be avoided, minimize the mortality of such bycatch.

There are two types of bycatch: fish that are discarded because they are unwanted, and those that are discarded because they are illegal to retain.

Fish that are discarded because they are unwanted are sometimes termed "economic discards." These are species that are the target of a fishery but that are not retained because they are of an undesirable size, sex, or quality, or for other economic reasons. For example, fishermen may not be able to sell their catch of sea ravens (a type of sculpin), and thus discard them at sea.

Fish that are illegal to retain are sometimes called "regulatory discards." These are fish that fishermen must discard whenever caught, or must retain but not sell. For example, regulations require the discard of all crabs caught in bottom-trawl fisheries in the North Pacific. In addition, some regulations can actually increase bycatch. For instance, size limits require fishermen to discard fish under the size specified in the regulations. The same is true when fishermen reach a bag limit or quota. These regulatory discards are considered bycatch.

Bycatch is a particularly challenging issue for the eight Regional Fishery Management Councils. Each fishery management plan prepared by the Councils must include a standardized reporting methodology to assess the amount and type of bycatch occurring in each managed fishery, and establish conservation measures to minimize bycatch. With the help of scientists and experienced fishermen, fishery management councils are working to minimize bycatch.

CONTRIBUTING FACTORS

Bycatch occurs because different species coexist in time and space and because some fishing gear is not selective in terms of species. For example, sea turtles occurring in the same area as groupers and other reef fish are sometimes caught by longline gear intended for grouper.

Juvenile mortality associated with bycatch directly affects recruitment. In the Gulf of Mexico, juvenile finfish, particularly red snapper, are caught in shrimp trawls and die before they have had a chance to enter into the fishery. This lowers recruitment and, eventually, the overall productivity of the fishery. In extreme overfishing situations, recruitment can be diminished resulting in fewer future adults reproducing the next generation of fish. When this happens, fishery managers may restrict

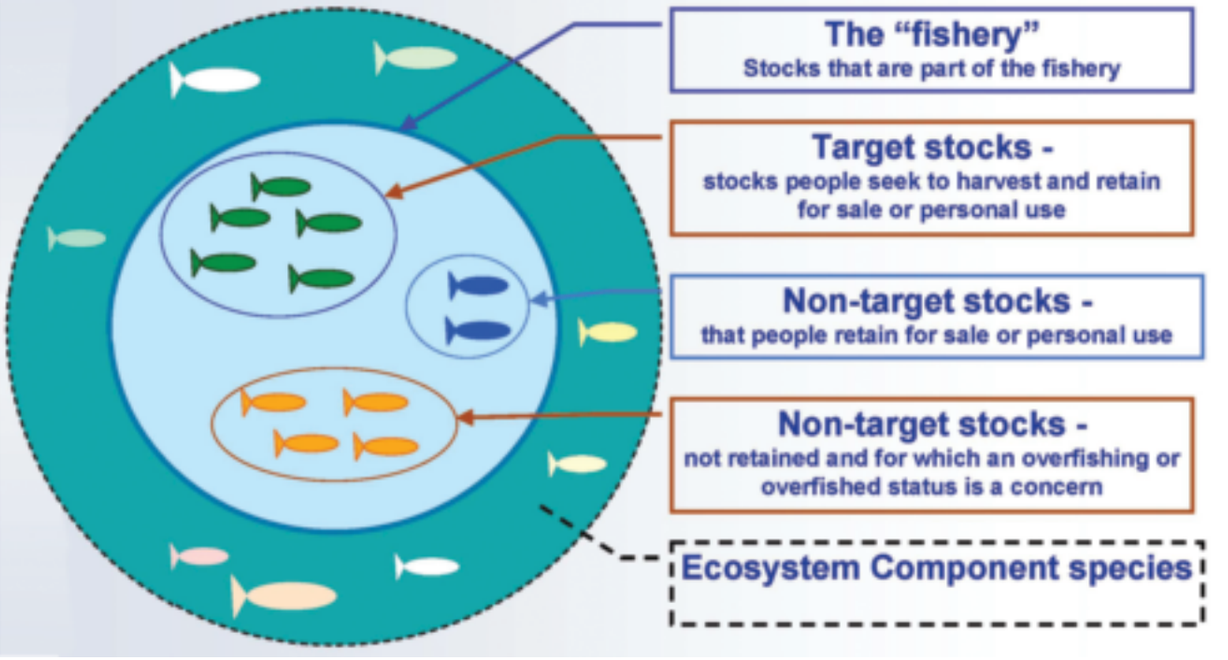


Figure 1. Bycatch are caught fish and other species that are not retained.

allocations for the directed recreational and commercial fisheries to offset reduced recruitment.

MONITORING, MANAGING AND REDUCING BYCATCH

Monitoring bycatch helps scientists assess the status of fish populations captured by a particular gear. Some ways scientists check bycatch are by placing observers on board fishing boats, observing the performance of bycatch reduction devices, and requiring vessel monitoring systems and electronic logbooks. Bycatch monitoring also helps scientists set appropriate optimum yield (OY) and overfishing levels and helps fishery managers develop measures to ensure that OYs are attained and that overfishing does not occur.

Fishery managers use various measures to manage bycatch within a fishery or affected species. Some management measures include individual fishing quotas (IFQs) or catch shares, limits on bycatch, closed areas, gear restrictions, and bycatch reduction devices.

IFQs can help reduce bycatch by ending "derby fishing," which forces fishermen into a race for fish. Fishermen can then take the time to find areas with high abundance of the target species of legal size and move away from areas where bycatch levels are high.

Examples of bycatch limits can be found in the Pacific. The North Pacific Fishery Management Council has established strict bycatch limits for halibut and salmon in fisheries for which these are non-target species. These fisheries close if and when the bycatch limits are exceeded. The Western Pacific Fishery Management Council has set annual limits on the bycatch of leatherback and loggerhead sea turtles by the Hawaii swordfish fishery. If the limit for either turtle species is reached, the swordfish fishery closes.

Closed seasons can help control bycatch by decreasing effort on a particular fishery. If effort is reduced, it stands to reason that bycatch reduction will follow. The Pacific Fishery Management Council has area closures that limit rockfish bycatch, while similar closures by the South Atlantic Fishery Management Council lessen bycatch in the snapper-grouper longline fishery.

Gear restrictions or modifications—such as bycatch reduction devices on shrimp and groundfish trawls, trawl footrope size limits that help keep trawls out of rocky reef habitat, specific mesh sizes on mid-water trawls, escape vents or rings in crab and lobster pots, and circle hooks to mitigate interactions between sea turtles and pelagic longline gear—help to both reduce bycatch and the mortality due to bycatch. In the South Atlantic and the Western Pacific, drift gillnets and trawls are prohibited. The South Atlantic also prohibits gillnets and entanglement nets, while shrimp trawls in the Gulf of Mexico are modified to include bycatch reduction and turtle excluder devices (TEDs) that allow finfish and turtles to escape. (For more information on protected species bycatch reduction, see article on page 32).

COOPERATION AND STEWARDSHIP

Industry stewardship is the key to the success of bycatch reduction efforts. Fishery managers rely on the coordinated

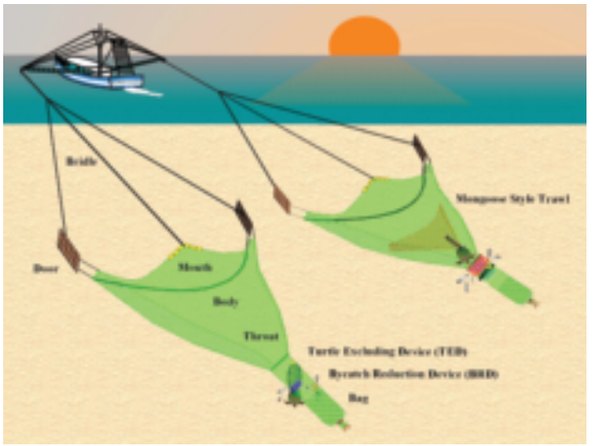


Figure 2. Bycatch reduction and turtle excluder devices.

efforts of scientists and stakeholders when developing new bycatch reduction strategies.

The successful seabird avoidance gear currently used in Alaska's longline fishery is a result of those coordinated efforts. In a collaborative study with the Washington Sea Grant Program and industry to lower the risk of catching endangered short-tailed albatross and other seabirds, participants discovered that streamer lines, lines with long red streamers that parallel the baited hooks set off the stern of a fishing vessel, dramatically reduced seabird bycatch. Use of the streamer lines has resulted in an 80 percent reduction in seabird bycatch in Alaska. Similarly, a collaborative process involving the Western Pacific Fishery Management Council, NOAA Fisheries, the U.S. Fish and Wildlife Service, the fishing industry, and Blue Ocean Institute resulted in a more than 90-percent reduction in seabird bycatch by the Hawaii longline fishery. Methods used include side-setting with bird curtains, night setting, and blue-dyed bait. Other methods tested included underwater setting and strategic offal discard, which showed that the best methods and gears to employ can differ by region and fishery.

Use of the streamer lines on longline vessels has resulted in an 80 percent reduction in seabird bycatch in Alaska.

Several programs and funding opportunities are available to encourage industry stewardship. For example, the World Wildlife Fund holds an International Smart Gear Competition each year, which is designed to inspire innovative ideas for fishing devices that reduce bycatch—the grand prize is $30,000.

The Marine Fisheries Initiative Program (MARFIN) was created to fund cooperative programs to facilitate and enhance the management of the marine fishery resources of the Gulf of Mexico and South Atlantic. The intent of the MARFIN program is to focus projects on key fisheries' issues in the southeast United States. Bycatch reduction research is an ongoing theme within the program.

The Cooperative Research Program (CRP), funded by Congress, is another program that allows scientists and fishermen to work together to improve our understanding of the complex interactions between fishery resources and fishing practices. Program projects cover a range of research topics. Since 2003, in the southeast region alone more than $10 million in CRP funding has been awarded, with just over $4 million going toward bycatch-related research. The program provides the necessary programmatic integration through cooperative planning, accomplishment of program activities, and sharing of results.

SUMMARY

Bycatch is a complex problem involving many issues, including the sustainability of fisheries, protection of endangered species, impacts to stakeholders and other concerned entities, and supply and demand of seafood. It is up to scientists, stakeholders, and fishery managers to develop sound strategies to reduce bycatch and ensure the sustainability of our fisheries.

CHARLENE PONCE is the public information officer for the Gulf of Mexico Fishery Management Council. She can be reached at (813) 348-1630 ext. 229 or charlene.ponce@gulfcouncil.org.

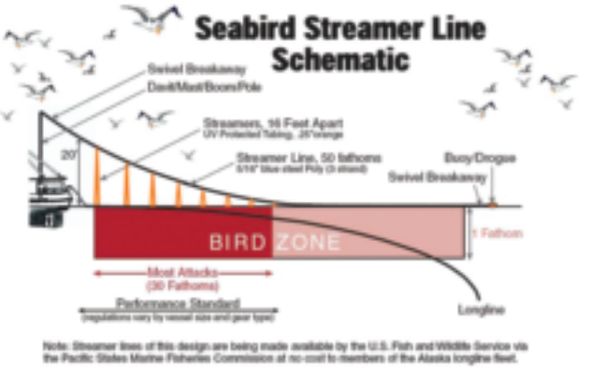


Figure 3. Diagram of streamer lines used to deter seabirds from longlines gear in the North Pacific

REFERENCES

Magnuson-Stevens Fishery Conservation and Management Act. (2007). Public Law 94-265

NOAA Fisheries. (July 2009). *Statistical Highlights, Fisheries of the United States, 2008*. Silver Spring, Maryland: National Marine Fisheries Service, Office of Science and Technology, Fisheries Statistics Division.

Rice, S., T. Baker, and P. Cullenberg. (2006). *Gear and Alternatives for Alaska Small Longline Vessels*. Fairbanks, Alaska: Alaska Sea Grant Marine Advisory Program, University of Alaska Fairbanks.

Tagart, J. (2003). Policy perspectives on bycatch. In *Managing Our Nation's Fisheries: Past, Present and Future*. Proceedings of a Conference on Fisheries Management in the United States, ed. D. Witherell. Washington, D.C.

Wallace, R., and K. Fletcher. (2001). *Understanding Fisheries Management: A Manual for Understanding the Federal Fisheries Management Process, including Analysis of the 1996 Sustainable Fisheries Act*, 2nd ed. Mississippi-Alabama Sea Grant. 22-23.

PHOTO CREDITS

Page 24: Courtesy of Georgia Sea Grant

Figure 1: Courtesy of NOAA Fisheries Office of Sustainable Fisheries

Figure 2: Courtesy of Georgia Sea Grant

Page 26 (bottom left): Courtesy of Ed Melvin, Sea Grant

Figure 3: Courtesy of Washington Sea Grant Program

current THE JOURNAL OF MARINE EDUCATION
Volume 25 • Number 3 • 2009

MANAGEMENT AND CONSERVATION OF DEEPWATER CORAL ECOSYSTEMS IN THE UNITED STATES

BY MYRA BROUWER

The words "coral" and "reef," particularly when used in conjunction, typically elicit images of vibrant and colorful underwater landscapes bathed by warm turquoise waters. Images of equally beautiful formations in the cold depths of the ocean where the only light is cast by bioluminescent creatures rarely come to mind. Because the depths of the world's oceans were largely inaccessible until fairly recently, features such as hydrothermal vents, methane seeps, and deepwater coral ecosystems remained poorly explored. Technological advances have made it possible for humans to reach, albeit remotely at times, and study life in the abyss. As entire marine ecosystems dominated by deepwater corals and sponges have been discovered across the world's oceans, we have come to realize their importance not only to the creatures within them but also to humankind.

Deep coral researcher John Reed and pilot Phil Santos dive the Johnson-Sea-Link submersible on a deepwater reef in the Straits of Florida. A manipulator arm is used to reach out and collect specimens of corals and sponges for research.

