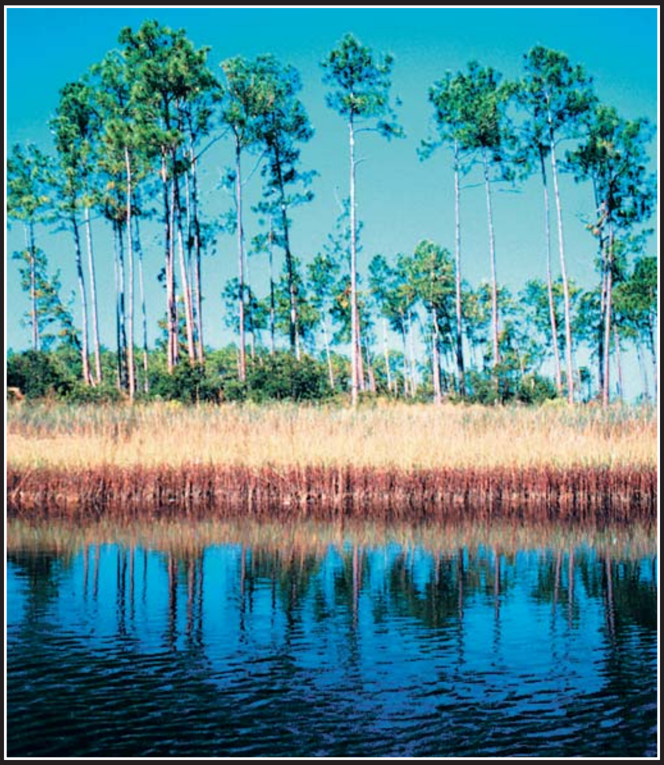
Our Living Oceans: Habitat

STATUS OF THE HABITAT OF U.S. LIVING MARINE RESOURCES



Policymakers' Summary, 1st Edition

U.S. DEPARTMENT OF COMMERCE

National Oceanic and Atmospheric Administration

National Marine Fisheries Service

Our Living Oceans: Habitat

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Our Living Oceans: Habitat

Status of the Habitat of U.S. Living Marine Resources

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Policymakers' Summary, 1st Edition

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U.S. Department of Commerce

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FOREWORD

Our Living Oceans: Habitat. Status of the Habitat of U.S. Living Marine Resources joins editions on living marine resources and economics as the third and final part of the *Our Living Oceans* publication series. Taken together, the volumes in this series serve as a report card on the state of U.S. living marine resources, their economic contributions to the Nation, and the condition of their habitats and availability of habitat use information. This *Policymakers' Summary*, an abridged version, and the complete *Our Living Oceans: Habitat* report provide the foundation for more targeted research and comprehensive and detailed reports in the future.

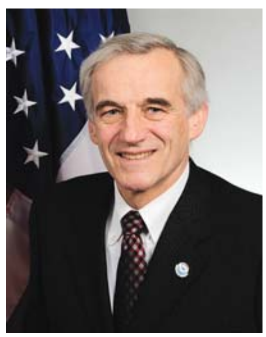
The most important laws governing activities of the National Marine Fisheries Service (NMFS) pertinent to habitat are the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA), recently reauthorized in 2006, and two laws on protected species, the Endangered Species Act (ESA) and Marine Mammal Protection Act (MMPA). The MSFCMA includes provisions to help manage and protect Essential Fish Habitat (EFH) which is defined as ". . . those waters and substrate necessary to fish for spawning, breeding, or growth to maturity" for commercially and recreationally harvested fish and invertebrates within the U.S. Exclusive Economic Zone (EEZ, typically 3–200 nautical miles from shore). The ESA as it applies to NMFS includes provisions to help conserve ecosystems and habitats required by those marine species threatened with, or in danger of, extinction (e.g. listed fish, invertebrates, sea turtles, marine mammals, and marine plants). The MMPA places restrictions on any habitat alteration that could adversely impact a marine mammal by disrupting behavioral patterns. This report covers the habitats of all species managed or protected by NMFS under the MSFCMA, ESA, and MMPA.

That this report is the first comprehensive nationwide review of the status and trends of these habitats, as well as the first comprehensive summary of information available on habitat use at the fishery management or species-group level, underscores the difficulty of the task. In addition to cataloging what is known about our Nation's aquatic habitats and the patterns of their use by living marine resources, the report also indicates what remains unknown. This will help to guide and prioritize research to address the most important gaps in knowledge. Recent technological advances in autonomous underwater vehicles, multibeam sonar, and satellites have increased our ability to fill in these gaps in habitat knowledge.

Our living marine resources are in various states of condition, ranging from heavily overfished or endangered through very healthy and functioning at a high level of productivity. Although the habitat needs of aquatic species often compete with other societal needs, NOAA must ensure that the quantity and quality of available habitat is sufficient to support each life history stage of every managed species at sustainable levels. There remains considerable scientific uncertainty in quantifying the habitat needs of many species, but there is substantial evidence that habitat degradation or loss may be constraining some populations.

This report should not be interpreted as one of despair nor of unbounded optimism. Federal and state governments have provided considerable protection by regulating pollution and development activities, and the increasing availability of habitat information is contributing to improved fishery and ecosystem-based management. However, the ever-increasing concentration of humans along the coasts, growing runoff from cities and agriculture, and changing climate continue to place pressure on aquatic habitats. The information provided in this report will give readers a chance to assess the current situation facing aquatic habitats and to consider the opportunities that we have today to protect the habitat that remains and repair or restore habitats that have been degraded or lost.

Many scientists throughout the National Marine Fisheries Service and many other organizations contributed to this report. As in any complex undertaking being pursued for the first time, the process was arduous and time-consuming. I extend my appreciation and compliments to all.



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Acting Assistant Administrator for Fisheries
National Marine Fisheries Service
Silver Spring, Maryland
May 2009

Preface

This *Policymakers' Summary* is an abridged version of the inaugural edition of *Our Living Oceans: Habitat. Status of the Habitat of U.S. Living Marine Resources*. The full report serves as a companion report to the two other reports in the *Our Living Oceans* series: *Our Living Oceans. The Economic Status of U.S. Fisheries* and *Our Living Oceans. Report on the Status of U.S. Living Marine Resources*. By presenting an initial assessment of the status and health of marine and coastal habitats important to living marine resources, the current edition completes the picture of marine resource status begun in the other two reports.

Our Living Oceans: Habitat. Status of the Habitat of U.S. Living Marine Resources represents the first comprehensive national summary of habitat information and will serve as a baseline on habitat knowledge and status for future comparisons. Included are the habitats of commercially and recreationally harvested fishes and invertebrates, as well as marine mammals, sea turtles, and other protected marine species.

The full report consists of three sections: an Introduction, a National Summary, and the Regional Summaries. The Introduction details the importance of habitat, the legislation under which Federal work is conducted, and the current status of habitat research. The National Summary provides an overview of the status and trends of habitats under the jurisdiction of the National Marine Fisheries Service, and covers items common to all regions. The Regional Summaries include more detailed information about habitat in each region.

This summary of the report presents key information in a concise form. The initial sections provide the highlights of the full report's Introduction and National Summary. Instead of regional summaries, the rest of this version consists of overviews of seven major issues affecting the habitats of living resources entrusted to the National Marine Fisheries Service's protection. For each of these issues, information is provided on the impacts to habitat, impacts to living marine resources, and solutions.

Contents

Executive Summary

Mangrove roots provide vital habitat for many species, especially young fish.

In 2006, commercial and recreational fisheries supported over 2 million jobs and contributed over $73 billion to the United States gross national product, making our Nation one of the largest seafood-producing countries in the world. However, habitat loss and degradation, including poor water quality; overfishing; and natural environmental changes have put increasing pressure on our living marine resources, including coastal, oceanic, and anadromous (species that spawn in fresh water but grow to maturity in salt water, such as salmon) resources, threatening the sustainability of the Nation's fisheries and protected resources. Ending overfishing in 2010–11, as stipulated in the Magnuson-Stevens Reauthorization Act (MSRA), will end one threat to fisheries resources. Nonetheless, much needs to be done to ensure the sustainability of the habitats upon which these living resources depend.

The MSRA mandates that the National Oceanic and Atmospheric Administration's (NOAA) National Marine Fisheries Service (NMFS) designate Essential Fish Habitat (EFH) and minimize the effects of fishing and non-fishing activities on EFH. The Act defines EFH as ". . . those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." In recent years, momentum has been building for a shift in fisheries management towards more holistic ecosystem approaches. This includes a broader focus on ecological relationships and processes, and on interactions with humans. Habitat is a key component of an ecosystem approach to management.

The *Our Living Oceans: Habitat* report provides the first national summary of the status and trends of the habitats used by the living marine resources under NMFS purview. The report covers the habitats occupied by fishery stocks and

protected marine mammals and sea turtles, ranging from inland streams where anadromous species spawn, to the marine waters of the U.S. Exclusive Economic Zone (EEZ) bounded by the 200 nautical mile (n.mi.; 370 km) limit and beyond. Nearly all of these animals use shallow marine and oceanic habitats at some stage of their life cycle. Many also use estuarine habitats, including many commercially valuable species. In keeping with NMFS's marine focus, fewer species use freshwater habitats, the major exception being anadromous species, such as salmon.

The overall message is mixed. Clearly the United States still possesses considerable functioning habitat that supports populations of protected species as well as substantial harvests of fishery resources. However, it is also clear that there has been substantial loss and degradation of habitat, especially where human activities occur. The cumulative impacts of these losses cannot readily be quantified, but they are undoubtedly considerable, especially in urbanized watersheds, estuaries, and coastal areas.

Although the issues affecting U.S. living marine resource habitats vary throughout the country, many are widespread, even if the impacts of some may be manifested differently in different regions. Certain issues are important in all aquatic habitats, while others have more specific and limited impacts within a certain habitat type. The quantity and quality of the water in many freshwater habitats have been declining for over a century. Changes in land use, industrialization, residential expansion, point and non-point source pollution, and dams and other flood-control structures are major contributing causes. Estuarine habitat has been dramatically impacted by many of the same factors. Nutrient pollution and the resulting eutrophication, and the continued loss of estuarine and coastal wetlands and submerged aquatic vegetation are of particular concern. Shallow marine and oceanic habitats generally have good water quality, and relatively little habitat has been lost to human activities. Nevertheless, there are localized problems and concerns, such as the Gulf of Mexico "dead zone" where the water underlying the Mississippi River plume contains little or no oxygen during the summer; the uncertain effects of long-term climate change; and the impacts of some fishing gear, particularly bottom trawls, on seafloor habitats.

As the U.S. population continues to grow, there is increasing pressure on the environment to provide humans with food, income, recreation, and other resources. This is especially evident in coastal areas, where human population growth is about five times faster than the rate inland. Use of aquatic habitats will of course affect those habitats, and society faces many choices, including how to responsibly manage growth, development, and resource use. To do this wisely, society and decisionmakers must understand the consequences of their decisions, including the potential for habitat impacts. In situations where habitat impacts cannot be avoided, decisionmakers must consider ways to reduce or mitigate impacts and to restore damaged habitats.

Scientific information is key to effectively managing habitat. Understanding the relationships between species and habitats, knowing where and how much habitat exists, and rigorously monitoring and assessing its condition can provide the scientific basis for managing habitat. However, this information is only effective in informing public policy when it is communicated to resource managers, stakeholders, and the public in a timely manner and in forms that are appropriate to the specific audiences.

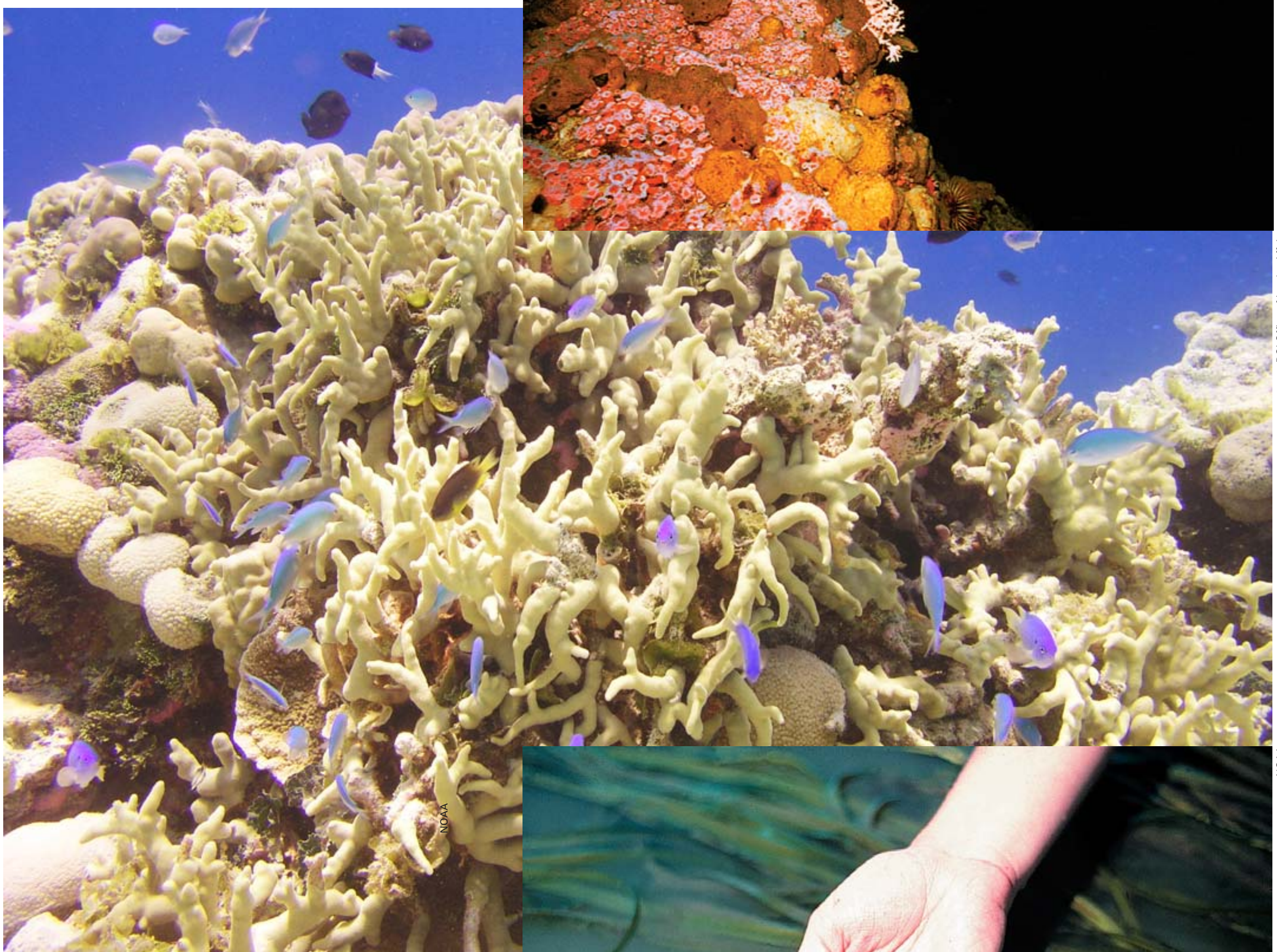
For our Nation to continue benefitting from abundant living marine resources, society must place a high priority on managing habitat. Human populations and economic activities will continue to expand, placing ever-increasing demands on the environment and the habitats it contains. Gaps in the relevant scientific information must be filled, and the information communicated, so that decisionmakers can be appropriately informed as policy is developed and implemented. The National Marine Fisheries Service has developed the *Our Living Oceans* series of reports to contribute to these vital processes.

Above: Salt marsh, an important habitat for fish species.

Opposite page: Kelp forest, providing habitat for many species.

Many of our Nation's living marine resources depend on living habitats

Cordell Bank National Marine Sanctuary



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Top: Yellowtail rockfish swim near heavily encrusted rock pinnacles in Cordell Bank National Marine Sanctuary off California.

Middle: Coral at Ailuk Atoll, in the Marshall Islands.

Bottom: A small Dungeness crab in eelgrass at the Padilla Bay National Estuarine Research Reserve off Washington.

INTRODUCTION

In 2006, commercial and recreational fisheries supported over 2 million jobs and contributed over $73 billion to the United States gross national product, making our Nation one of the largest seafood-producing countries in the world. Until quite recently, most people considered marine fishery resources to be abundant and inexhaustible. Overfishing and natural environmental changes, and habitat loss and degradation, including poor water quality, have put increasing pressures on coastal, anadromous, and oceanic resources. River, lake, estuary, coast, and deep ocean habitats provide essential services such as food, shelter, and space for reproduction and growth for many species, including fish, shellfish, crustaceans, birds, marine mammals, and sea turtles. Habitat damage and loss threatens the sustainability of the Nation's fisheries and protected resources. It also makes coastal areas much more vulnerable to hurricanes and coastal storms.