Deepwater corals differ from their shallow-water counterparts in several ways. Deepwater corals are generally found in water temperature ranging between 4°C and 13°C. In contrast, shallow-water species are distributed in tropical and subtropical seas where temperature ranges between 18°C and 31°C. Shallow-water corals maintain a symbiotic relationship with zooxanthellae (photosynthetic algae that reside within their tissue). The coral polyps provide shelter for the algae, and they in turn supply the corals with nutrients derived from photosynthesis. The zooxanthellae are what give shallow-water corals their sometimes breathtaking coloration. However, during times of stress, such as from high ocean temperatures, the coral polyps expel the algae, thereby becoming "bleached." Deepwater coral species are azooxanthellate—they have to capture their prey from the surrounding environment, since no light to sustain photosynthesis penetrates to the depths they inhabit. Hence, a healthy colony of *Lophelia pertusa*—a common deepwater coral species—is a creamy white. In a shallow-water species such as staghorn coral (*Acropora cervicornis*), such coloration would be indicative of severe stress.

Not all corals, however, have hard, white skeletons. Unlike the "stony corals" or "true corals" (Family Scleractinia), most octocorals and their relatives do not produce substantial calcareous skeletons and differ in elements of body plan and symmetry. The octocorals, also commonly known as "soft corals," include sea whips and sea fans (collectively known as gorgonians), sea pens, sea pansies, and "blue" and "organ-pipe" corals. Stony and soft, reef-building and non-reef-building coral species are found in deep water, generally from 50 meters to 3,000 meters throughout the world's oceans.

Over the past 15 years, a wealth of information has been gathered on deepwater coral communities. Huge numbers of other species are often associated with stony coral "reefs," as well as thickets of gorgonians and other corals suggesting that their ecological function may be similar to that of their shallow-water cousins. Three-dimensional structures, such as deepwater reefs, may provide enhanced feeding opportunities for aggregating species, a nursery area for juveniles, refuge from predators, suitable spawning aggregation sites, and places for sedentary invertebrates to attach. In the United States, many economically valuable species inhabit deepwater coral ecosystems, including species of rockfish, grouper, shrimp, and crabs. In addition, such a hotspot of diversity provides numerous opportunities for chemical and biological research. Several deepwater sponges, for instance, contain compounds of pharmaceutical interest while bamboo corals offer potential in the field of medicine as bone graft material. Other uses of corals have included the production of jewelry. Black, pink, and red corals are still harvested for that purpose.

MANAGEMENT AND CONSERVATION EFFORTS BY U.S. REGIONAL FISHERY MANAGEMENT COUNCILS

South Atlantic

The South Atlantic region may be home to the most extensive and best developed deepwater coral ecosystems in U.S. waters, comprising at least 114 species. *Lophelia pertusa* is the dominant deepwater stony coral in the region. Since 2004, the South Atlantic Fishery Management Council has been actively working

A spider-like galatheid crab perches on a deepwater gorgonian coral to snare some food floating by.

Squat lobster resting on *Lophelia pertusa*.

to designate deepwater coral habitat areas of particular concern (HAPCs) to protect the known extent of these unique ecosystems in the region. A total of 62,716 km^2 is being proposed for such designation, which would also impart protection from bottom trawls, bottom longlines, fish traps, pots, dredge, grapple and chain, anchor and chain, and anchoring by fishing vessels. In order to accommodate the existing fisheries operating in this area, the South Atlantic Council also proposed establishment of Allowable Gear Areas for the golden crab fishery. This would essentially freeze the footprint of this fishery so that fishing activity can continue in the fishery's historic grounds. The deepwater coral HAPCs will be implemented in 2010.

U.S. Caribbean

Many species of deepwater corals occur within the U.S. Caribbean; however, no significant deepwater coral ecosystems have yet been discovered in this region. NOAA is currently conducting research in the region that includes the exploration and characterization of seafloor habitats down to 1,000 meters within the U.S. Virgin Islands and Puerto Rico.

The Caribbean Fishery Management Council so far has focused its efforts on the management of shallow-water coral reef areas and associated fisheries (grouper, spiny lobster, conch, etc.). The Caribbean Council manages corals under the Corals and Reef Associated Invertebrates of Puerto Rico and the U.S. Virgin Island Fishery Management Plan (FMP; CFMC 1994). Even though several deepwater coral species (including black corals) are included in the FMP, there are currently no management or conservation efforts focusing on deepwater corals in the U.S. Caribbean.

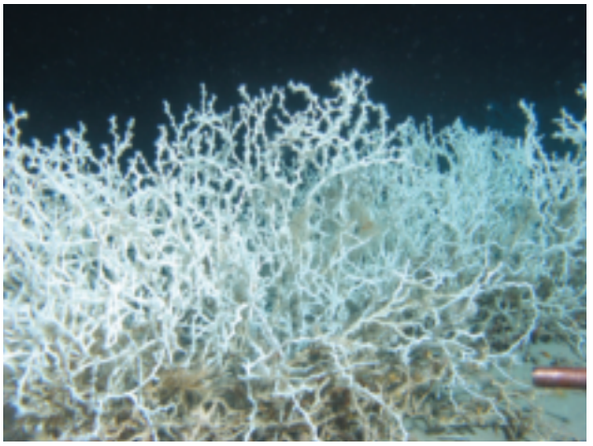
Gulf of Mexico

The coral habitats of the Flower Garden Banks National Marine Sanctuary are the most extensively studied in this region. The past few years have seen an expansion of research activities, such as multi-beam mapping coupled with remotely operated vehicles (ROVs) and manned submersible operations, in deep waters of the shelf. Also, the deep shelf and slope areas in the northern Gulf of Mexico have been mapped and surveyed extensively during exploratory operations for oil and gas resources. Regional differences among faunal communities in the Gulf of Mexico are marked. For instance, reef-forming corals predominate above 50 meters, while *Lophelia*-dominated communities are found on the hard substrate of the northern and eastern slope below 200 meters. Between 50 and 150 meters, in parts of the deep slope habitats, and on hard-bottom features in and around the reefs and banks, the primary structure-forming groups are gorgonians and black corals.

Deepwater corals in the Gulf of Mexico are included in the Corals and Coral Reefs FMP, initially developed jointly by the Gulf of Mexico and South Atlantic Fishery Management Councils (GMFMC and SAFMC 1982). In January 2006, the National Marine Fisheries Service (NMFS) established HAPCs proposed by the Gulf Council. In addition, HAPCs have been established that do not carry any fishing regulations. However, regulations will be considered by the Gulf Council during individual FMP amendments. The HAPCs in the Gulf of Mexico, however, do not include habitats where structure-forming deepwater stony corals, such as *L. pertusa*, are found (below 300 meters).

Pacific

Through implementation of Amendment 19 to the Pacific Coast Groundfish FMP (PFMC 2005), the Pacific Fishery Management Council designated many of the coral and sponge habitats known at the time as essential fish habitat (EFH) and HAPCs. The FMP is comprehensive because it addresses both fishing and non-fishing impacts and establishes procedures for adaptive management. The Pacific Council also adopted mitigation measures such as closed areas, bottom-contact closed areas, and a bottom-trawl footprint closure. The 34 bottom-



Lophelia pertusa thicket in deep waters off Cape Canaveral, Florida.

trawl closed areas prohibit all types of bottom-trawl fishing gear. The bottom-trawl footprint closure closes areas in the exclusive economic zone (EEZ) between 1,280 meters and 3,500 meters. In addition to prohibiting mobile bottom-fishing gear, the 17 bottom-contact closed areas are also closed to fixed gear such as longlines and pots. These areas are distributed throughout the length of the coast and include both federal and state waters. Some of the habitats being protected are hard-bottom habitats likely to contain deepwater corals.

Western Pacific

In contrast to shallow water corals that develop extensive reefs in many tropical seas, precious corals are generally found in much deeper and colder water and at higher latitudes, and they generally exist as solitary colonies. Many species of octocorals and black corals are found in high densities at the tops of seamounts or other high-relief structures, where they may form extensive coral gardens, or "beds," sustaining a large and diverse invertebrate fauna. Over the past four decades, deepwater coral research in the Western Pacific Region has expanded partly due to the establishment of commercial fisheries for black, pink, red, bamboo, and gold corals off the main Hawaiian Islands; and subsequent management activity by the Western Pacific Fishery Management Council, NMFS, and the State of Hawaii.

The Western Pacific Council manages the precious coral fishery and other associated deepwater corals under the Precious Coral FMP (WPFMC 1980). Soon after implementation of the management plan, the Council prohibited use of demersal fish trawls, bottom longlines, and bottom-set gillnets throughout the U.S. Pacific islands EEZ waters. WesPac Bed, in the Northwestern Hawaiian Islands (NWHI), is the only area that has been closed specifically to protect deepwater corals. It was set aside through the Precious Coral FMP as a refuge from coral harvesting. The area was subsequently designated the NWHI Coral Reef Ecosystem Reserve where most commercial fishing, including harvesting of deepwater corals, was prohibited. In 2006, the reserve was proclaimed a national monument and renamed Papahanaumokuakea Marine National Monument.

North Pacific

Deepwater corals are widespread throughout Alaskan waters as far north as the Beaufort Sea. The Aleutian Islands have the highest diversity of deepwater corals in Alaska and possibly in the North Pacific Ocean. The majority of the data on coral distribution in Alaska comes from fisheries bycatch and stock assessment surveys. Many commercial fishery species and other species are associated with deepwater corals in this region. Fish and crabs, particularly juveniles, find abundant prey in deepwater coral habitat and use it as refuge from predators. This habitat may also provide spawning sites to some structure-associated fishes, such as rockfish.

Under the North Pacific Fishery Management Council, deepwater coral habitat constitutes EFH for some groundfish species. Also, in 2005, HAPCs were designated to protect vast areas (957,361 km^2) of deepwater habitat in the Gulf of Alaska and Aleutian Islands. Establishment of the Aleutian Islands Habitat Conservation Area (AIHCA) closed approximately 52 percent of the commercial trawling grounds (~100,000 km^2). The majority of this habitat has not been scientifically studied, but likely contains a few species of commercial importance that would have placed the habitat at risk from fishing gear impacts. Included in the AIHCA are six coral gardens in the central Aleutian Islands where all bottom-contact gear is now prohibited. HAPCs, where the use of all bottom-contact fishing gear is prohibited, have also been established in the Gulf of Alaska.

MYRA BROUWER is a biologist at the South Atlantic Fishery Management Council. She may be reached at myra.brouwer@safmc.net.

REFERENCES

CFMC (Caribbean Fishery Management Council). (1994). *Fishery Management Plan for Corals and Reef Associated Plants and Invertebrates of Puerto Rico and the United States Virgin Islands*. San Juan, Puerto Rico: Caribbean Fishery Management Council.

GMFMC (Gulf of Mexico Fishery Management Council) and SAFMC (South Atlantic Fishery Management Council). (1982). *Fishery Management Plan and Final Environmental Impact Statement for Coral and Coral Reefs of the Gulf of Mexico and South Atlantic*. Tampa, Florida: Gulf of Mexico Fishery Management Council.

PFMC (Pacific Fishery Management Council). (2005). *Amendment 19 to the Pacific Coast Groundfish Fishery Management Plan - Essential Fish Habitat Designation and Minimization of Adverse Impacts*. Portland, Oregon: Pacific Fishery Management Council.

WPFMC (Western Pacific Fishery Management Council). (1980). *Fishery Management Plan for the Precious Coral Fisheries (and Associated Non-Precious Corals) of the Western Pacific Region*. Honolulu, Hawaii: Western Pacific Fishery Management Council.

PHOTO CREDITS

Page 28: Courtesy of Mark Carroll, camera@outerside.com

Page 29: Courtesy of John Reed, Harbor Branch Oceanographic Institute

Page 30: Courtesy of Myra Brouwer, South Atlantic Fishery Management Council

NMEA 2010 Annual Conference

From the Mountains to the Sea: NMEA 2010!

Save the dates: July 18-23, 2010
Conference location: Gatlinburg Convention Center
Hotel: Glenstone Lodge

The Tennessee Educators of Aquatic and Marine Science (TEAMS) invite you to Gatlinburg, Tennessee at the foothills of the Great Smoky Mountains National Park.

The conference begins Monday afternoon with an exhibit preview and reception. Before taking it to the top of Mount Harrison aboard the Gatlinburg Aerial Tramway, we will enjoy the Stegner Lecture performance. Tuesday through Thursday are jam-packed with general and concurrent sessions. Tuesday will conclude with a fun-filled night at Ripley's Aquarium of the Smokies. The annual auction will take place Wednesday evening so be sure to bring your checkbook! The highlight of the afternoon is the awards presentation followed by a real Tennessee Hoedown at Dumplin Valley farm; and Friday is full of field trips that will take you to exciting destinations around East Tennessee and concludes with a stampede at Dolly Parton's Dixie Stampede. For more information, visit www.nmeaweb.org/gatlinburg2010.

current THE JOURNAL OF MARINE EDUCATION
Volume 25 • Number 3 • 2009

PROTECTED SPECIES CONSERVATION AND FISHERY MANAGEMENT

BY ASUKA ISHIZAKI

Fisheries management, particularly in the United States, involves more than managing fish. Regulations regarding protected species such as the Endangered Species Act (ESA), the Marine Mammal Protection Act (MMPA), the Migratory Bird Treaty Act (MBTA), and other public laws greatly influence how our fisheries are managed. Under the ESA, federal, state, and private entities are restricted from carrying out activities that may jeopardize the continued existence of a threatened or endangered species. Under the MMPA, annual limits for marine mammal interactions with commercial fisheries in U.S. waters are set, and measures must be taken if limits are exceeded. The MBTA prohibits take, capture, and killing of any migratory bird, unless otherwise permitted by regulations. These restrictions create unique circumstances in which the continuation of fisheries may depend on compliance with regulations regarding protected species. If adverse impacts to protected species are deemed to exist, U.S. fisheries may be closed or minimized—a rare and unthinkable response in most countries around the world. The U.S. Regional Fishery Management Councils have each worked with fishermen and industry to reduce fishery impacts on protected species and to contribute to their recovery.

SEA TURTLES

All six species of sea turtles occurring in U.S. waters are listed as endangered or threatened under the ESA. Sea turtles face many anthropogenic threats throughout their life cycle, including habitat loss at nesting and foraging grounds, direct take, egg harvest, egg predation by domestic and feral animals, and impacts from fisheries. Due to their highly migratory nature, coupled with the wide range of habitat use across different species, sea turtles interact (i.e., hooked, entangled, or captured) with both coastal and pelagic fisheries, as well as with a variety of fishing gear. It is important to note that many interactions do not result in turtles being seriously injured or killed, and some gear or methods may be less harmful than others.