This abridged report provides an overview of the first national summary of the status and trends of the habitats used by the living marine resources under the purview of NOAA's National Marine Fisheries Service (NMFS)[1]. The report is part of the *Our Living Oceans* (*OLO*) series, joining *OLO Living Marine Resources* and *OLO Economics*. For the first time, there are comprehensive published reviews of the Nation's living marine resources, the habitats they use, and the economic vitality and value of the industries that depend on them. Appropriate information also is included in the full *OLO Habitat* report on nearshore species managed by the states or regional state fisheries commissions.

The habitats addressed range from inland streams used for spawning by anadromous species (species that spawn in fresh water, but grow to maturity in salt water, such as salmon) to the entire U.S. Exclusive Economic Zone (EEZ) bounded by the 200 n.mi. (370 km) limit, and beyond. This report provides a conceptual framework and a baseline for future updates on habitat, identifies the shortcomings in relevant information, and describes how these shortcomings can be addressed through additional research.

[1]See http://spo.nwr.noaa.gov/TM75.pdf for the full report.

Importance of Habitat

Habitat can be defined as the places where organisms live, including areas used in every life stage and activity. For fish, habitat supports spawning, feeding, growth, and shelter from predators. Clearly habitat is essential for maintaining healthy stocks of living marine resources.

Habitat is structured by both biotic (living) and abiotic (non-living) elements. Geological features are key abiotic elements. Examples include intertidal rocks, subtidal or deep-sea sediment, and seamounts that rise steeply from the abyssal plain. Water itself is a critical abiotic component of habitat. Attributes of sea water, such as salinity (determined by the mixing of fresh and sea waters), play a major role in defining the habitat of estuarine species. Farther offshore, ocean frontal zones, where distinct bodies of water meet, provide food-rich habitat for large pelagic predators, such as tunas. The biotic components of habitat consist of living or dead organisms. Some biotic components are of plant origin, such as the grasses that grow in salt marshes, submerged aquatic vegetation (e.g. eelgrass), and kelp beds. Others are of animal origin, such as oyster bars and coral reefs. Some marine species can opportunistically occupy man-made habitats, including oil rigs, pier pilings, and bridges, which attract encrusting invertebrates and fish.

Ecosystem Approaches to Management

In recent years, momentum has been building for a shift in fisheries management away from the traditional single-species approach and towards ecosystem approaches (NRC, 1999). In its basic form, the single-species approach relies on an assumption that abundance of a target stock is affected only by factors such as the abundance of its spawning adults, natural mortality and mortality caused by fishing, and the recruitment of juveniles to its population. This enables a mathematical modelling approach to stock assessment. Because other factors are not considered, there is an

Jim Raymont, Florida Keys NMS

Yellowtail snapper, a shallow-water reef fish included in the Fishery Management Plan (FMP) for the South Atlantic Snapper-Grouper Fishery, the FMP for Reef Fish Resources of the Gulf of Mexico, and the FMP for the Shallow-water Reef Fish Fishery of Puerto Rico and the U.S. Virgin Islands, is shown here in the Florida Keys National Marine Sanctuary.

The definition of Essential Fish Habitat stresses the importance of having ample, healthy habitat available, especially when different habitats are required for each stage of life:

". . . those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity" [Magnuson-Stevens Act, 16 U.S.C. 1802(10)].

implicit assumption that the stock exists in isolation from the ecosystem in which it resides.

Ecosystem approaches to management are still evolving, but generally embody a more holistic philosophy. They include a broader focus on ecological relationships and processes, and interactions with humans. They also include a broader consideration of management tradeoffs by placing the management of natural resources, such as fish stocks and their habitats, into a broader context of societal priorities, such as ecosystem services (e.g. improved water quality), scenery, employment, and economic activity.

Operationally, implementation of ecosystem approaches to management requires that the essential ecosystem components and processes be conserved. Habitat, as a functioning element of ecosystems, is clearly a major consideration in this new and evolving philosophy of management.

NMFS Responsibilities for Habitat

Several Federal agencies and state and local governments participate in decisions involving conservation and protection of aquatic habitats. The major Federal agencies outside of NOAA include the U.S. Army Corps of Engineers, the Environmental Protection Agency, the Department of Agriculture, the Federal Energy Regulatory Commission, and the Department of the Interior. Notable U.S. habitat protection legislation includes the Clean Water Act, which aims to prevent destruction of aquatic ecosystems; the National Environmental Policy Act, which requires Federal agencies to analyze the potential effects of any proposed Federal action that would significantly affect the environment; and the Federal Power Act, which provides authority to NMFS to recommend hydropower license conditions.

The most important laws governing many of the activities of NMFS pertinent to habitat are the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) and two laws on protected species: the Endangered Species Act (ESA) and the Marine Mammal Protection Act (MMPA).

The MSFCMA, which was originally enacted as the Fishery Conservation and Management Act in 1976, amended through the Sustainable Fisheries Act in 1996, and most recently reauthorized in 2007, is the primary legislation governing marine fisheries. The original act established eight regional Fishery Management Councils to manage fisheries in the EEZ under Fishery Management Plans (FMPs). Essential Fish Habitat (EFH) provisions were added with the Sustainable Fisheries Act in 1996. The recent reauthorization through the 2006 Magnuson-Stevens Reauthorization Act (MSRA), which was signed into law in January 2007, did not include any changes affecting EFH regulations or guidance. However, it authorized the Community-based Restoration Program for Fishery and Coastal Habitats, established the Deep Sea Coral Research and Technology Program, and directed FMPs to designate zones to protect deep-sea corals from damage or loss due to fishery gear interactions.

To implement the EFH provisions, NMFS and the Councils are required to undertake the following three activities:

Designate EFH—describe and identify EFH for each life stage of the species included in their FMPs.

Minimize to the extent practicable the adverse effects of fishing on EFH—Fishing impacts to EFH must be assessed and minimized to the extent practicable, taking into special consideration Habitat Areas of Particular Concern (HAPC),

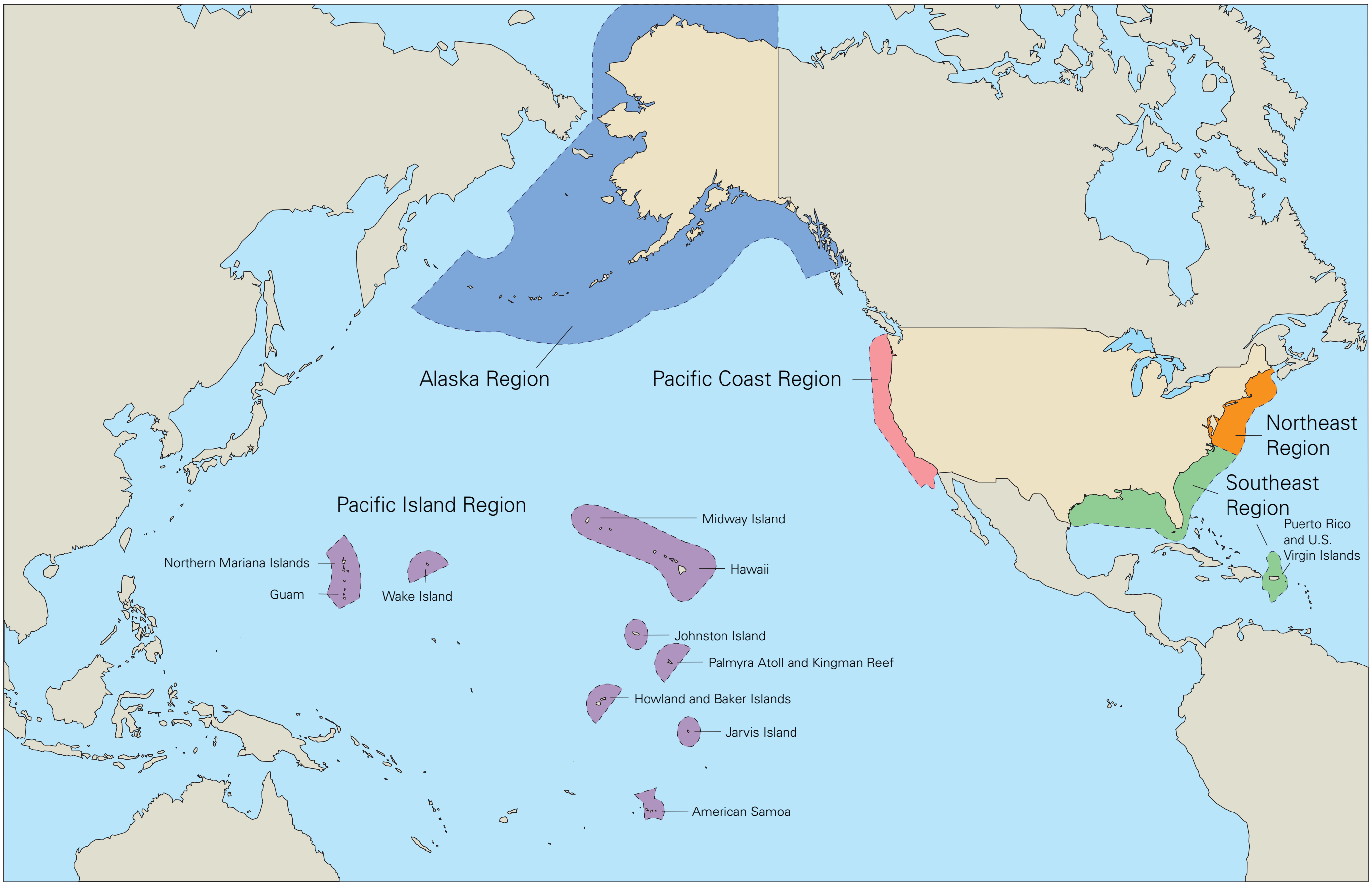


Figure 1

Living marine resources in the Exclusive Economic Zone (EEZ) of the United States are managed by NMFS. The EEZ is divided into five regions in this report.

which are habitats that are especially sensitive. This may lead to fishing gear restrictions and time/area closures.