One of the earliest efforts to reduce sea turtle interactions in the United States began in the 1970s in trawl fisheries. Both the Gulf and the South Atlantic Fishery Management Councils were involved in this initiative, holding public hearings and workshops. Trawl gear are actively towed behind boats and tend to catch large amounts of non-target species. In traditional trawl gear, incidentally captured sea turtles often drowned due to the lack of escape mechanisms. In response to the large numbers of sea turtles captured in shrimp trawl fisheries, development of turtle excluder devices (TEDs) began in the 1970s, and voluntary use of the devices were recommended by the early 1980s (Lutz et al. 2003). However, adoption of TEDs by the industry remained minimal, partly due to the perception that each fisherman's

Specialized gear and annual workshops to safely handle protected species are required in the Hawaii longline fishery.

impact was small, coupled with the perception that TEDs would reduce their target catch. The earlier TEDs were also heavy and unwieldy, factors that discouraged fishermen and the industry from using the device. After nearly a decade of unsuccessful attempts to encourage voluntary use, the National Marine Fishery Service (NMFS) published a regulation to seasonally require TEDs in 1987. By 1994, all shrimp trawlers operating in inshore and offshore waters south of Cape Hatteras, North Carolina, were required to use TEDs in their nets at all times. Designs of TEDs have vastly improved in recent years, becoming not only more effective for allowing sea turtles to escape, but also lighter and less cumbersome for fishermen.

Much of the challenge of implementing TED regulations in the shrimp trawl fishery resulted from a lack of collaboration with industry. Top-down approaches to mitigating fishery impacts on sea turtles and other protected species are likely to be ineffective and difficult. The involvement of fishermen and industry throughout the process of developing solutions to protected species interactions is critical.

In New England, stakeholder collaboration has helped reduce sea turtle interactions. Fishermen operating under the rules of the New England Fishery Management Council's Sea Scallop Fishery Management Plan (FMP) worked with science partners to address entanglements of threatened and endangered sea turtles in the Mid-Atlantic region. Several years of methodical research produced a solution that reduces the risks associated with scallop gear interactions. After lengthy trials, a regulation is now in place requiring the use of modified gear when and where turtles are most likely to occur in the region.

Following several years of lawsuits filed by environmental organizations over concerns of high numbers of sea turtle

interactions, and a number of emergency rules that restricted fishing in certain seasons and areas, Hawaii's swordfish longline fishery was temporarily closed in 2001 to mitigate interactions with sea turtles. While the ruling resulting in the closure was later invalidated as a procedural violation under the ESA for excluding the Hawaii Longline Association during the consultation process, the closure nevertheless impacted the industry and local communities, and fueled the immediate need to develop effective solutions to sea turtle interactions. Experiments to test proposed "turtle-friendly" gear and fishing methods were conducted in the Atlantic, which resulted in the discovery that the use of circle hooks and mackerel bait instead of the conventional "J" hooks and squid bait significantly reduced sea turtle interactions (Watson et al. 2006; see Figure 1). The Hawaii-based swordfish fishery reopened in 2004 with regulations that required the use of circle hooks and mackerel-type bait, called for 100 percent observer coverage, required proper handling of turtles, and limited fishing effort. In addition, the fishery implemented a limit of either 17 loggerhead or 16 leatherback turtle interactions per year, after which the fishery would be closed for the remainder of the year. These regulations have successfully reduced sea turtle interactions in the Hawaii-based swordfish fishery by approximately 90 percent (Gliman et al. 2007).

Leatherback and loggerhead turtles interacting with the Hawaii-based fishery are known to nest in the Western Pacific such as Japan and Indonesia, while their foraging and developing grounds expand as far east as California and Mexico. For this reason, the Western Pacific Council, in addition to successfully mitigating the impacts of the Hawaii-based longline fishery on sea turtles, actively contributes to the recovery of sea turtle populations by supporting international conservation projects. Since 2003, the Western Pacific Council has contributed to activities such as nesting beach conservation of loggerhead turtles in Japan, nesting beach conservation of leatherback turtles in Indonesia and Papua New Guinea, and fishery impact mitigation for loggerhead turtles in Baja California, Mexico. In addition, it has encouraged other countries around the Pacific to adopt measures to reduce fishery impacts on sea turtles and other protected species.

The Western Pacific Council supports nesting beach conservation and fishery mitigation projects throughout the Pacific. Leatherback sea turtles that nest in Papua New Guinea (such as the one pictured) migrate through Hawaii to foraging grounds off the West Coast of North America.

More recently, impacts to sea turtles from bottom longline fishing gear in the Gulf of Mexico has received a great amount of attention. According to a 2006-2008 NMFS report, the number of threatened loggerhead sea turtles that have been caught in the bottom longline fishery has exceeded authorized levels. In January 2009, the Gulf of Mexico Fishery Management Council requested an emergency rule that would address the issue in the short term by temporarily closing the bottom longline fishery in waters less than 50 fathoms (300 feet deep) for the entire eastern Gulf of Mexico. The emergency rule was implemented May 18, 2009 and can remain in effect for 180 days. A formal amendment to the reef fish regulation is currently being developed, which proposes to seasonally limit bottom longline fishing during certain seasons and in areas where sea turtle interactions are most likely to occur.

MARINE MAMMALS

All marine mammals occurring in U.S. waters, regardless of the listing status on the ESA, are protected under the MMPA. If the number of fisheries interactions exceeds the designated limit (called the potential biological removal or PBR) for that given species, a take reduction team (TRT) must be convened to develop a plan to reduce the interactions. Regional Fishery Management Councils have implemented efforts to reduce fishery impacts on marine mammals through a variety of mechanisms, including the MMPA.

A right whale and calf swim off the South Atlantic coast.

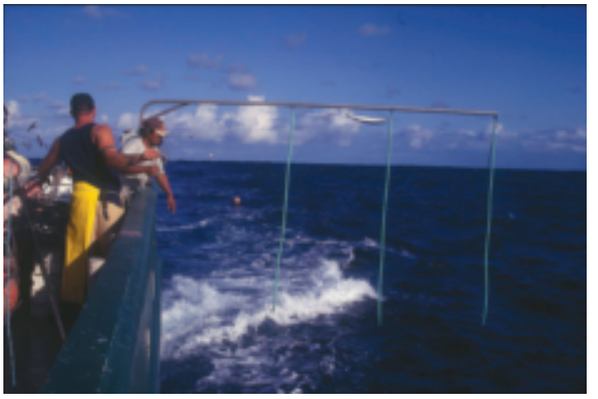
Beginning in the mid-1990s, and prior to the enactment of the TRT mechanism under the MMPA, the New England Fishery Management Council included the goal of reducing the bycatch of harbor porpoise in the Gulf of Maine sink gillnet fishery as part of its Northeast Multispecies (Groundfish) FMP. In response to the problem, fishermen in New England individually explored and later participated with scientists in a series of experiments to determine the efficacy of "pingers," which are designed to

emit high frequency sounds that act as deterrent devices to keep marine mammals away from fishing gear. The experiments showed that pingers were an effective means of reducing porpoise entanglements in gillnets. Pingers are now employed as a primary tool in reducing takes of harbor porpoise in the Gulf of Maine and, in concert with groundfish area closures, have produced significant results.

Following the harbor porpoise experience, the New England Council continued to actively engage in the protection of marine mammals that interact with fisheries in the Northeast. In the late 1990s, the New England Council restricted the use of fishing gear known to entangle the Northern Atlantic right whales, which are considered to be one of the most endangered whale species. Waters within and adjacent to the right whale critical habitat designated under the ESA were seasonally closed based on the annual, predictable aggregations of right whales. The closure was the first step in the development of the Atlantic Large Whale Take Reduction Plan. The plan continues to evolve today as more information becomes available regarding whale entanglements and how fishing practices might be modified to reduce the risk of entanglement.

In the North Pacific, various measures have been implemented to protect the Steller sea lions from fishery impacts. The western stock of Steller sea lions were listed under the ESA in 1990 due to a large decline in the population. A number of factors may have contributed to the decline, including but not limited to intentional shooting, disease, predation, ecosystem change, and indirect impacts from fisheries through resource competition. To address the indirect impacts of Steller sea lions from fisheries, the North Pacific Fishery Management Council and NMFS have focused on reducing potential effects of competition and minimizing localized depletion of prey species. Major food items for Steller sea lions include fishery target species such as pollock, Pacific cod, Atka mackerel, and salmon, as well as non-target species such as octopus and squid, which may be retained for sale, and capelin, a forage species. In 2002, protection measures were implemented that include fishery and gear-specific closures around Steller sea lion rookeries and haul outs, limitations of catch from critical habitat areas, and seasonal and area apportionments of the total allowable catch limits for pollock, Pacific cod, and Atka mackerel. Although it is difficult to determine the extent to which these fishery closures have been effective, the Steller sea lion population is showing signs of recovery.

The Western Pacific Council established a Marine Mammal Advisory Committee in 2005 to address entanglement and hooking of false killer whales as they depredate (i.e., feed) on fish caught in longline fisheries.



Side-setting and the use of bird curtains has resulted in a 90 to 95 percent reduction bird interactions with the Hawaii longline fishery.

False killer whales are large dolphins that are found worldwide in many tropical and warm-temperate waters. Favoring large fish for prey, false killer whales occasionally prey on fish caught in longline fisheries, leaving only the fish head on the hook to be hauled back to the fishing boat. Longline fishermen in Hawaii report that they frequently lose their catch to false killer whales and other large dolphins and are troubled by the economic loss they endure as a result (TEC Inc. 2009). To add to the challenge, a handful of false killer whales are also hooked in the longline fishery every year, and those numbers have exceeded the PBR levels of 2.2 animals set under the provisions of the MMPA. The Western Pacific Council established a Marine Mammal Advisory Committee in 2005 to address the false killer whale depredation and bycatch issue, as funding limitations prevented NMFS from convening a false killer whale TRT at the time. NMFS is now preparing to convene a TRT in 2010, partially in response to a petition submitted by several environmental organizations. Technological solutions are also being proposed to keep false killer whales away from longlines and prevent depredation as well as bycatch.

SEABIRDS

Seabird interactions with fisheries had long been a challenge for many commercial fisheries. Most migratory bird species in the U.S. are protected by the MBTA. In addition, the short-tailed albatross is listed as endangered under the ESA. Potential interactions with such protected seabirds have been a source of

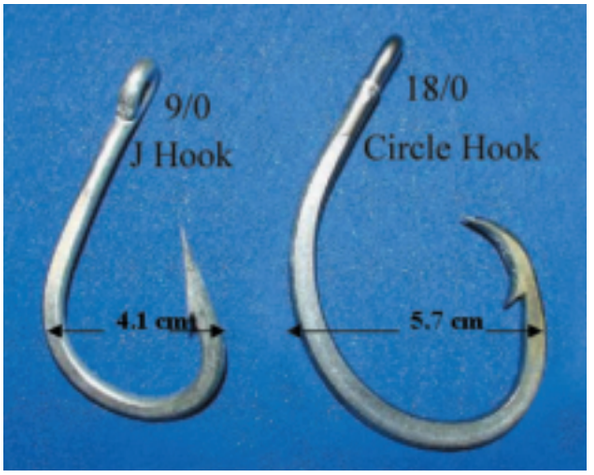


Figure 1. Circle hooks and mackerel bait instead of the conventional "J" hooks and squid bait helped to reduce sea turtle interactions with the Hawaii longline fishery by 90 percent.

concern particularly in commercial longline fisheries. Seabirds become hooked during line setting as they dive for the sinking bait and drown as the gear continues to sink. Longline fisheries in both Alaska and Hawaii have successfully reduced seabird interactions through methods such as the use of streamer lines and bird curtains to deter seabirds during line setting, setting gear from the side of the vessel, and using blue-dyed bait to reduce the visibility of bait underwater. In both regions, new methods were developed and tested in collaboration with the industry, resulting in methods that were easily accepted by fishermen.

CONCLUSION

The balance between fisheries and protected species conservation is not always an easy one to achieve, but the examples set by the Regional Fishery Management Councils show that it is not impossible. A number of fisheries in the United States have successfully addressed the issue of protected species interactions through a variety of mechanisms. Perhaps the most valuable lesson learned from these fisheries is the importance of collaborating with the fishing industry to develop solutions. Without industry collaboration and support, solutions may not be successfully adopted and compliance may be compromised. The Councils continue to work closely with the industry to actively address protected species issues and, in many cases, set positive examples that are subsequently adopted in other regions and countries.

ASUKA ISHIZAKI is the protected species coordinator at the Western Pacific Fishery Management Council. She may be reached at asuka.ishizaki@noaa.gov.

REFERENCES

Gillman, E., D. Kobayashi, T. Swenarton, N. Brothers, P. Dalzell, and I. Kinan-Kelly. (2007). Reducing sea turtle interactions in the Hawaii-based longline swordfish fishery. *Biological Conservation* 139: 19-28.

Lutz, P.L., J.A. Musick, and J. Wyneken (eds.). (2003). *The Biology of Sea Turtles*, Volume II. Boca Raton, FL: CRC Press.

TEC Inc. (2009). Cetacean depredation in the Hawaii longline fishery: Interviews of longline vessel owners and captains. *Final Report to the National Marine Fishery Service Pacific Islands Regional Office*.

Watson, J., S. Epperly, A. Shah, and D. Foster. Fishing methods to reduce sea turtle mortality associated with pelagic longlines. *Canadian Journal of Fisheries and Aquatic Sciences* 62(5): 965-981.

RESOURCES

Status, threats, and conservation of sea turtles:
http://www.nmfs.noaa.gov/pr/species/turtles/

Marine Mammal Protection Act:
http://www.nmfs.noaa.gov/pr/laws/mmpa/

Migratory Bird Species Act:
http://www.fws.gov/pacific/migratorybirds/mbta.htm

PHOTO CREDITS

Page 32: Courtesy of Western Pacific Fishery Management Council

Page 33 (left): Courtesy of Nicholas Pilcher/Marine Research Foundation

Page 33 (right): Courtesy of NOAA Fisheries Southeast Regional Office

Page 34 (left): Courtesy of Robin W. Baird

Page 34 (right): Courtesy of Nigel Brothers/Blue Ocean Institute

current THE JOURNAL OF MARINE EDUCATION
Volume 25 • Number 3 • 2009

Working Cooperatively: International Fisheries Management in the 21st Century

By Sylvia Spalding

Many important U.S. fisheries target stocks that inhabit not only the waters of the U.S. exclusive economic zone (EEZ), but also the EEZ waters of other countries as well as the high seas. To successfully conserve such straddling and highly migratory fish stocks, U.S. fisheries managers engage in extensive cooperative efforts with other fishing nations to share data, engage in rebuilding programs, and enforce mutually agreed upon measures. Today, international management arrangements and regional fishery management organizations (RFMOs) have become the engines driving the conservation of these fish stocks. The U.S. Regional Fishery Management Councils participate in these multi-national regional fishery bodies. The Councils also ensure that domestic fishery management measures are consistent with applicable international agreements.

U.S.–CANADA RESOURCE SHARING AGREEMENT

Georges Bank is a large elevated area of the sea floor situated between Cape Cod, Massachusetts and Cape Sable Island, Nova Scotia. Several stocks on Georges Bank are transboundary and, to be effectively managed, require bilateral coordination. Since the international maritime boundary line between the U.S. and Canadian federal waters was drawn in 1984, the two countries have worked closely to better manage these resources, collaborate on stock assessments and other types of research, and enforce conservation programs.

To improve the system, the Transboundary Management Guidance Committee (TMGC), which includes New England Fishery Management Council members and National Marine Fisheries Service (NMFS) representatives, was established to develop a management advisory process. In December 2001, the TMGC agreed to an important compromise to determine how several transboundary stocks should be allocated between the two nations.

The New England Council responded in July 2002 by voting to amend its Northeast Multispecies Fishery Management Plan (FMP) to incorporate the U.S.–Canada Resource Sharing Agreement. Georges Bank cod, haddock, and yellowtail flounder are now subject to the terms of the agreement. An allocation of cod, haddock, and yellowtail flounder is given to each country based on a formula that includes historical catch percentage and present resource distribution.

The sharing agreement has now been in place for five years, a particularly important accomplishment as stocks of cod and yellowtail flounder rebuild. Along with their Canadian counterparts, the New England Council and NMFS representatives crafted a compromise that ensures equity, adherence to an effective conservation program, and long-term benefits to both nations.

Figure 1. Digital bathymetry map of the Gulf of Maine. The United States and Canada have an agreement that allocates each country with a share of cod, haddock, and yellowtail flounder from Georges Bank.

CANADA–U.S. PACIFIC SALMON TREATY

In managing salmon that range from the U.S. Pacific Northwest into Canadian and Alaskan waters, the Pacific Fishery Management Council complies with the Pacific Salmon Treaty and other international treaty obligations. The Pacific Council coordinates on salmon issues with Canada and Alaska through the Pacific Salmon Commission, which was formed to implement the Pacific Salmon Treaty. The United States allowed Canadian fishing in U.S. waters under a reciprocal agreement until 1978. Negotiations between the two governments, including those within the context of the Pacific Salmon Commission, continue to seek a resolution of all transboundary salmon issues. These negotiations are aimed at stabilizing and reducing, where possible, the interception of salmon originating from one country by fishermen of the other. No U.S.–Canada reciprocal salmon fishing is contemplated in the foreseeable future.

U.S.–RUSSIA INTERGOVERNMENTAL CONSULTATIVE COMMITTEE ON FISHERIES AND THE DONUT HOLE CONFERENCE

The North Pacific Fishery Management Council participates in international fishery management with Russia through two venues: 1) the U.S.-Russia Intergovernmental Consultative Committee (ICC) on Fisheries; and 2) the Central Bering Sea Conference of the Parties to the Convention on the Conservation and Management of Pollock Resources in the Central Bering Sea (or better know as the Donut Hole Conference). The Donut Hole Conference is both a forum for exchange of information on pollock stocks in the international waters of the Donut Hole and the group that determines allowable fishing levels for pollock in this area by countries who are party to the Convention. The ICC is specifically between the governments of the United States and the Russian Federation and is a forum for discussion of the international boundary line agreement between the United States and Russia. The ICC has also discussed boundary line violations, joint enforcement agreements between the U.S. Coast Guard and the Russian Border Guard, and scientific research information on pollock and other Bering Sea resources, as well as potential fishing agreements for limited fishing in the respective EEZs. The North Pacific Council's executive director represents the Council at meetings of the Bering Sea Fisheries Advisory Board, which advises the U.S. Department of State in this forum.

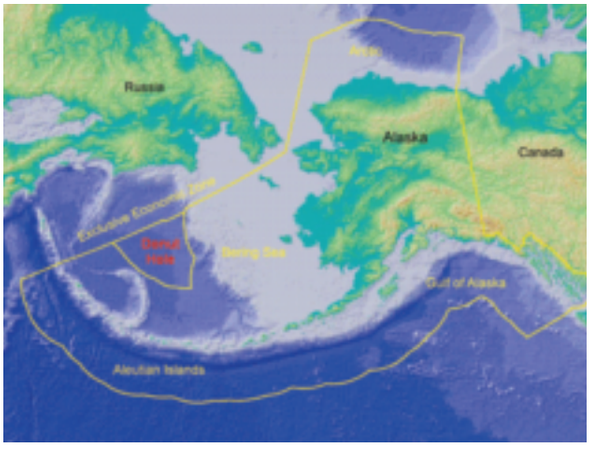


Figure 2. The Bering Sea Fisheries Advisory Board determines allowable fishing levels of pollock in the international waters of the Central Bering Sea by countries who are party to the Donut Hole Convention.

WESTERN AND CENTRAL PACIFIC FISHERIES COMMISSION AND THE INTER-AMERICAN TROPICAL TUNA COMMISSION

Two RFMOs are responsible for international management and conservation of highly migratory species (HMS), primarily tuna and billfishes, in the Pacific—the Western and Central Pacific Fishery Commission (WCPFC) and the Inter-American Tropical Tuna Commission (IATTC; Figure 3). The Western Pacific and Pacific Fishery Management Councils participate in the U.S. delegation of these RFMOs. Under the Pelagics Fishery Ecosystem Plan of the Western Pacific Council and the HMS FMP of the Pacific Council, management measures stemming from RFMOs may be implemented by the Councils via the Magnuson-Stevens Fishery Conservation and Management Act.

The WCPFC has been in effect for six years and its member nations are composed largely of small Pacific Island nations, Australia, the United States, and Asian nations. The IATTC has been established for nearly 60 years and its membership includes countries of the Americas, including the United States and various distant water fishing nations.

Figure 3. Areas of responsibility and overlap of the WCPFC and IATTC. The United States is party to both conventions, so U.S. fishing vessels in the Pacific are subject to their international measures for tuna and other highly migratory species.

Both the WCPFC and IATTC have implemented limits on fleet-wide catches of bigeye tuna by longline vessels, in addition to management measures for purse-seine vessels.

In December 2008, the WCPFC reached consensus on a new conservation measure for the years 2009-2011, applicable to tuna catches from the Western and Central Pacific Ocean. This new measure includes a 30 percent catch reduction of bigeye tuna by longline vessels (as compared to 2004 landings) phased in by 10 percent increments over the three-year period, with some exceptions. Yellowfin tuna catches are not to increase over the 2001–2004 catch levels. Because Hawaii longline catches of bigeye in 2004 were under 5,000 mt and the fishery lands only fresh fish (not frozen), it must make the initial 10 percent reduction in year one and then maintain that reduction in the second and third years. However, the 10 percent reduction may cause the fishery to close just as the high-demand holiday season for sashimi in Hawaii begins.

The U.S. Territories of American Samoa, Guam, and the Commonwealth of the Northern Mariana Islands are recognized by the WCPFC as Participating Territories and have special

exemptions similar to Small Island Developing States that are undertaking responsible development of their domestic fisheries and have annual landings of less than 2,000 mt. As such, the catch limits for bigeye and yellowfin do not apply; however, the Western Pacific Council may set domestic catch limits for longline fisheries in these areas.

Recently, the WCPFC has been discussing using the Western Pacific Council's measures to address longline bycatch of sea turtles (such as circle hooks, mackerel bait, and side-setting) and its allowable takes of sea turtles as benchmarks for other longline fisheries to meet.

The Northern Committee of the WCPFC addresses the North Pacific albacore tuna stock. The troll fishery for albacore tuna is the most economically important HMS fishery on the U.S. West Coast, worth about $22 million in ex-vessel revenue in 2008. The most recent albacore stock assessment, completed in 2006, revealed that although stock biomass is large, recent exploitation levels may be too high, leading to population decline over the long term. The Pacific Council has supported the identification of reference points for the stock to guide management and has called on members of the WCPFC and IATTC to not increase fishing effort on the stock.

NORTH PACIFIC FISHERIES COMMISSION

In response to a growing concern of the international community over possible negative impacts of bottom-fisheries activities on seamount ecosystems in the high seas areas, Japan, the Republic of Korea, the Russian Federation, and the United States started discussion on a new RFMO or arrangement in August 2006. As of July 2009, six scientific working group meetings and six intergovernmental meetings had been held, and Canada has joined as a participant. Interim measures have been established, and discussion on the new organization or arrangement is ongoing. The Western Pacific Fishery Management Council participates in the U.S. delegation of this emerging North Pacific RFMO.

OTHER INTERNATIONAL INITIATIVES

Besides involvement in international fishery treaties and arrangements, the Western Pacific Council has taken a lead role in organizing, hosting, and sponsoring a variety of conferences, meetings, workshops, programs, and research projects to promote best practices in fishery management internationally. A partial list includes four of the seven multi-lateral high level conferences that resulted in the creation of the WCPFC; the first three international marine debris conference; three of the four International Fishers Forums focused on protected species and bycatch issues; the first international workshop on South Pacific albacore longline fisheries; the first international black-footed albatross population dynamics workshop; the Technical Workshop on Mitigating Sea Turtle Bycatch in Coastal Net Fisheries; the Fisheries Legislation and Community-Based Fisheries Management Workshop; the circle hook exchange program in South American artisanal longline fisheries; and the International Pacific Marine Educators Conference, which created the International Pacific Marine Educators Network (IPMEN).

SYLVIA SPALDING is the communications officer for the Western Pacific Fishery Management Council and a member of the International Pacific Marine Educators Network steering committee. She was previously with the Secretariat of the Pacific Community and the Marine Aquarium Council. She may be reached at sylvia.spalding@noaa.gov.

RESOURCES

Inter-American Tropical Tuna Commission:
http://www.iattc.org/

North Pacific Regional Fishery Management Organization:
http://nwpbfo.nomaki.jp

Western and Central Pacific Fisheries Commission:
http://www.wcpfc.int/

PHOTO CREDITS

Figure 1: Courtesy of National Oceanographic and Atmospheric Administration and U.S. Geological Survey (USGS), Woods Hole, Massachusetts

Figure 2: Courtesy of North Pacific Fishery Management Council

Figure 3: Courtesy of Western Pacific Regional Fishery Management Council

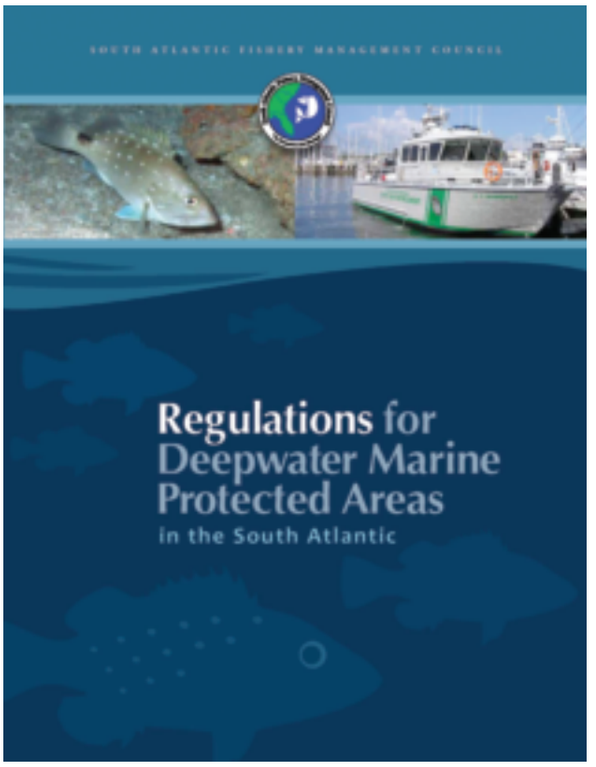
MARINE PROTECTED AREAS FOR FISHERY MANAGEMENT

BY DAVID WITHERELL

Closed areas, or in the modern vernacular, marine protected areas (MPAs), have a long history as a useful tool for managing fisheries. U.S. Regional Fishery Management Councils have established MPAs in federal waters for a variety of reasons. MPAs designed to regulate fishing for sustainable fish production and to preserve marine biodiversity covers a substantial portion of U.S. federal marine waters.

MARINE PROTECTED AREAS

Closing discrete areas of the ocean to some fisheries is a management tool that has been around for along time. For example, in 1886 the Massachusetts State Legislature prohibited the use of commercial fishing nets in Buzzards Bay at the urging of local recreational anglers and the first U.S. Fish Commissioner, Spencer Baird, to protect spawning aggregations and prevent local depletion of coastal species such as scup, black seabass, bluefish, and other species sought after by hook and line fishermen. As the story goes, President Grover Cleveland, who was an avid recreational angler who fished for these same species in Buzzards Bay where he had a summer home, was also influential in closing this area to commercial net fishing. This historical fishing area closure, like many others established since, involved a mix of science, human-use values, allocation, and politics.



Eight MPAs were recently implemented in the South Atlantic region to help protect deepwater species of snapper grouper and their associated habitat.

MPA is the modern term for an area of the ocean designated for special protection. The official federal definition of an MPA (per Executive Order 13158) is "any area of the marine environment that has been reserved by federal, state, tribal, territorial, or local laws or regulations to provide lasting protection for part or all of the natural and cultural resources therein." MPAs can range in level of protection from a simple seasonal closure of an area for a single activity, to a no-access marine reserve where all human activities are prohibited (National Research Council 2001).