Consult on potential impacts to EFH—Comments must be provided on activities proposed by Federal action agencies (e.g. U.S. Army Corps of Engineers) that may adversely impact areas designated as EFH.

The ESA and the MMPA define the protected species mandates of NMFS. Under the ESA, NMFS is responsible for protecting marine species that are threatened with, or in danger of, extinction. Fish, invertebrates, sea turtles (when in the marine environment), most marine mammals (cetaceans [whales, dolphins, and porpoises] and pinnipeds [seals and sea lions]), and marine plants are included. Critical habitat that contains physical or biological features essential for conservation must be identified for every species listed under the ESA, and NMFS issues Biological Opinions for Federal actions that may impact the critical habitat of listed species. Under the MMPA, NMFS is responsible for protecting all species of cetaceans and pinnipeds, regardless of their status under the ESA. When human-related impacts are identified that may cause declines or impede recovery of marine mammal stocks, NMFS is responsible for developing and implementing measures to alleviate these impacts on rookeries, mating grounds, feeding grounds, migratory routes, or other ecologically significant areas.

SCOPE AND HABITAT USE

For this report, the United States was divided into five regions: Northeast, Southeast, Pacific Coast, Alaska, and Pacific Islands (Figure 1). To develop the data for the report, habitat specialists reviewed available data for each of the Federally managed or protected species in their region and classified them as to how frequently each species uses four types of habitat: freshwater, estuarine,

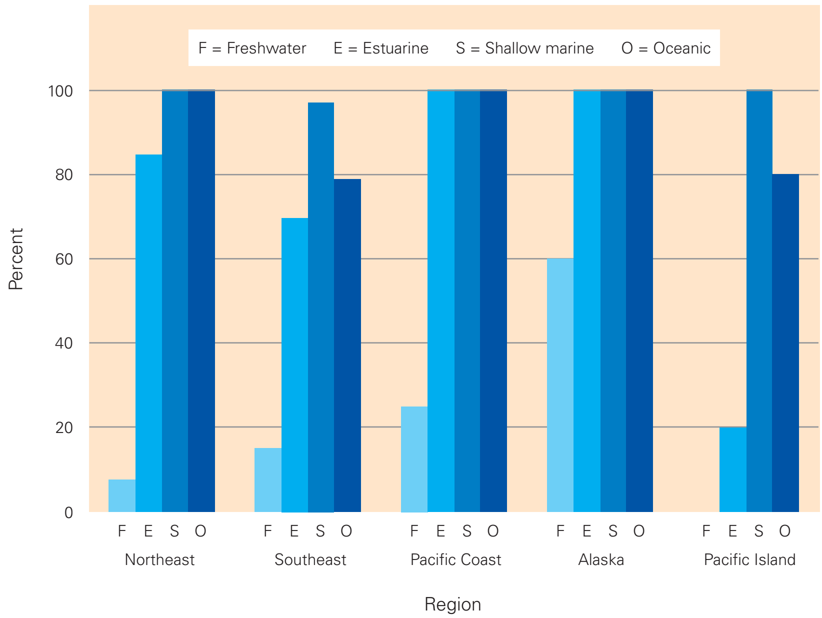


Figure 2

Percentage of FMPs and species groups that use each habitat type by region.

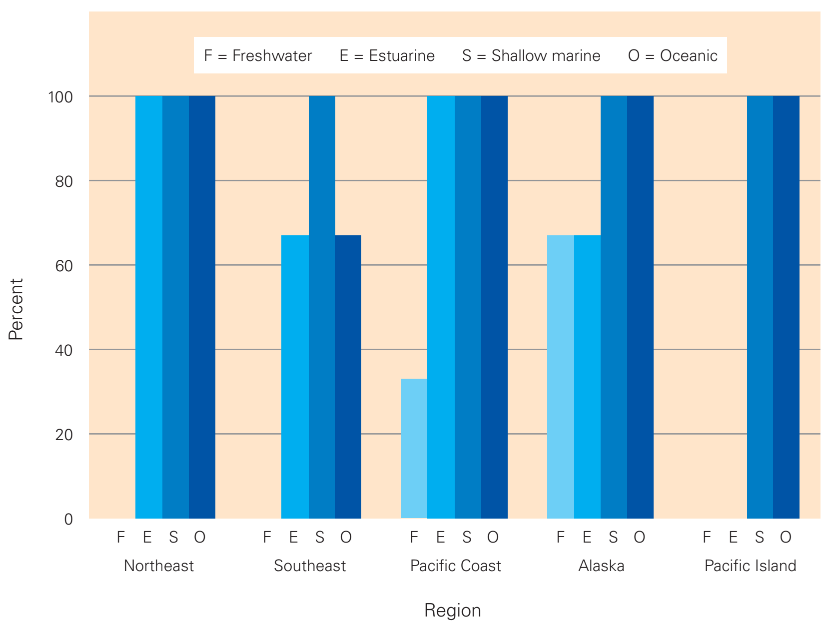


Figure 3

Percentage of protected species groups (cetaceans, pinnipeds, and sea turtles) that use each habitat type by each region.

shallow marine (<200 m [<656 ft] depths), and oceanic (>200 m depths). The specialists also determined the relative quality of the available information for each of the Fishery Management Plans (FMPs) or species groups,[1] using the information levels for EFH, as defined in the MSFCMA. These levels are: Level 1 (distribution), Level 2 (habitat-related density), Level 3 (habitat-related growth, reproduction, and/or survival by life stage), and Level 4 (habitat-specific production). This report also uses an additional level of information quality, Level 0 (complete lack of scientifically credible data on habitat use). Although not mandated in the ESA or MMPA, these same levels were used to evaluate the quality of available information for protected species. The methods are described in greater detail in the complete *OLO Habitat* report.

Figure 2 shows the percentage of each region's FMPs and species groups that use each of the four habitat categories (FMPs can cover a single species or multiple species). Shallow marine habitats are used by over 95% of Federally managed fishery species in all regions, followed by oceanic habitats, which are used by over 75% of Federally managed fishery species and species groups. All regions also exhibit a high degree of estuarine usage, with the exception of the Pacific Islands, which have relatively little estuarine habitat. There are relatively few FMPs (and none in the Pacific Islands) that include any species, such as anadromous salmon, that use freshwater areas.

Figure 3 shows the percentages by region of habitat usage by three distinct groups: cetaceans (whales, dolphins, and porpoises), pinnipeds (sea lions and seals), and sea turtles. As the figure shows, these animals use shallow marine and oceanic habitats in every region. The three groups also use estuarine habitats to some degree in every region except the Pacific Islands Region, which has relatively little estuarine habitat. Fresh water is the habitat least used by the Nation's cetaceans, pinnipeds, and sea turtles, as only pinnipeds in the

[1]For this analysis, four FMPs in the Southeast Region that cover many species with different habitat associations were divided into a total of 18 species groups. See the complete *OLO Habitat* report for a detailed discussion.

Pacific Coast and Alaska Regions, and one cetacean (the beluga whale), occasionally use Alaskan freshwater habitats.