In 1976, with the passage of the Magnuson-Stevens Fishery Conservation and Management Act, federal jurisdiction of U.S. fisheries was extended out to 200 nautical miles (nm) from the shoreline. The Regional Fishery Management Councils, which were charged by the Act with developing fishery management plans for fisheries outside of state waters, use MPAs as one tool to manage fisheries in federal waters of their region. Regional Fishery Management Councils have established MPAs in federal waters to meet objectives such as 1) preventing overfishing and increasing yields; 2) minimizing potential effects of fishing on essential fish habitat (EFH); 3) protecting spawning aggregations or spawning and nursery areas; 4) minimizing disturbance or potential competition with marine mammals; and 5) preserving ecosystem biodiversity. Many MPAs achieve more than one objective.

PREVENTING OVERFISHING AND INCREASING YIELD

MPAs have been used as a tool to prevent overfishing by controlling the harvest rate of fish by providing spatial refugia. MPAs can be successfully used particularly for non-migratory species. Extensive closed areas have been used to reduce the exploitation rate of groundfish in New England, groundfish and rockfish in the Pacific, reef fish in the Gulf of Mexico, and deepwater species of grouper and tilefish in the South Atlantic.

MPAs can also be used to increase yield from fisheries by allowing fish to grow to larger sizes, to reproduce before capture, and to replenish areas outside the MPA. In New England, the sea scallop fishery is managed using an area rotation system, whereby areas are closed intermittently to protect juvenile scallops while they grow large enough to spawn and provide higher yields when the area is re-opened. In the Gulf of Mexico, state and federal waters off Texas are closed seasonally to

Extensive closed areas have been used to reduce the exploitation rate of fish, including rockfish, groundfish, and lingcod (pictured here) in the Pacific.

shrimp fishing to allow brown shrimp to grow substantially larger before they are harvested. In the South Atlantic, spillover of fish from closed areas to open areas may provide opportunities for fishermen to increase overall catches as well as increase the size of fish taken.

PROTECTING FISH HABITAT

MPAs can be an effective tool to minimize impacts of fishing operations on benthic habitat. The potential for and severity of habitat impacts due to fishing depends on gear type used as well as the benthic characteristics (e.g., depth, substrate, fauna). Regional Fishery Management Councils have adopted numerous MPAs to ensure fisheries do not have more than minimal adverse impacts to EFHs. In the Pacific and North Pacific regions, bottom trawling and dredging have been prohibited over much of the area to limit impacts on benthic habitat (Figure 1), and these gear types have been prohibited entirely in the Western Pacific region. In the North Pacific, longlining and pot fisheries have been prohibited in dense coral areas, which could be impacted by these gear types. In the South Atlantic, eight deepwater MPAs stretching from North Carolina to Florida prohibit bottom fishing to protect habitat for snappers and groupers. Closures to hook and line and other fisheries have also been implemented in the Gulf of Mexico to protect coral habitats.

PROTECTING SPAWNING AND NURSERY AREAS

MPAs have been established to conserve and increase the reproductive potential of fish stocks and increase survival of young. MPAs can be used to protect spawning aggregations, prevent disturbance during spawning, protect the larger and more reproductively successful females, and protect juveniles while they develop. In the Gulf of Mexico, no-take MPAs have been implemented in several locations to protect spawning sites of several species of snappers and groupers. Trawling and dredging have been prohibited in nursery areas of juvenile red king crabs and blue king crabs in the North Pacific.

MINIMIZING EFFECTS ON MARINE MAMMALS

Marine mammals can be impacted by fisheries through incidental capture by fishing gears, by being injured by moving vessels, by being disturbed or prevented access to their haul outs on land, and potentially through competition with fisheries for food where prey is limited. MPAs can be used to prohibit or limit fisheries in critical areas. For example, in the North Pacific, fishing is prevented within 12 miles of Pacific walrus haul outs to keep vessels from disrupting individuals at haul outs and while they are feeding nearby. In addition, an extensive array of fishing area closures has been implemented to ensure fishing does not significantly impact or adversely affect the critical habitat of endangered Steller sea lions. The Western Pacific Council established a Protected Species Zone in 1991 to prohibit longline fishing within 50 miles of the Northwestern Hawaiian Islands to minimize interactions with Hawaiian monk seals. The area later became the Papahanaumokuakea Marine National Monument through a Presidential proclamation that will prohibit all commercial and recreational fishing in the area by June 2011.

PRESERVING BIODIVERSITY

Because sustainable fisheries depend on healthy diverse ecosystems, the U.S. Regional Fishery Management Councils have also established numerous MPAs to maintain biodiversity, including marine reserves where all fishing is prohibited. For example, the Councils have prohibited bottom-contact fishing on all Pacific Ocean seamounts in federal waters to protect these unique ecosystems with endemic stocks or species, as well as fragile epifauna such as deep sea corals and sponges. Deep sea coral ecosystems are protected by MPAs throughout the United States. Off New England, the Oceanographer and Lydonia Canyons have been closed to fishing for monkfish. In the Pacific and North Pacific, most areas known to have aggregations of coldwater corals have been closed to bottom trawls

Figure 1. Year-round MPAs in the North Pacific for groundfish fisheries.

and dredges to protect these deep sea coral ecosystems. Other deep sea coral ecosystems and tropical coral reef ecosystems have been protected with MPAs established off the South Atlantic, at the Tortugas Ecological reserves and reefs, at the Flower Gardens in the Gulf of Mexico, and off Puerto Rico, the U.S. Virgin Islands, and the Hawaiian Islands.

A FEW WORDS OF CAUTION

Although MPAs have been a useful tool for fisheries management, they are not a panacea for all the problems facing the ocean. Further, MPAs may not provide the benefits anticipated when they were established, even for fishery-related MPAs. In some cases, MPAs have failed due to non-compliance with the regulations, unrealistic goals of the program, poorly chosen size or location, influence of outside factors or activities, or other overriding factors such as environmental conditions. For example, beginning in 1995, all trawling and dredging were prohibited in the Bering Sea around the Pribilof Islands area (7,000 nm^2) to increase the survival and recruitment of blue king crabs. After 15 years, the crab stock has not shown signs of recovery and in fact has worsened possibly due to unfavorable environmental conditions (Witherell and Woodby 2005). In many cases, however, there is no monitoring program within a MPA to see if it is indeed providing the expected benefits.

Establishing an MPA changes the location of where, when, and what activities can take place in and around the area. For fishery-related MPAs, this can mean a redistribution of fishing effort to locations outside of an MPA. Depending on the relative location of the area, this redistribution can increase bycatch, habitat impacts, and interactions with protected species or have other undesirable effects. There are also added costs to fishermen who must travel further to fishing grounds that may have potentially lower catch rates. For large MPAs located close to shore in the vicinity of coastal or indigenous communities, the impacts can be relatively major on a local scale, if residents depend on that area for their food or livelihood. MPAs that lead to reduced domestic catches can also increase U.S. imports at a time when the United States already imports 85 percent of the seafood it consumes. For example, when Presidential executive orders announced the eventual closure of the NWHI bottomfish fishery, Hawaii saw almost immediate increases of foreign imports. Development of MPAs from the bottom-up, using an open public process based on scientific analysis of potential impacts—as provided by the U.S. Regional Fishery Management Council process—allows for all aspects of an MPA to be adequately considered and weighed prior to implementation.

A LOOK AHEAD

In 2000, President Clinton signed Executive Order 13158, which required the Departments of Commerce and the Interior to establish an MPA Center and develop a comprehensive national system of MPAs representing diverse marine ecosystems. In 2008, the MPA Center published the Framework for a National System of MPAs that established the process for listing sites to be part of the national system and defined priority conservation objectives for MPAs. Over the next few years, the MPA Center will be reviewing the protection provided by existing MPAs and comparing these with the priority conservation objectives to identify conservation gaps. Results of the gap analysis will be used by federal agencies such as the National Marine Fisheries Service (NMFS) to strengthen existing MPAs or establish new MPAs.

The Executive Order requires that activities conducted, approved, or funded by federal agencies avoid harm to the natural and cultural resources that are protected by an MPA to the extent permitted by law and to the maximum extent practicable. To meet this new mandate, NMFS (the agency that implements measures developed by the Regional Councils) will be required to ensure that fisheries and other activities avoid harm to specified resources protected by MPAs that are part of the national system. The Councils may make recommendations to NMFS about whether MPAs under their authority should be considered and whether they meet the requirements to be included in the national system.

Comprehensive marine spatial planning ("ocean zoning") is also being discussed within NOAA at the national level, and implementation of these zones would affect where fisheries are conducted in the future. To reduce user conflicts and minimize impacts, areas of the ocean may be designated for exclusive activities such as fishing, recreation, oil and gas extraction, and wind farms. As with the establishment of MPAs for fisheries, the design of these zones will undoubtedly involve a mix of science, human-use values, allocation, and politics.

DAVID WITHERELL is the deputy director of the North Pacific Fishery Management Council. He has authored many peer-reviewed scientific papers on fisheries science, conservation, and management. He can be reached at David.Witherell@noaa.gov.

REFERENCES

National Research Council. (2001). *Marine Protected Areas: Tools for Sustaining Ocean Ecosystems*. National Academies Press: Washington, D.C., 272.

Witherell, D., and D. Woodby. (2005). Application of marine protected areas for sustainable production and marine biodiversity off Alaska. *Marine Fisheries Review* 67(1):1-27.

National MPA Center: **www.mpa.gov**

PHOTO CREDITS

Page 39: Courtesy of South Atlantic Fishery Management Council

Page 40 (top): Courtesy of Pacific Fishery Management Council

Figure 1: Courtesy of North Pacific Fishery Management Council

current THE JOURNAL OF MARINE EDUCATION
Volume 25 • Number 3 • 2009

CATCH SHARE PROGRAMS IN THE UNITED STATES: AN OVERVIEW

BY JENNIFER GILDEN

The term "catch shares" refers to limited access privilege programs (LAPPs), which includes individual fishing quota (IFQ) programs. Catch share programs allow fishermen, gear groups, or other entities to harvest a quantity of fish, usually expressed as a share of a fishery's total allowable catch. Catch share programs have been hailed as an innovative way to solve some of our most pressing fishery problems—including overcapitalization, excessive bycatch, unsafe and chaotic "derby" fisheries, lack of accountability, and inefficient fleets. Catch share programs can reduce overcapitalization, lead to higher quality fish products, help fishermen plan for the future, reduce bycatch, and increase scientific data available to managers. Such programs must be carefully designed and monitored to address potential negative impacts.

WHAT ARE CATCH SHARE PROGRAMS?

The term "catch shares" is a more inclusive way to refer LAPPs, which includes IFQs. A catch share program sets a biologically based annual catch limit for each stock and allocates a specific portion of that limit to entities such as fishermen, cooperatives, and communities. Catch shares are not a permanent right to harvest an amount of fish; harvest privileges may be taken away if the shareholder does not comply with federal fishing standards. In an IFQ program, quota pounds are issued to quota (or catch) shareholders each year based on the allowable catch for that year. If quota shares are transferable, fishermen may lease or sell them in order to maximize profits and tailor their "portfolio" of target species. IFQs are sometimes called individual transferable quotas, individual quotas, or quota shares, while the process of implementing an IFQ program is sometimes called "rationalization."

Deadliest no more. A catch share program implemented in 2005 transformed the Bering Sea crab fisheries, ending the race to catch the limits regardless of weather conditions.

Catch shares are seen as a potential way to "protect the environment; increase profits; provide higher quality fish; create more full-time jobs; and save lives" (EDF 2007). The programs vary considerably, depending on the fishery in which they are used and the regulations for each specific program. The way catch share programs are designed and monitored can have profound effects on fisheries, communities, and individuals.

BENEFITS OF CATCH SHARE PROGRAMS

A summary report of North American LAPPs (Redstone Strategy Group and Environmental Defense 2007) looked at catch share programs in the Mid-Atlantic, Pacific, South Atlantic and Alaska regions, and in British Columbia. The study found that in these fisheries, the programs were usually implemented to address economic issues not easily solved by traditional management measures. Overall, the fisheries experienced major economic

A catch shares program for the Central Gulf of Alaska rockfish fishery has resulted in substantially reduced halibut bycatch.

improvements, clear environmental gains, and a mixture of social changes. Compliance with the total allowable catch increased, while discards, gear loss, and habitat impacts were reduced. In addition, improved fishing practices allowed better management of commercial landings.

Catch share programs can have varied community and social impacts. In general, the study noted that "positive effects included increased safety and a higher percentage of fishermen employed full time. Negative effects included community, processor, and job losses; private economic gains at public expense; and in some cases increased ownership concentration and consolidation. Generally, newer LAPPs addressed these concerns through improved LAPP design" (2007:14).

From an economic standpoint, the primary benefit of catch share programs is to reduce overcapitalization (too many boats and too much gear participating in a fishery). Catch shares can provide fishermen with an economic incentive to support conservative harvest levels that allow fish populations to grow or recover. Having access to catch shares allows fishermen to plan their business operations knowing in advance how many fish they will be able to catch. Catch shares help create a sense of accountability for the resource, and an incentive to protect the resource in order to ensure future fisheries income.

Catch share programs can lead to higher quality fish products, particularly compared to a derby fishery. Processors are better able to coordinate with fishermen, and harvesters can focus on providing the highest quality product when the market demands, rather than rushing to fish when the management season requires. In effect, the focus of harvesting shifts from quantity to quality, and innovation is rewarded. Catch share programs also provide compensation for fishermen and businesses desiring to leave a fishery, as quota shares in most programs can be sold or leased.

The Alaska Halibut and Sablefish IFQ program has resulted in fresh halibut being available to consumers nearly year-round.

From an environmental standpoint, catch shares can reduce bycatch and increase scientific data available to managers when fisheries are sufficiently monitored. When catch shares apply to incidentally caught non-target species, harvesters have an economic incentive to avoid these species in order to reduce the cost of covering those species with IFQs. In addition, harvesters have more time available to fish selectively and use more selective gears. From a safety perspective, IFQs may increase safety (compared to derby fisheries) because they allow fishermen to time their trips for better weather, resulting in safer working conditions.