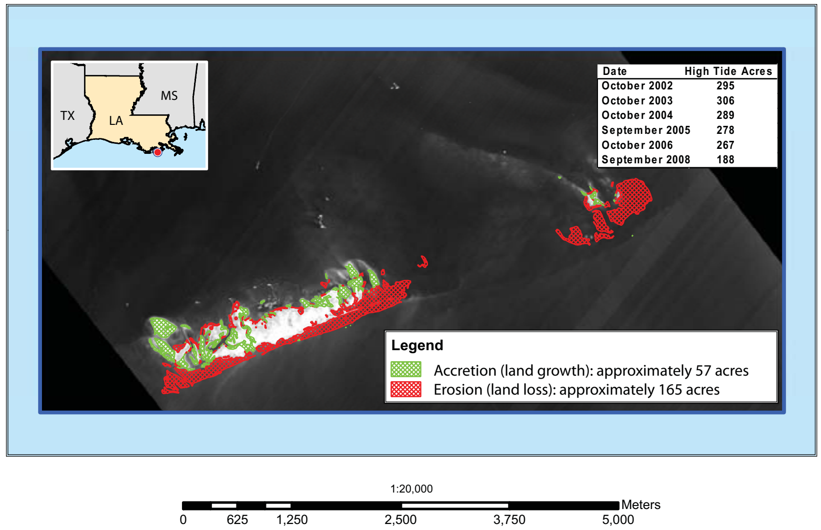
HABITAT STATUS AND TRENDS

Geospatial data on the amount and condition of the habitats used by the species managed by NMFS are collected and held by many different organizations, and for many different purposes. Scientific standards and classification systems vary widely. Hence, a quantitative analysis is simply not feasible. However, it is clear that habitat impacts occur where human activities alter the environment. Consequently, habitats in proximity to high human population densities tend to be subjected to the highest degree of stress. The general trend is that habitat loss and degradation are highest in freshwater and estuarine habitats, where the impacts of development and pollution are most direct, and lowest in shallow marine and oceanic habitats, where fewer human activities occur.

The quantity and quality of the water in many freshwater habitats have been declining for over a century. Farming, industrialization, residential expansion, and flood control have reduced the flow of fresh water, changed the timing and severity of flood events, and increased the quantity of nutrients and contaminants draining from upland habitats (Heinz Center, 2002). For example, in the Columbia River basin more than half of the streams historically used by salmon are no longer accessible due to construction of large dams (PSMFC, 2006). In the last 10 years, efforts have been made to restore access, but many areas, such as those above Grand Coulee Dam, remain inaccessible to Pacific salmon. Diversion of fresh water can significantly modify reproductive patterns and success for anadromous fish such as salmon. Reduced freshwater inflow and flushing in the bays and estuaries that are downstream results in changes to salinity distributions, which greatly affect the habitats of estuarine species.

Estuarine habitat also has been dramatically impacted by human activities. For example, within Puget Sound and California, more than 70% of estuarine wetlands have been lost due to factors such as pollution, diking, and filling (Emmett et al., 2000), though much of that occurred long ago, and efforts are underway to protect and restore these habitats in many areas. The loss of submerged vegetation continues in many estuaries, often due to an excess of suspended sediment associated with poor land-use practices, as well as algal blooms stimulated by excess nutrients, which block light penetration. Beds of submerged aquatic vegetation are almost completely absent from Delaware Bay and nearby coastal bays (Bricker et al., 2007). Chesapeake Bay submerged aquatic vegetation has shown a rebound from extremely low levels in 1984 due to some improvements in water quality. Although the Bay's underwater grasses covered almost 26,300 hectares (65,000 acres) in 2007, nearly double the 1984 levels, this is still only 35% of the way towards the 2010 restoration goal of 75,000 hectares (185,000 acres) (Chesapeake Bay Program, 2008).

The continued loss of wetland habitats in coastal areas is a particular concern. These wetlands comprise about one-third of all the wetlands in the continental United States, and are important to diadromous fish and to maintaining the overall health of the estuaries. Coastal wetlands, particularly coastal freshwater wetlands, continue to be lost at a disproportionately high rate, compared to inland wetlands. Estimates for 1998 to 2004 show that coastal wetlands continue to be lost at a rate of tens of thousands of acres per year



NOAA and USGS

East Timbalier Island, off the southeastern coast of Louisiana, is shrinking and being pushed shoreward due to the combined effects of sea-level rise, land subsidence (sinking), and Hurricanes Rita and Katrina. These forces cause the sediments from the seaward margins of the island to erode. Some of those materials are re-deposited on the landward side, and some are carried away. The island lost over 35% of its above-high-tide area between October 2002 and September 2008.

Mary Hollinger, NODC, NOAA

Reeds and a narrow channel at low tide in a marsh on the Patuxent River.

(Zedler et al., 2001; Dahl, 2006). This loss is greatest in freshwater non-tidal forested wetlands on the coast. Coastal watersheds experienced a net loss of wetlands of around 23,877 hectares (59,000 acres) per year between 1998 and 2004. Estuarine coastal wetlands declined at an annual average rate of 2,240 hectares (5,540 acres) per year, with valuable estuarine salt marshes experiencing the steepest declines (Stedman and Dahl, 2008). Most of that loss was in coastal Louisiana.

Much of the loss of wetlands occurred in the distant past. For example, between 1780 and 1980, it is estimated that California lost over 90% of its wetlands, Connecticut lost 74%, Maryland lost 73%, and the majority of the other coastal states lost at least 50% or more. With the advent of Federal and state laws requiring a permit for many activities that destroy wetlands, wetland losses have slowed in recent decades. However, with more than half of the Nation's population living within 50 miles of the coast, development pressure in coastal areas continues to result in wetland loss.

Shallow marine and oceanic habitats generally have good water quality, and relatively little habitat has been lost to human activities. Nevertheless, there are significant problems, such as the Gulf of Mexico "dead zone," where the water underlying the Mississippi River plume may contain little or no oxygen during the summer (Rabalais et al., 2002), and the impacts of some fishing gear, particularly bottom trawls, on seafloor habitats. There are additional unquantifiable but generally negative effects from plastics and other debris in the sea, oil spills and slicks, and discarded or lost (ghost) fishing gear. Harmful algal blooms and other toxin-producing algae, which can render seafood unfit for consumption by marine animals, people, or pets, are a recurring problem in some areas. At least some portion of this problem may be caused by increased nutrient inflows, and the problem could increase if ocean temperatures warm as projected in climate change scenarios. Many facets of climate change (warming, sea-level rise, sea-ice loss, oceanic acidification, etc.) will further stress habitats and could exacerbate the effects described here.

INFORMATION QUALITY AND RESEARCH NEEDS

In providing scientific advice on habitat-related issues to resource managers and officials responsible for living marine resources, information is needed on how species use habitat, where habitat exists, its quantity and condition, the best practices to conserve it, and how marine communities, and, ultimately, sustainable fishery yields, depend on the amount and condition of available habitat. Species in all habitats, including the open ocean, are vulnerable to inappropriate human actions when their habitat requirements, availability, and dynamics are not known.

The quality of habitat-related information has a major effect on the quality of decisions that are based on it. An assessment of the quality of habitat information was done to identify gaps in the available information and to identify research needed to fill those gaps.

Information Quality

At the national level, habitat information for most Federally managed FMPs or species groups (as a whole or by life stage) primarily consists of distribution (Level 1) and habitat-related density (Level 2) information (Figure 4). Less information is available for habitat-related growth, reproduction, and/or survival by life stage (Level 3), and habitat-specific production (Level 4) information is rare. Approximately 11% of the information is Level 0, indicating a complete lack of data on habitat use for one or more species (or life stages) within the given FMP or species group. However, the species and species groups with unknown habitat use generally constitute a relatively minor portion of the commercial and recreational catch.

Information on habitat-specific productivity (Level 4) is the highest and most quantitative level of information for identifying EFH, and provides the most definitive information for understanding relationships between species and their habitats. Such information is necessary for quantifying the contributions of specific habitats to the production of a species. Level 4 information is generally not available for even the most valuable species. The main exceptions include Alaska salmon in fresh water and a species of seaweed, Atlantic *Sargassum*, in shallow marine and oceanic habitats.

Figure 5 depicts the levels of habitat-use information available for the protected species groups (cetaceans, pinnipeds, and sea turtles) at the national level. Approximately 15% of the information is Level 0, indicating a lack of habitat-use data for some species in particular habitats. Data gaps exist on habitat for particular life stages of various sea turtle species in shallow marine and oceanic habitats of the Northeast, Southeast, and Alaska Regions, as well as in estuarine habitats of the Northeast and Southeast Regions. There is a complete absence of data for some cetaceans in shallow marine and oceanic habitats in the Northeast, Southeast, and Pacific Islands Regions. Of all the habitat-use information, distribution information (Level 1) accounts for approximately 45%, habitat-related density information (Level 2) accounts for approximately 31%, and habitat-specific growth, reproduction, or survival information (Level 3) accounts for 10%. This general pattern is consistent with the pattern of information levels for fishery species. However, no habitat-specific productivity information (Level 4) exists for any of the Nation's cetaceans, pinnipeds, or sea turtles.