CHALLENGES

Catch share programs must be carefully designed to address potential issues and concerns. These include how to fairly allocate initial shares; possible concentration of wealth and monopolization; equity concerns (particularly the fear that small boats and small communities will be harmed); possible absentee ownership of quota shares; the need for careful design; monitoring costs; possible cultural changes created by a new ownership system; perceptions that catch shares allocate public resource rights to private citizens, and, alternatively, reduce fishermen's access to a public resource; and the possibility of unreported catch due to an increased incentive to "high grade" (throw back lower-quality fish in favor of better fish). Depending on how a catch share program is designed and monitored, many of these factors can be mitigated. With each new catch share program, more is learned about unforeseen impacts and how to mitigate them.

BRIEF HISTORY OF U.S. CATCH SHARE PROGRAMS

Catch share programs have existed in Iceland since the 1970s, in New Zealand since the 1980s, and in Australia since the 1990s. A Congressional moratorium on catch share programs was put into place in 1996 by the Sustainable Fisheries Act, stalling progress on catch share programs; however, the moratorium was lifted in 2002. Recently, several new programs have been proposed. (See Table 1 on page 44.)

It should be noted that this table does not include detailed community impacts, in part because the community impacts of many of the programs have not been studied. More information about the long-term community impacts of catch share programs would help managers create programs that minimize negative socioeconomic impacts and maximize benefits.

Several new catch share programs are now being developed. The Pacific Fishery Management Council is currently in the process of rationalizing its groundfish trawl fishery through a combination of IFQs and co-ops. The Pacific Council has taken final action for a program to be implemented in 2011. The program includes a 10 percent quota set-aside to help processors and communities adapt to unforeseen negative consequences of rationalization. The program is expected to result in consolidation of the non-whiting trawl fishery by 50 to 66 percent, along with decreased

Region	Year	Fishery affected	Type of program	Problems addressed	Impacts
Mid-Atlantic	1990	Surf clam and ocean quahog	IFQs	Costly enforcement and management, unused fishing capacity, health and safety concerns, constricted fishing seasons	Fewer discards, reduced fleet size, decline in harvest capacity, drop in clam industry employment, increased working hours for remaining jobs, increased economic efficiency
South Atlantic	1992	Wreckfish	IFQs	Rapid fishery growth, lack of scientific information, derby fishery, short seasons	Reduced fleet size, season length increased. Smaller program is easier to enforce, administer, and monitor
North Pacific	1995	Alaska halibut and sablefish	IFQs	Derby fisheries, short seasons, safety issues, gear conflicts, excess capacity, increased bycatch	Season length increased, landings broadly distributed throughout season, higher prices for catches, halibut available throughout year
North Pacific	1998	Bering Sea Aleutian Islands pollock	Harvest cooperatives	Derby fishery, excess capacity	Less bycatch, increased utilization and economic returns, improved safety, better accommodation of conservation measures
Pacific	2001	Fixed-gear sablefish	Permit stacking	Derby fishery, short seasons, safety issues, excess capacity	Season length increased from five days to seven months; harvest capacity declined; economic efficiency increased
North Pacific	2005	Bering Sea Aleutian Islands crabs	Processor quotas and IFQs	Excess capacity, declining stocks, decreasing economic returns, safety, short seasons	Vessel registration declined by two-thirds to one-half; crab jobs declined; remaining jobs earned higher income
Gulf of Mexico	2007	Red snapper	IFQs	Derby fishery, reduced seasons, excess fishing capacity	Reduced bycatch, increased prices for red snapper
North Pacific	2007	Central Gulf of Alaska rockfish	Cooperatives	Derby fishery, short seasons, and loss of product quality	Reduced halibut bycatch and longer season
North Pacific	2008	Flatfish trawl	Cooperatives	Derby fishery, excessive levels of bycatch and waste	Reduced bycatch and increased retention

Table 1. Summary of U.S. catch share programs implemented to date.

bycatch of currently rebuilding rockfish species; there will be 100 percent observer coverage of participating vessels.

The Western Pacific Fishery Management Council is meeting with commercial fishermen in the bottomfish and pelagic fisheries about catch shares.

The South Atlantic Fishery Management Council formed a workgroup in 2007 to explore possible use of LAPPs in the snapper-grouper fishery. While a program was not implemented at that time, catch shares are currently being considered for both the commercial tilefish and black sea bass fisheries in the South Atlantic region.

An Atlantic sea scallop IFQ program is set to be implemented in 2010 in New England in which qualifying federally permitted, general category scallop vessels will share five percent of the annual available landings; each vessel's quota will be set according to its historical participation in the fishery. The other 95 percent of the scallop fishery will continue to be managed under a limited entry program that is primarily controlled by days-at-sea limits and possession limits in controlled access areas.

In June 2009, the New England Fishery Management Council approved a plan to allocate catch shares to fishing sectors in order to help rebuild haddock, flounder, and other groundfish stocks. Sectors will be based on where fishing occurs, the fish targeted,

and gear type. If approved by the Secretary of Commerce, the plan will go into effect May 1, 2010. This program differs from IFQs in that quota shares are not allocated individually (and are not transferable).

Most recently, in August 2009, NMFS approved two new catch share programs. The first, for the Mid-Atlantic Fishery Management Council's tilefish fishery, addresses problems with a derby-style fishery and early annual closures and allots each fisherman a share of the annual tilefish quota. The second, for the Gulf of Mexico commercial grouper and tilefish fisheries, also aims to solve problems associated with a derby fishery and overcapacity in the fishery.

CONCLUSION

By lengthening seasons, reducing fishing capacity, reducing bycatch, and allowing fishermen to better plan their businesses and coordinate with markets, catch share programs offer a promising solution to many common problems faced by fishery managers. As managers design catch share programs in the future, it is important to learn from the experiences of existing catch share programs in order to design robust programs that contribute to the sustainability of fish, fisheries, and fishing-dependent communities.

JENNIFER GILDEN is a staff officer for the Pacific Fishery Management Council in Portland, Oregon. She recently contributed to an analysis of community and social impacts for an environmental impact statement on a catch share program for the groundfish trawl fishery. She also develops outreach and educational materials, contributes to social science efforts, staffs the Pacific Council's Habitat Committee, and enhances the Pacific Council's communication with constituents. She may be reached at jennifer.gilden@noaa.gov.

Trawl net on North Pacific fishing vessel.

REFERENCES

Environmental Defense Fund. (2007). *Sustaining America's Fisheries and Fishing Communities: An Evaluation of Incentive-Based Management. New York: Environmental Defense Fund*. **http://www.edf.org/documents/6119_sustainingfisheries.pdf**

NRC (National Research Council). (1999). *Sharing the Fish: Toward a National Policy on Individual Fishing Quotas*. Washington D.C.: National Academy Press.

NPFMC (North Pacific Fishery Management Council) Staff. (2002). *Report to the U.S. Congress and the Secretary of Commerce: Impacts of the American Fisheries Act*. **http://www.fakr.noaa.gov/npfmc/summary_reports/AFACongress202.pdf**

Redstone Strategy Group and Environmental Defense Fund. (2007). *Assessing the Potential for LAPPs in U.S. Fisheries. New York: Environmental Defense Fund*. **http://www.edf.org/documents/6128_assessinglapps.pdf**

PHOTO CREDITS

Page 42: Courtesy of Mark Fina, North Pacific Fishery Management Council

Page 43: Courtesy of Diana Evans, North Pacific Fishery Management Council

Table 1: Courtesy of North Pacific Fishery Management Council

Page 45 (left): Courtesy of Diana Stram

Page 45 (right): Courtesy of North Pacific Fishery Management Council

The North Pacific flatfish trawl fishery catch share program was implemented in 2008 to reduce bycatch and increase retention.

STUDENT ACTIVITY: DESIGN A FISH

GRADE LEVEL

4th to 6th

NATIONAL SCIENCE EDUCATION STANDARDS

Content Standard A: Science as Inquiry

- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

Content Standard C: Life Science

Grades K-4

- Characteristics of organisms
- Organisms and environments

Grades 5-8

- Structure and function in living organisms
- Diversity and adaptations of organisms

OCEAN LITERACY OBJECTIVES **(www.coexploration.org/oceanliteracy)**

- Students will understand that the ocean supports a great diversity of life and ecosystems (Essential Principle 5); and
- Students will understand that ocean biology provides many unique examples of life cycles, adaptations, and important relationships among organisms (symbiosis, predator-prey dynamics, and energy transfer) that do not occur on land (Fundamental Concept 5d).

OVERVIEW

The individual features of a fish help to determine where it lives and how it survives. Fish come in many different sizes and shapes. The dwarf Pygmy goby found in the Philippines is less than one-half inch (about eight millimeters) long and weighs about 1/1000 of an ounce (four to five milligrams). The ocean sunfish (mola) can grow up to 13 feet (almost four meters) long and weigh up to 3,307 pounds (about 1,500 kilograms). The shape of the fish provides clues about where they might live and how they move. Many reef fish are compressed (flattened from side-to-side). When seen head on, these fish seem to disappear. Some fish have a fusiform or football shape, rounded, and tapering at both ends. This shape reduces drag and allows the fish to swim fast. In this lesson, students will explore fish morphology, or the form and function of a fish.

ACTIVITIES

1. **Parts of a Fish.** Start this lesson by having the students draw a fish from memory. Encourage them to think about the shape they are giving the fish and the type of fins and tail. Then give students the "Fish Basics" information sheet and go over the information with them.
2. **Design a Fish.** Using the information on the "Fish Basics" sheet, students are to create a fish. They need to be able to justify why the fish has a particular body part or adaptation. Students are to write a paragraph explaining where their fish lives and what adaptation the fish has that helps it survive in the chosen habitat. You may want to give them the following scenarios:
    - A powerful fish that swims long distances.
    - A fish that hangs out on the bottom of the ocean floor.
    - A fish that can easily hide itself.
3. This is a great lesson to encourage some creative writing. Have the students create a habitat for their fish, and then write a story about the life and adventures of the fish.

MATERIALS NEEDED

- "Fish Basics" worksheet
- Paper and colored pens or materials for creating a fish

FOR MORE INFORMATION

Communications Officer, Western Pacific Fishery Management Council, 1164 Bishop Street, Suite 1400, Honolulu, Hawaii 96813; info.wpcouncil@noaa.gov (email); **www.wpcouncil.org/education** (web)

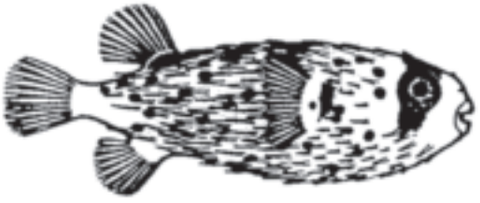
CREDIT

This lesson is based on a lesson of the same title in the *FishQuest* curriculum by the Western Pacific Fishery Management Council in partnership with Pacific Resources in Education and Learning, the Hawaii Department of Education, and Hawaii Public Television. It was modified by the Western Pacific Fishery Management Council with the gracious assistance of Craig Strang, Lawrence Hall of Science, University of California; Mellie Lewis, College of Exploration; and Gary Karr.

STUDENT WORKSHEET: FISH BASICS

Compressed

Sphere



Depressed

Rod

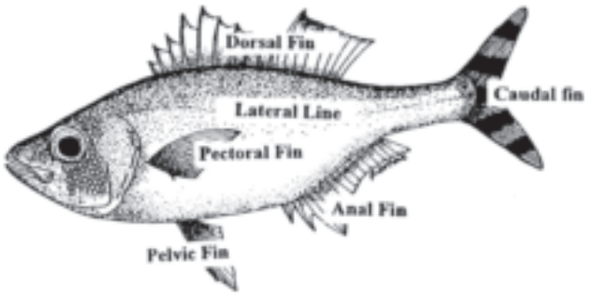
Fusiform

Ribbon

IMPORTANCE OF BODY SHAPE

The shape of a fish's body gives us clues about where it lives and how it moves throughout the ocean or reef. There are six basic fish shapes.

- **Compressed:** The body is flattened from side-to-side. The advantage of this shape is that when it is viewed head on it is very difficult to see. The flattened body makes it easy to turn quickly and move through a coral reef or rock structure. The disadvantage is they usually do not swim rapidly (some schooling fish are an exception).
- **Depressed:** These fish are flattened from top to bottom. They burrow themselves down into the sand and use camouflage to protect themselves. An example is stingrays.
- **Fusiform:** These fish have a long oval shape with tapered ends, like a cigar or a football. This streamlined shape reduces drag and allows them to swim fast. They usually live in open water and include fish like the barracuda or jack.
- **Sphere:** These fish have the ability to puff themselves out. They fill their bodies with air so they are too big to be swallowed.
- **Rod:** These fish have a long arrow-like body. They are often ambush hunters; they can lunge quickly and move fast.
- **Ribbon:** These fish have a snake-like body. They tend to move slowly and can move quickly through rocks and corals. The electric eel and moral eels are good examples of fish with this body shape.



FISH FINS

All fish have fins. The fins come in different sizes and shapes. Where a fish lives and how it moves helps determine the type of fins a fish has. Fins help stabilize and propel fish. Fins can be stiff and spiny or soft and flexible.

Pectoral Fins

- Paired pectoral fins are responsible for turning.
- Pectoral fins can be used to help support a fish as it sits on the bottom of the ocean or on the reef.
- Pectoral fins can also be used for propelling the fish forward.

Pelvic Fins

- Pelvic fins can give the fish stability.
- Some pelvic fins also have modified sucking devices on them.

Dorsal Fins

- The dorsal fin may be a single fin or separated into several fins.
- The dorsal fin acts as a keel and helps keep the fish stable in the water.

Anal Fins

- Anal fins are used to provide stability while swimming.

Caudal Fins

- Caudal fins are responsible for propulsion through the water.

IMPORTANCE OF CAUDAL FIN SHAPE

The shape of a fish's tail (caudal fins) gives us clues about what type of a swimmer it is and how it moves throughout the ocean or reef.

- **Rounded:** Fish with a rounded tail are generally slow moving, but are capable of short, accurate bursts of speed.

- **Truncate:** These fish are generally strong, slow swimmers.

- **Forked:** Fish with forked tails, like the striped bass, are also fast swimmers, though they may not swim fast all of the time. The deeper the fork, the faster the fish can swim.

- **Lunate or Crescent:** These fish are fast, strong swimmers that are continuously on the move, like swordfish.

IMPORTANCE OF MOUTH SIZE AND LOCATION

The size and location of the mouth can be a good indicator of diet, method of eating, and where the fish lives.