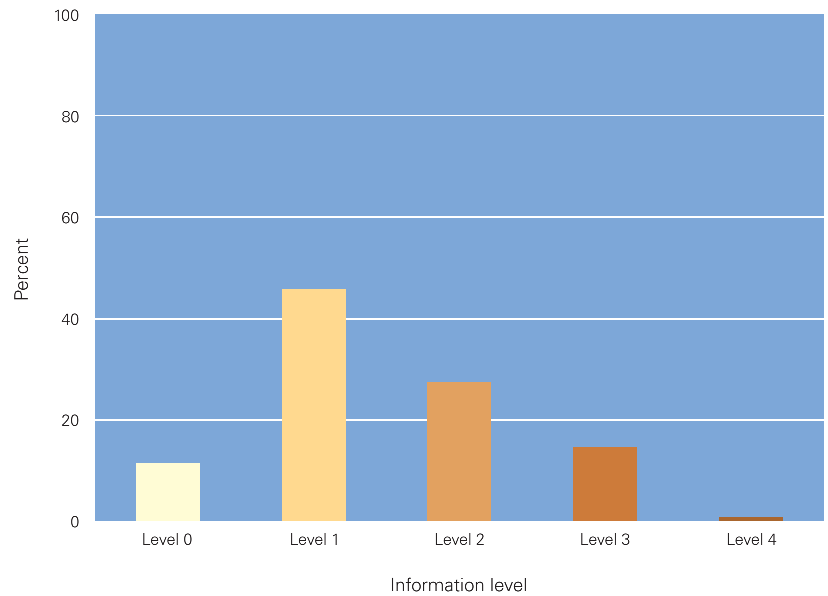


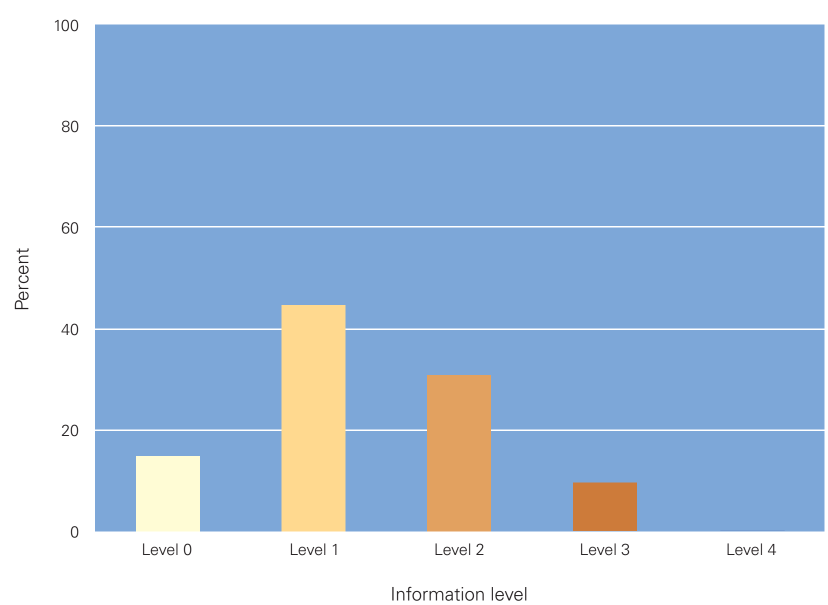
Figure 4

Habitat use information levels available for Fishery Management Plans and species groups, all regions combined.

Level 0 = No credible data on distribution or habitat use.
Level 1 = Distribution data for some or all portions of the geographic range.
Level 2 = Habitat-related density data.
Level 3 = Data on growth, reproduction, or survival rates within habitats.
Level 4 = Data on production rates by habitat.

Figure 5

Habitat use information levels available for protected species groups (cetaceans, pinnipeds, and sea turtles), all regions combined.



R. Crawford, NOAA National Estuarine Research Reserve Collection

Above: Eelgrass meadows in the Waquoit Bay National Estuarine Research Reserve, Massachusetts.

Below right: Wetlands and tidal streams in the Ashe Island area of the ACE Basin National Estuarine Reserve, South Carolina.

Research Needed

The fundamental goal for NMFS's habitat research is to provide managers with the information they need to optimize the benefits society derives from our living marine resources while maintaining long-term ecological sustainability. Understanding species–habitat relationships is an important component of the information required for implementing ecosystem-based approaches to management, including setting fishery targets, ensuring recovery of species of conservation concern, protecting and restoring habitat, and maintaining ecosystem functions. There are many factors to consider in setting habitat-research priorities, including the economic value of harvested species, conservation concerns for overfished or protected species, the roles of species in the ecosystems they occupy, the degree of dependence of species on their habitats, and the vulnerability of those habitats to human-caused or natural disturbance, including climate change.

Addressing the fundamental goal identified above requires obtaining new information through research, as well as making better use of the information that already exists. From the management perspective, the highest priorities for habitat research should be the life stages most sensitive to habitat concerns or that play a major role in determining population dynamics, and the habitats most vulnerable to disturbance. For species of minimal economic, conservation, or ecological importance, information on presence/absence or density by habitat type may suffice. For the most important or sensitive species and habitats, productivity data by habitat type will provide the most comprehensive information to scientists and the managers they advise.

Key research needs are summarized in Table 1. Even for the most-studied fishery species, which have been the subject of intensive research for many years, important questions related to fish–habitat linkages remain unanswered. These include: seasonal habitat usage by life stage, relationships between habitat alteration and fish survival and production, lethal and sublethal effects of pollutants, and effectiveness of restoration techniques.

Table 1
Key habitat research needs identified by NMFS scientists.

Research needs
Determine critical habitat requirements for each species and life stage.
Conduct life history studies (including studies of age, growth, maturity, and fecundity) and relation to environment for all managed species, particularly for the early life stages.
Determine impacts of natural and human-caused habitat variability.
Characterize and describe seafloor and open-ocean habitats and associated fish assemblages on spatial scales relevant to fishery management and habitat protection.
Delineate and map important habitats including coastal shorelines, estuaries, salt marsh wetlands, anadromous streams, riparian zones, submerged aquatic vegetation (e.g. eelgrass), deepwater corals, pinnacles, seamounts, and fishing grounds on the Continental Shelf and Slope.
Determine effects of fishing gear on all species and their habitats, and develop methods to reduce damaging practices.
Develop and implement advanced methods for research and management, including remote sensing for oceanography and stock assessment, and the use of marine protected areas.
Expand research and monitoring of habitat condition.
Develop methods to protect and restore habitat.
Determine societal and economic benefits of conserving and restoring habitat.

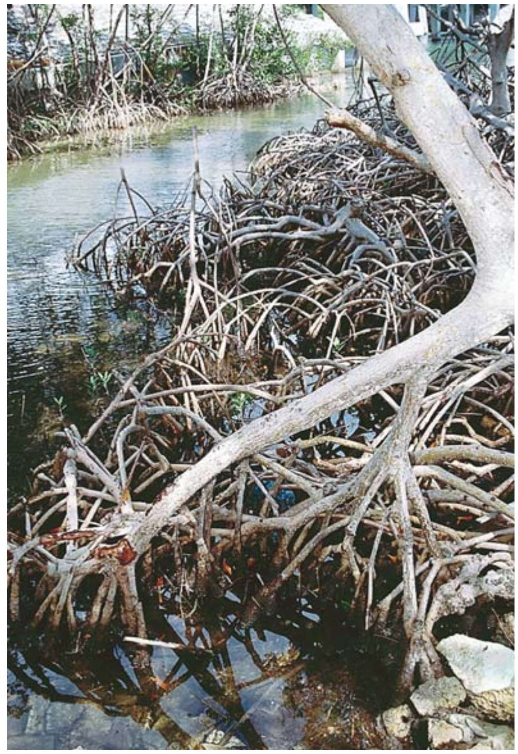
NOAA

Many of the same research needs exist for marine mammals and sea turtles as for fishery resources. A primary research need is to characterize habitats for cetaceans, and to better understand movement patterns and local abundances. There are recent and ongoing efforts to model cetacean-habitat occurrence using oceanographic data, but more detailed studies are needed to gain a better understanding of important habitats and their variability. For endangered or threatened sea turtles, the primary need is to determine habitat use during migration and while foraging (for example, through tagging studies), and also to determine abundance and trends at key forage areas and nesting beaches. This knowledge will enable mitigation of impacts from commercial fisheries and other causes.

There are important research needs in the area of habitat economics. It is necessary to inventory and review the scattered existing information on the economic values of habitat types, so that gaps in our knowledge regarding different regions and at different scales can be identified and addressed. To support managers who evaluate proposed actions that may affect habitat, research is needed to quantify the full range of potential costs and benefits to all sectors of society. Bioeconomic models are needed that quantify cumulative effects of habitat degradation and loss, as well as the economic consequences from beneficial uses, such as habitat restoration using dredged materials.

ISSUES AFFECTING HABITAT

As the U.S. population continues to grow, there is increasing pressure on the environment to provide humans with food, income, recreation, and other resources (Heinz Center, 2002). This is especially evident in coastal areas, where human population growth is about five times faster than in inland areas. Human use of aquatic habitats will of course affect those habitats, and society faces many choices, including how to responsibly manage growth, development, and resource use. To do this wisely, society and decisionmakers must understand the consequences of their decisions, including the potential for habitat impacts. In situations where habitat impacts cannot be avoided, decisionmakers must consider ways to reduce or mitigate impacts and to restore damaged habitats.


NOAA

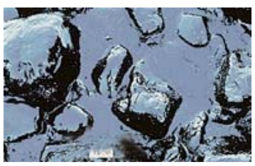
Mangrove habitat is essential to many juvenile fish species in the subtropical Atlantic and Gulf of Mexico coastal waters.

Although the issues affecting U.S. living marine resource habitats vary throughout the country, many issues are widespread, even if the impacts are manifested differently in different regions. Certain issues are important in all aquatic habitats, while others have greater impacts within a certain habitat type. The following section presents information on seven of the most important issues on a national scale:

- Pollution and water quality;
- Alteration and degradation of rivers and migratory pathways;
- Fragmentation and loss of estuarine and shallow marine habitats;
- Fishing effects on habitat;
- Climate variability and change;
- Invasive species and marine debris; and
- Vessel traffic and noise.

Information is also provided on ways to reduce or mitigate impacts, and on progress that has been made.

Exxon Valdez Oil Spill Trustee Council



ORR, NOS, NOAA

Upper photo: Cleaning up oil from the 1989 *Exxon Valdez* spill. Approximately 2,080 km (1,300 mi) of shoreline in the region of Prince William Sound, Alaska, was impacted. About 320 km (200 mi) was moderately or heavily oiled, especially intertidal habitats. Although massive mortalities resulted, many of the living marine resources have recovered. Nonetheless, residual oil remains in some habitats, with chronic impacts on the species that spawn or forage in the affected areas.

Lower photo: Close up of *Exxon Valdez* oil on the beach.

ISSUE: POLLUTION AND WATER QUALITY

Water itself is habitat. Reduced water quality results from point sources, which release harmful substances into the water from a discrete source, from spills, from non-point sources, which are more diffuse and widespread, and from atmospheric deposition.

The U.S. Environmental Protection Agency (EPA, 2008a) rated the overall quality of the Nation's coastal waters as good to fair and improving, with the best ratings in Alaskan and Hawaiian waters. Sediment quality was rated good to fair overall, also with the best ratings in Alaska and Hawaii, but with poor ratings in the Gulf of Mexico and Puerto Rico.

Habitat Impacts

Excess nutrients can come from point sources (e.g. sewage treatment plants), from non-point sources (e.g. runoff from farms and suburbs), and from small particles deposited from the atmosphere. Although not directly toxic, their effects are pervasive, especially in estuaries and coastal waters. They overstimulate algal growth, leading to eutrophication (Rabalais et al., 2002; Bricker et al., 2007). Eutrophic waters contain reduced oxygen, are typically highly turbid (reducing the growth of submerged aquatic vegetation), or may be impacted by harmful algal blooms that can be toxic to fish, or even to humans.

Stormwater runoff contains many harmful materials. The sediments washed from cities, suburbs, construction sites, and farm fields can smother marine plants and also carry contaminants such as pesticides, oil and grease, and pathogens.

Particulates from the atmosphere can be deposited as dust, or carried in precipitation. This is becoming recognized as a significant source of nutrients and certain contaminants, such as the heavy metal mercury.

Toxic chemicals, such as heavy metals, petroleum products, and pesticides, can be lethal in high concentrations. Even at sub-lethal concentrations, toxic chemicals can accumulate in the environment, often in sediments, where they can remain for a very long time. For example, the insecticide DDT was banned in the United States in 1972, but it is still readily found in the sediments of many of our Nation's waterways and in the bodies of living marine resources.

Impacts to Living Marine Resources

Poor water quality degrades ecosystems, lowering the productivity of many fishery and protected species. According to a recent NOAA report (Figure 6; Bricker et al., 2007), approximately two-thirds of the estuaries along the coasts of the continental United States exhibited at least moderate symptoms of eutrophication in 2004. Oxygen levels that are too low cannot support marine life, and the loss of submerged aquatic vegetation reduces important habitat and food for many estuarine and coastal species. Toxic algal blooms have been implicated in the mortality of fish and marine mammals along coastal areas and are likely having impacts throughout the food chain. Significant portions of U.S. fishing areas are closed each year to protect the public from sewage contamination and potentially dangerous concentrations of algal toxins in shellfish.

Chemical spills can cause acute mortalities of marine mammals, seabirds, fish, and invertebrates. However, chronic impacts are often a greater concern. Many substances, including metals, pesticides, and other organic compounds, can bioaccumulate, increasing in concentration in the tissues of animals that feed on contaminated food sources, increasing mortality and reducing reproduction.

Solutions

Progress has been made to reduce water quality impacts, particularly from point sources. Technology exists to monitor and reduce point sources of pollution, and the Clean Water Act has regulated point-source discharges since 1972. Regulations exist to ensure proper cleanup of contaminants after an oil or chemical spill as well. Enforcement of such laws has reduced the prevalence

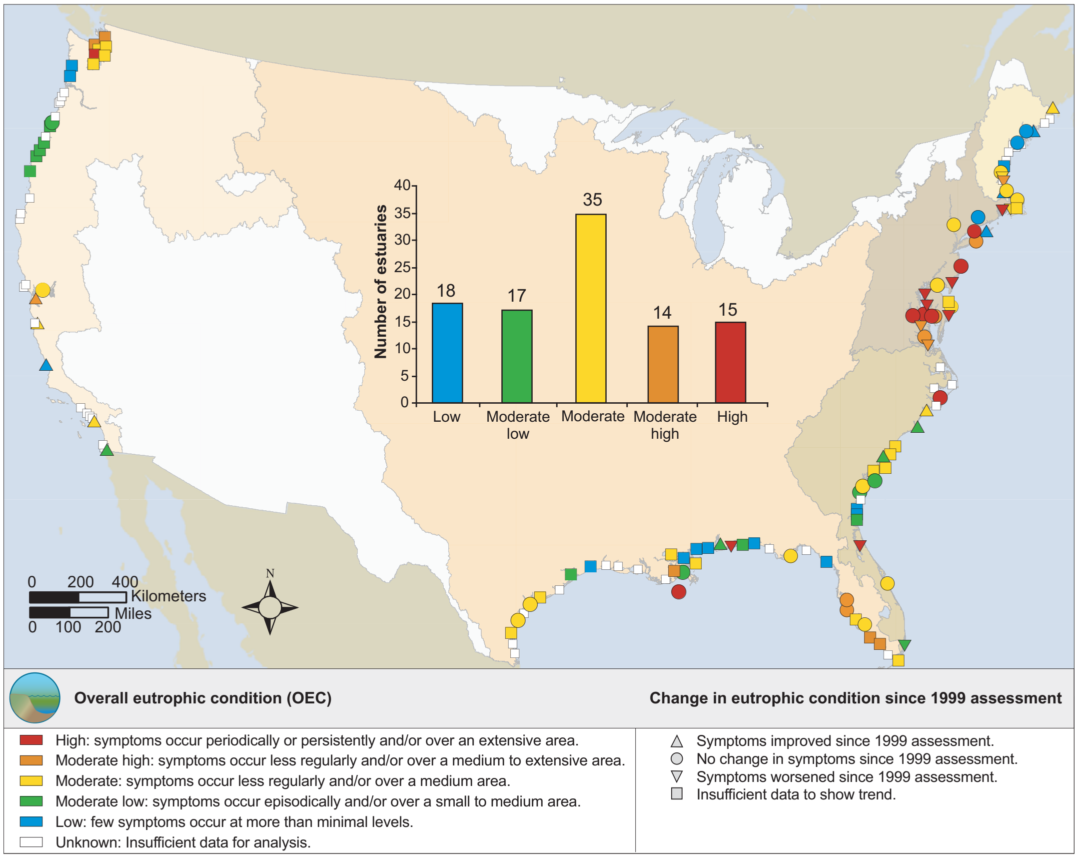
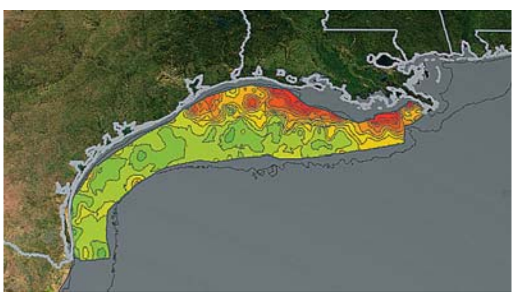


Figure 6
Eutrophic conditions in U.S. coastal waters in 2004, and change since 1999 (Bricker et al., 2007).