- **Large:** Fish with large mouths generally eat large food items like other fish.
- **Small:** Fish with small mouths eat small food items, like small crustaceans or mollusks.
- **Tiny:** Fish with tiny mouths eat tiny things like zooplankton.

- **Terminal:** A terminal mouth is located on the end of the head. Fish with terminal mouths, like the tuna, may chase and capture things or, like the butterfly fish, may pick at things.

- **Up-Pointing:** A fish with an up-pointing mouth has a long lower jaw. The mouth opening is toward the top of the head. The tarpon has this kind of mouth. It feeds near the surface.

- **Sub-Terminal:** A sub-terminal mouth is on the underside of the head. Fish with this type of mouth usually feed on the bottom. The bonefish has a sub-terminal mouth.

STUDENT ACTIVITY: THE LIFE AND TIMES OF A FISH

GRADE LEVEL

6th to 8th

NATIONAL SCIENCE EDUCATION STANDARDS

Content Standard A: Science as Inquiry

- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

Content Standard C: Life Science

- Reproduction and heredity
- Populations and ecosystems
- Diversity and adaptations of organisms

OCEAN LITERACY OBJECTIVES **(www.coexploration.org/oceanliteracy)**

- Students will understand that the ocean supports a great diversity of life and ecosystems (Essential Principle 5);
- Students will understand that ocean biology provides many unique examples of life cycles, adaptations, and important relationships among organisms (symbiosis, predator-prey dynamics, and energy transfer) that do not occur on land (Fundamental Concept 5d); and
- Students will understand that ocean habitats are defined by environmental characteristics. Due to interactions of abiotic factors such as salinity, temperature, oxygen, pH, light, nutrients, pressure, substrate, and circulation, ocean life is not evenly distributed temporally or spatially, (i.e. it is "patchy"). Some regions of the ocean support more diverse and abundant life than anywhere on Earth, while much of the ocean is considered a desert (Fundamental Concept 5f).

KEY WORDS

- **Bottomfish Ecosystem:** On or near the ocean bottom
- **Coral Reef Ecosystem:** Among coral reefs
- **Pelagic/Open Ocean:** In the water column, not near the ocean bottom

OVERVIEW

Animals in the ocean have adaptations that enable them to survive in different habitats. No matter where they live, fish need suitable protection from predators, food, clean water, and a spawning site to ensure the continuation of their species. Some fish migrate to find these things, but others stay in one area their entire life. In this activity, students will explore three different ecosystems in the ocean. See the "Zones in the Ocean" chart for descriptions of the coral reef, pelagic, and bottomfish habitats.

ACTIVITIES

1. Give students copies of the "Habitats Map" and the "Zones in the Ocean" chart. The Habitats Map defines the zones. The chart gives zones and some of the environmental factors. Students need to brainstorm ideas for adaptations that fish living in these zones might have. Students are to list fish found in each of these zones. Also, have students include other environmental factors for each zone. Students can use the map to list where the different species live. Have students refer to the "Fish Basics" pages used in the "Design a Fish" activity. This will give them ideas of different kinds of fish for the different zones.

2. Give students copies of the "Fish Identification" pages that give examples of fish found in the pelagic, bottomfish, and coral reefs zones. Have students create a mural that depicts the three zones. Include in this mural the environmental factors. Students are to create three-dimensional models of fish that would be found in the different zones.

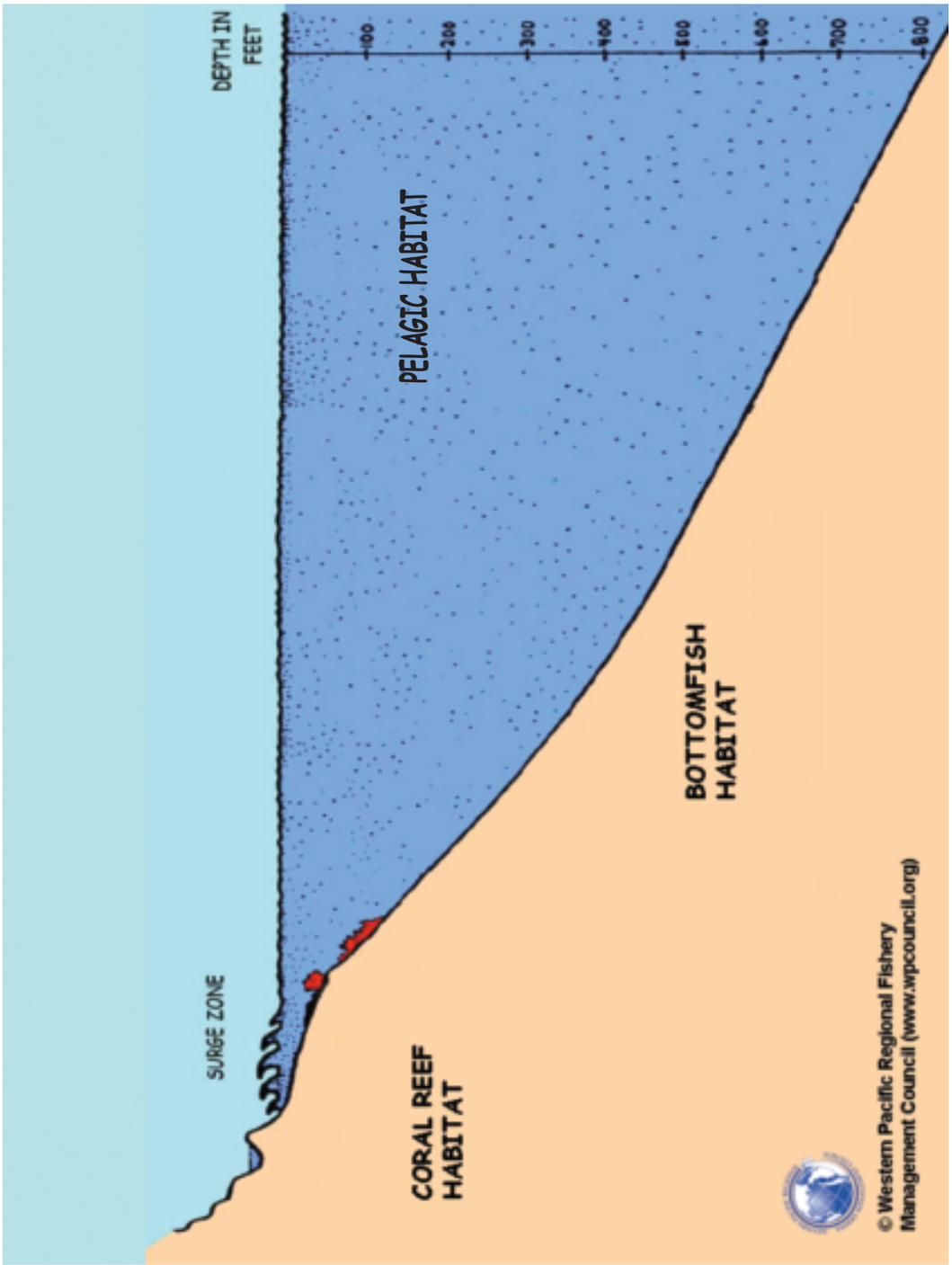
FOR MORE INFORMATION

Communications Officer, Western Pacific Fishery Management Council, 1164 Bishop Street, Suite 1400, Honolulu, Hawaii 96813; info.wpcouncil@noaa.gov (email); **www.wpcouncil.org/education** (web)

CREDIT

This lesson is based on a lesson of the same title in the *FishQuest* curriculum by the Western Pacific Fishery Management Council in partnership with Pacific Resources in Education and Learning, the Hawaii Department of Education, and Hawaii Public Television. It was modified by the Western Pacific Council with the gracious assistance of Craig Strang, Lawrence Hall of Science, University of California; and Mellie Lewis, College of Exploration.

STUDENT WORKSHEET: HABITATS MAP

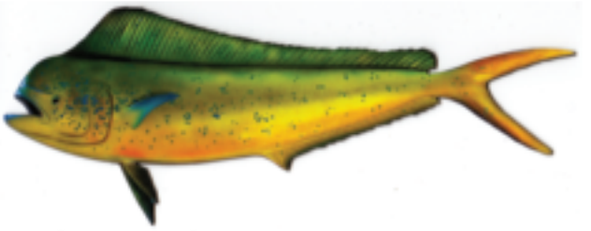
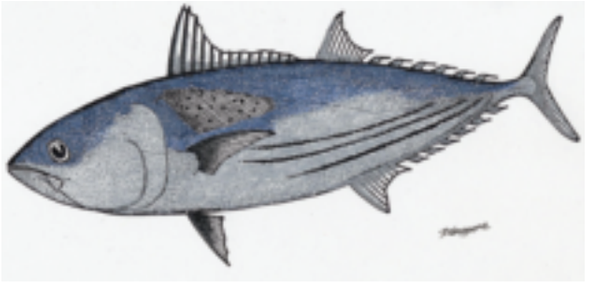


STUDENT WOKSHEET: ZONES IN THE OCEAN

Name: _____ Date: _____

Habitat	Environmental Factors	Adaptations	Types of Fish
Coral Reef	Quiet waters Coral structures Sunlight available Dark hiding places Predators Competition for food Ranges from 0-300 feet		
Pelagic/Open Ocean	Wide open spaces Lack of hiding places Predators Waves and currents Migrate from region to region		
Bottomfish Ecosystem	Cool dark waters Ocean floor Rocky ledges Undersea cliffs Pinnacles and holes Ranges from 90-900 feet		

STUDENT WORKSHEET: PELAGIC FISH IDENTIFICATION

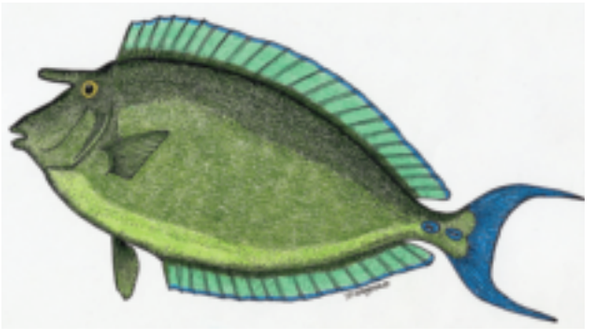
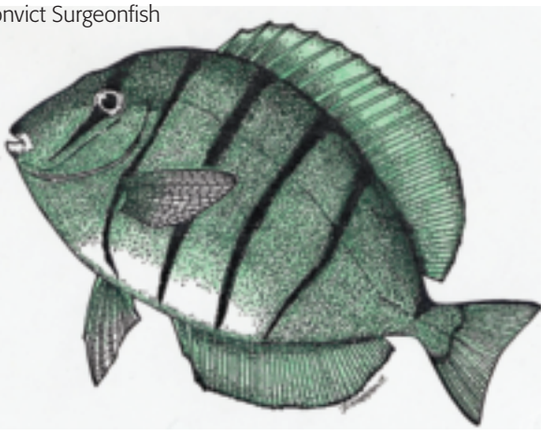
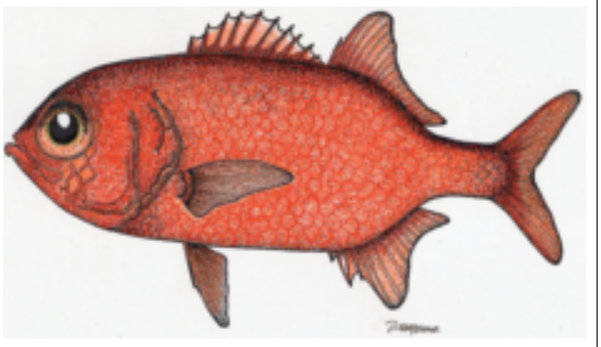
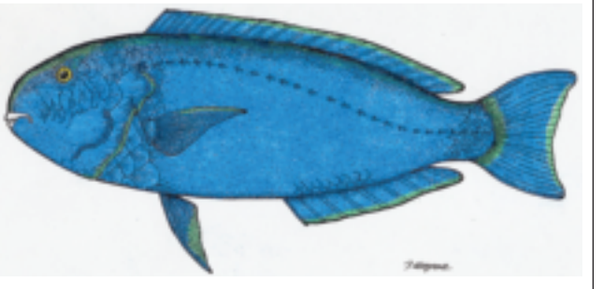
Pelagic Fish	
Yellowfin Tuna 	Blue Marlin 
Albacore Tuna 	Dolphinfish (Mahimahi) 
Skipjack Tuna 	Moonfish 

STUDENT WORKSHEET: BOTTOMFISH IDENTIFICATION

Bottomfish	
Pink Snapper 	Von Siebold's Snapper 
Sea Bass 	Longtailed Red Snapper 
Grey Snapper 	Flower Snapper 

Illustrations (except grey snapper): Courtesy of Hawaii Division of Aquatic Resources.

STUDENT WORKSHEET: REEF FISH IDENTIFICATION

Reef Fish	
Bluespine Unicornfish 	Convict Surgeonfish 
Goldring Surgeonfish 	Squirrel Fish 
Whitesaddle Goatfish 	Parrotfish 

STUDENT ACTIVITY: THE FISH TRAP CHALLENGE

GRADE LEVEL

5th to 8th

NATIONAL SCIENCE EDUCATION STANDARDS

Content Standard A: Science as Inquiry

- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

Content Standard E: Science and Technology

- Abilities of technological design
- Understanding about science and technology

Content Standard F: Science in Personal and Social Perspectives

- Populations, resources, and environments
- Natural hazards
- Risks and benefits
- Science and technology in society

STEM OBJECTIVES

Science: Students will understand the ecology, anatomy, and diet of the animal they are studying.

Technology: Students will use the Internet to research and learn about their animal.

Engineering: Students will build a trap.

Mathematics: Students will design a trap.

OCEAN LITERACY OBJECTIVES
(www.coexploration.org/oceanliteracy)

- Students will understand that the ocean and humans are inextricably interconnected (Essential Principle 6).
- Students will understand that humans affect the ocean in a variety of ways. Laws, regulations, and resource management affect what is taken out and put into the ocean (Fundamental Concept 6e).

OVERVIEW

Bycatch is fish harvested in a fishery that are not sold or kept for personal use. It includes **economic discards** (fish not retained because they are of an undesirable size, sex, or quality or for other economic reasons) and **regulatory discards** (fish that fishermen are required by regulation to discard whenever caught). Some examples are sea turtles caught in shrimp trawls in the Gulf of Mexico or in tuna or swordfish longlines in the Pacific Ocean; salmon caught in pollock trawls in Alaska; and undersized cod caught in New England.

Fishery managers use various measures to reduce bycatch and to facilitate their post-release survivability.

- **individual fishing quotas** or **catch shares** are established so fishermen can then take the time to find areas with high abundance of the target species of legal size and move away from areas where bycatch levels are high;
- **limits on bycatch** are set so the fisheries close if and when the bycatch limits are exceeded;
- **closed areas, closed seasons, and time-area closures** are established so the effort of a particular fishery is reduced, which in turn reduces that fishery's bycatch; and
- **gear restrictions or modifications** are used so unwanted fish and protected species are less likely to be caught, can escape after being caught, and have improved likelihood of survivability after being released if they are caught.

Examples of gear restrictions:

- ban on drift gillnets, long gillnets, and limits on fish traps/pots in the U.S. South Atlantic region; and
- ban on demersal fish trawls, bottom longlines, bottom-set gillnets, drift gillnets, and other potentially harmful gear in the entire 1.5 nm^2 U.S. exclusive economic zone (EEZ) waters surrounding the U.S. Pacific islands.

Examples of gear modifications:

- **bycatch reduction devices** on shrimp and groundfish trawls;
- **circle hooks** and **minimum fishing depths** to help to reduce sea turtle bycatch and decrease mortality of turtles that are released;
- **side-setting with bird curtains, night setting,** and **blue-dyed bait** on longline vessels to reduce seabird bycatch; and

- **excluder devices, specific mesh sizes,** and **escape vents or rings** designed to allow unwanted species or undersized fish to escape before they become bycatch.

ACTIVITIES

Option 1: For schools in urban or other areas without access to a body of water for field work

1. Students use the Internet and other available resources to research their local fisheries to see what marine resources are found and if there are any regulations regarding fishing seasons, minimum sizes, restricted areas, etc.

2. Students select a fish, crab, or crayfish that can be caught legally in nearshore waters. This can be a freshwater or saltwater species. They do further research to understand the ecology, anatomy, and diet of the animal they are studying.

3. Students create a paper and pencil design of a trap that would catch only the legal size individuals of their selected species, while safely releasing any bycatch caught in their trap. The biggest challenge of this project is to make sure that the trap has escape hatches or vents or something else to allow unwanted, undersized, and illegal species to escape.

4. Students build a model of their fish trap.

5. Students present an oral report to the class on how their trap would work to address bycatch.

Option 2: For schools in rural or other areas with access to a body of water for field work

1. Students do a field study to identify the fish and invertebrates found in a nearby body of water. The local Department of Fish and Wildlife or equivalent may be a useful resource.

2. Students select a fish or invertebrate to study. They use the Internet and other available resources to see if there are any regulations regarding fishing seasons, minimum sizes, restricted areas, etc., and to learn about the ecology, anatomy, and diet of the animal they are studying

3. Students create a paper and pencil design of a trap that would catch only the legal size individuals of their selected species, while safely releasing any bycatch caught in their trap. The biggest challenge of this project is to make sure that the trap has escape hatches or vents or something else to allow unwanted, undersized, and illegal species to escape.

4. Students build a model of their fish trap. This trap could be made out of natural or manmade materials. Woven palm fronds, willow branches, milk cartons, or anything that will not injure the animals or pollute the waters can be used. Students need to figure out what they might want to use for bait.

5. *Optional:* With an accompanying adult (such as their parent), students can test their trap on a given Saturday, or the teacher can pick a date to meet the students and their parents at a given site to see and test their designs. Prior to setting the trap, teachers should seek permission from their local fish and game office. Traps should be placed out in safe waters and monitored to see what is caught. Anything that won't be eaten, won't be used in an aquarium, or can't be caught or kept legally must be released as bycatch. The students or observers log the catch and bycatch.

6. Students present an oral report to the class on how their trap would work or how the trap worked if it was tested.

FOR MORE INFORMATION

Communications Officer, Western Pacific Fishery Management Council, 1164 Bishop Street, Suite 1400, Honolulu, Hawaii 96813; info.wpcouncil@noaa.gov (email); **www.wpcouncil.org/education** (web)

CREDIT

This lesson is based on a lesson of the same title in the *FishQuest* curriculum by the Western Pacific Fishery Management Council in partnership with Pacific Resources in Education and Learning, the Hawaii Department of Education, and Hawaii Public Television. It was modified by the Western Pacific Council with the gracious assistance of Craig Strang, Lawrence Hall of Science, University of California; and Mellie Lewis, College of Exploration.

STUDENT ACTIVITY: PARADISE ISLAND

GRADE LEVEL

9th to 12th

OBJECTIVES

- Students will be able to explain why a fishery management plan is important;
- Students will be able to describe how a scientist monitors a fishery ecosystem; and
- Students will develop a fishery management plan for Paradise Island.

NATIONAL SCIENCE EDUCATION STANDARDS

Content Standard A: Science as Inquiry

- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

Content Standard C: Life Science

- Interdependence of organisms
- Behavior of organisms

Content Standard F: Science in Personal and Social Perspectives

- Personal and community health
- Environmental quality
- Science and technology in local, national, and global challenges

OCEAN LITERACY OBJECTIVES **(www.coexploration.org/oceanliteracy)**

- Students will understand that the ocean and humans are inextricably interconnected (Essential Principle 6);
- Students will understand that humans affect the ocean in a variety of ways. Laws, regulations, and resource management affect what is taken out and put into the ocean. Human development and activity leads to pollution (point source, non-point source, and noise pollution) and physical modifications (changes to beaches, shores and rivers) … (Fundamental Concept 6e); and
- Students will understand that everyone is responsible for caring for the ocean. The ocean sustains life on Earth and humans must live in ways that sustain the ocean. Individual and collective actions are needed to effectively manage ocean resources for all (Fundamental Concept 6g).

OVERVIEW

Students are to develop a fishery management plan (FMP) for "Paradise Island." The ocean surrounding the island is filled with a wide variety of different fish and crustaceans. The economy of the community is dependent on the fisheries. Fishing vessels from outside have come to Paradise Island to fish. The local community is concerned. They need to develop a plan to protect their fishing industry. The students' task is to brainstorm ideas to protect the fisheries by developing a FMP.

MATERIALS

- Desk size paper and colored pencils
- Student worksheet "Paradise Island"

ACTIVITIES

1. Have the class brainstorm ideas to describe Paradise Island in more detail. Give them the following suggestions (they may also come up with other creative ideas):
   - What is the approximate latitude and longitude of the island?
   - What currents surround the island or are near the island?
   - What kind of island is it? Is it a large, high island or a small, low-lying atoll?
   - What fish and invertebrates exist in the marine environment?
   - What fisheries exist or may potentially exist, including species caught, gear and/or method used, and locations fished?
   - Are there land-based or other non-fishing issues impacting the fisheries and/or the marine environment?
   - Who are the individuals and/or communities with a vested interest in the fishery and/or marine ecosystem?
2. After they have characterized Paradise Island, have the students brainstorm ideas on their own, coming up with things they may want to include in their management plan. Give them the following suggestions of things they may want to include in their plans. They may also come up with other creative ideas.
   - Closures of different sections of the ocean to fishing
   - Limit the types of fishing gear allowed

- Seasonal closures
- Limit the amount of fish that is allowed to be harvested
- Limit the number of boats that can fish in a certain area
- Limit the size of the boat that can be used
- Allocate portions of the catch to different individuals or groups

3. **Role Playing:** Divide the students into teams, and give them copies of the "Paradise Island" worksheets (see pages 59-60) to complete. Explain to the class that in this scenario, they are the Paradise Island Fishery Management Council and they must do something to keep the fish stocks and habitat healthy and the fishery operating at a sustainable level. The challenge they face is to decide who will get to use the resource and what management measures to put in place.

FOR MORE INFORMATION

Communications Officer, Western Pacific Fishery Management Council, 1164 Bishop Street, Suite 1400, Honolulu, Hawaii 96813; info.wpcouncil@noaa.gov (email); **www.wpcouncil.org/education** (web)

CREDIT

This lesson is based on a lesson of the same title in the *FishQuest* curriculum by the Western Pacific Fishery Management Council in partnership with Pacific Resources in Education and Learning, the Hawaii Department of Education, and Hawaii Public Television. It was modified by the Western Pacific Council with the gracious assistance of Craig Strang, Lawrence Hall of Science, University of California; and Mellie Lewis, College of Exploration.

STUDENT WORKSHEET: PARADISE ISLAND

Name: _____ Date: _____

THE CHALLENGE

Out in the middle of the ocean is a small, very beautiful island. The waters around the island are filled with a variety of fish and invertebrates. The main source of economy for the island is fishing. The local community has a very successful fishing fleet. Fish are caught for local consumption and are also exported for sale off the island. Over time, the outside world learns of this incredible fishing site. Large fishing vessels move in. The island's economy grows, and the island thrives. Eventually, though, the local people begin to see changes. Fish are harder to catch. The boats need to go further and further out to sea. The local fishermen are finding it harder to make a living. The local fishermen start asking hard questions. Who really owns the fish? How long before the fish run out? Can we keep these other, larger boats from fishing in our waters?

U.S. Regional Fishery Management Councils address these questions. In 1976, Congress created the Magnuson-Stevens Fisheries Conservation and Management Act (MSA) to conserve and manage fisheries resources in federal waters, which span from the edge of state and territorial waters to the outer limit of the 200-mile exclusive economic zone (EEZ). Individual states and territories manage the waters from their shorelines, generally out to three miles. The U.S. EEZ is the largest in the world, containing 3.4 million square miles (11,351,000 km^2) of ocean and 90,000 miles of coastline, located not only along the eastern and western seaboards and Gulf of Mexico shoreline of the U.S. continent, but also in the Caribbean Sea, Pacific Ocean, and Arctic Ocean.

Eight U.S. Regional Fishery Management Councils were established by the MSA. There are Councils for the Western Pacific Region, the North Pacific, New England, the Mid-Atlantic, the South Atlantic, the Caribbean, the Pacific, and the Gulf of Mexico.

The main task of the Councils is to protect fishery resources, while allowing fishing to occur at sustainable levels. The emphasis is on preventing overfishing, rebuilding stocks, minimizing bycatch, and protecting habitats necessary for spawning, feeding, and growth. To accomplish this, the Councils develop fishery management plans or fishery ecosystem plans (FEP).

The Councils meet several times a year in their respective regions to discuss current issues and then make fishery management recommendations to the Secretary of Commerce. Because decisions can't be made and solutions recommended without understanding the facts, scientists and fishery managers monitor the ecosystems.

Your task is to brainstorm ideas to protect the environment and to develop a fisheries management plan or FEP for Paradise Island. The local community is concerned. A plan needs to be developed to protect their fishing industry.

ACTIVITIES

1. Draw Paradise Island on a large piece of paper. Indicate where the different fish and shellfish can be found around the island.

2. Brainstorm ideas with your fellow Paradise Island Fishery Management Council members (i.e., your team), and fill out the chart (see page 60).

3. Use the information listed above to come up with a Paradise Island Fishery Management Plan or Fishery Ecosystem Plan. List the regulations, research, monitoring, and enforcement that will help protect your fishing industry, as well as the island's marine resources.

4. Have your team share your management plan with the rest of the class. *Optional:* Share your plan as a PowerPoint presentation.

STUDENT WORKSHEET: PARADISE ISLAND

Interest Group	Issue/Concern	Solution
Local fishermen		
Off-island fishermen		
Businesses		
Scientists		
Politicians		

U.S. Regional Fishery Management Council Contacts

Kids learn to fish early from the North Pacific (top) to the South Atlantic (bottom).

PHOTO CREDITS

Page 61 (top): Courtesy of North Pacific Fishery Management Council

Page 61 (bottom): Courtesy of South Atlantic Fishery Management Council

Produced by the Regional Fishery Management Councils under NOAA Award #NA05NMF4410033.

North Pacific Fishery Management Council
605 West Fourth Avenue, Suite 306
Anchorage, Alaska 99501-2252
Phone: (907) 271-2809
Fax: (907) 271-2817
Website: www.alaskafisheries.noaa.gov/npfmc

Pacific Fishery Management Council
7700 NE Ambassador Place, Suite 101
Portland, Oregon 97220-1384
Phone: (503) 820-2280
Toll Free: (866) 806-7204
Fax: (503) 820-2299
Website: www.pcouncil.org

Western Pacific Regional Fishery Management Council
1164 Bishop Street, 1400
Honolulu, Hawaii 96813
Phone: (808) 522-8220
Fax: (808) 522-8226
Website: www.wpcouncil.org

New England Fishery Management Council
50 Water Street, Mill 2
Newburyport, MA 01950
Phone: (978) 465-0492
Fax: (978) 465-3116
Website: www.nefmc.org

Mid-Atlantic Fishery Management Council
Suite 2115 Federal Bldg.
300 S. New Street
Dover, DE 19904-6726
Phone: (302) 674-2331
Toll Free: (877) 446-2362
Fax: (302) 674-5399
Website: www.mafmc.org

South Atlantic Fishery Management Council
4055 Faber Place Drive, Suite 201
North Charleston, SC 29405
Phone: (843) 571-4366
Toll free: (866) SAFMC-10
Fax: (843) 769-4520
Website: www.safmc.net

Caribbean Fishery Management Council
268 Muñoz Rivera Avenue, Suite 1108
San Juan, Puerto Rico 00918-1920
Phone: (787) 766-5927
Fax: (787) 766-6239
Website: www.caribbeanfmc.com

Gulf of Mexico Fishery Management Council
2203 N. Lois Avenue, Suite 1100
Tampa, FL 33607
Phone: (813) 348-1630
Toll Free: (888) 833-1844
Fax: (813) 348-1711
Website: www.gulfcouncil.org

current

THE JOURNAL OF MARINE EDUCATION

NATIONAL MARINE EDUCATORS ASSOCIATION

c/o Johnette Bosarge
P.O. Box 1470
Ocean Springs, MS
39566-1470

INSIDE current

Volume 25 • Number 3 • 2009

*Printed on **Recycled Paper** ♻*