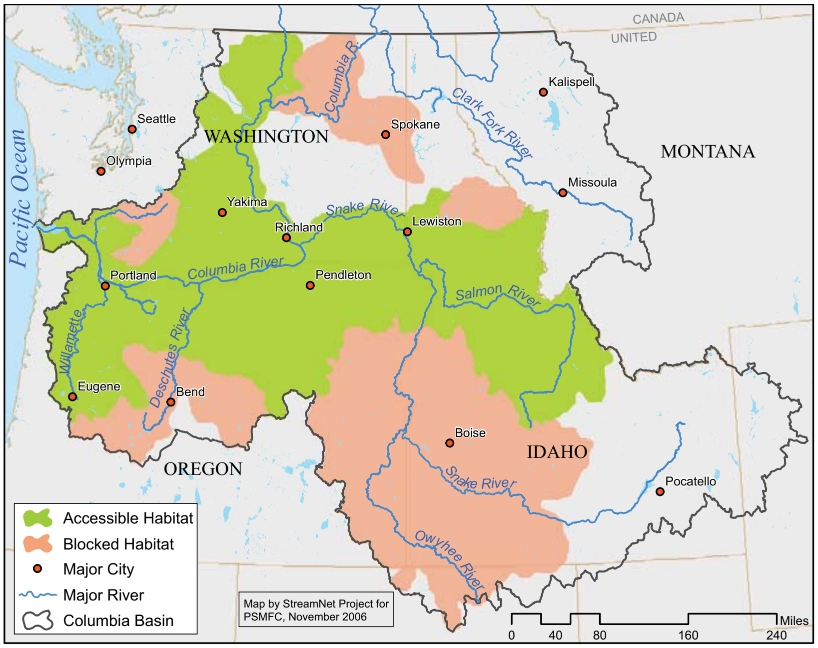


Left: NOAA ship surveys of water quality show low oxygen areas in the Gulf of Mexico "dead zone" as reds and oranges.

Right: Gulf menhaden killed by hypoxia in Matagorda Bay, Texas.

and impacts of point-source pollution on water quality and improved the Nation's waterways, but additional progress is needed.

Less progress has been made at controlling non-point sources of pollution (Heinz Center, 2002; Chesapeake Bay Program, 2008), because it was more recently recognized as a problem and is much more diffuse than point-source pollution. Although non-point source pollution is difficult to control, sections of the Clean Water Act require jurisdictions to reduce surface runoff to the "maximum extent practicable." Individuals and citizen groups can reduce non-point pollution through awareness and environmentally responsible actions (e.g. proper disposal of household chemicals, maintenance of septic systems and cars). Improved land-use practices can reduce run-off from urban and agricultural landscapes, as well as reduce the concentrations of contaminants in the water that does run off. Spills can be prevented (e.g. by requiring enhanced safety practices for industrial facilities and shipping), and the clean-up of spills can be expedited.



PSFMC, 2006

Todd Bennett, NMFS

Left: Accessible and blocked anadromous fish habitat in the Columbia River basin. On the Columbia River and its main tributaries, over 250 reservoirs and 150 hydroelectric projects reduce access and use of a majority of the 647,500 km^2 (250,000 mi^2) drainage basin (PSMFC, 2006).

Right: Spawning pink salmon are holding in a pool in Bacon Creek, Washington. Note the clean gravel in the riverbed that is clear of mud and silt. This is a requirement of habitat suitable for egg laying.

ISSUE: ALTERATION AND DEGRADATION OF RIVERS AND MIGRATORY PATHWAYS

Many factors affect river habitats, such as urbanization, agriculture, timber harvest, and mining. Of these activities, dams and other water-control structures have the greatest overall impacts. There are thousands of these structures in U.S. rivers. For example, the Columbia River and its main tributaries contain over 250 reservoirs and 150 hydroelectric projects, including 18 mainstem dams.

Habitat Impacts

Dams fragment river habitats and present impediments to catadromous fishes such as eels (which spawn in the ocean and grow to maturity in fresh water) and anadromous fishes such as salmon, sturgeon, striped bass, shad, and river herring (Roni, 2005; NMFS, 2008). Dams also change upstream habitat by creating reservoirs that slow water velocities and alter temperatures. Reduced freshwater flows resulting from water removals for domestic and commercial use can affect river and downstream estuarine habitats as well. Altering natural flows and the processes associated with flow rates (such as nutrient and sediment transport) impact in-stream habitats, shoreline riparian habitats, and prey bases. Water quality may also be reduced from water withdrawals: temperature, salinity, and concentrations of toxic chemicals all increase as water volumes shrink; dissolved oxygen decreases; and pathogens may be introduced.

Changes to stream beds and banks and streamside vegetation can have major impacts on adjacent aquatic habitats. Hydrologic characteristics such as temperature and dissolved oxygen can be altered, and habitat complexity can be reduced by lowering the availability of large woody debris. Changing flow and channel structure, increasing stream bank instability and erosion, and altering nutrient and prey sources also degrade riverine habitat.

Impacts to Living Marine Resources

By blocking upstream access for migrating species, dams greatly reduce the amount of habitat available for spawning, feeding, growth, and migration. Adequate freshwater flow is critical to all life stages, from eggs to spawning adults, so reduced flow can have a negative effect on anadromous and catadromous fish populations. As an example, a drought extending from 2001 through 2005 in the Klamath River basin of California and Oregon, combined with above-average withdrawals for agricultural use during the drought, allowed for the proliferation of endemic diseases, causing large fish kills. As a result, the Klamath River Chinook salmon stock fell below conservation objectives. This triggered the declaration of a commercial fishery failure by the Secretary of Commerce in 2006, which authorized a total of $60.4 million for distribution to eligible participants in the West Coast salmon fishery (DOC, 2006).

New Hampshire Department of Environmental Services/NOAA

The removal, with the help of NOAA funding, of New Hampshire's West Henniker Dam, 18 feet tall, opened 15 miles of riverine habitat in the Contoocook River to migratory fishes such as Atlantic salmon and American eel.

Solutions

Healthy riparian corridors are important components of river ecosystems (Roni, 2005). The most effective strategy is to conserve existing intact systems. However, human populations and associated development are continuing to expand. To reduce human impacts, activities such as urban development, mining, and timber harvest should maintain a reasonable minimum distance between streams and rivers and their operations. Restoration activities, such as native vegetation replanting and the addition of large woody debris, are currently improving river habitats for anadromous species. An example is the Chewuch River in Washington State, where restoration efforts have been successful at improving habitat for resident and migratory species of fish, including several threatened or endangered species.

Mitigation measures, such as fish ladders and barging of migrating juvenile salmon, may be partially effective, but are in place only at some dams (NMFS, 2008). Juvenile bypass systems to guide out-migrating juveniles past the turbines have efficiencies as low as 30% for some species. Moreover, mitigation often targets salmon exclusively, ignoring the impact of dams on other anadromous and freshwater species.

In some instances, removal of a dam can reverse habitat damage and restore historical river flows and fish migration routes. For example, Sennebec Dam, built in 1916 on the St. George River in Union, Maine, blocked passage to over half the St. George watershed for Atlantic salmon, alewife, shad, eel, and river herring. By the end of the 20th century, this was the only remaining barrier in the watershed. Trout Unlimited, with substantial NOAA funding, removed the dam in 2002 and replaced it with a roughened fish ramp about 0.4 km (0.25 mi) upstream. This resulted in 27 km (17 mi) of available fish habitat on the St. George River, while increasing safety below the former hydropower dam, reducing maintenance costs, and maintaining the recreational value of Sennebec Pond. Success stories such as this are propelling a movement in the United States to remove obsolete dams and restore healthy river habitats.

Although dam removal has proved successful at restoring damaged river habitats, it is often not a viable option due to competing river uses (including use of dams for flood control). There is currently heated debate about whether four dams on the Lower Snake River in eastern Washington should be removed (see Columbia River Basin map on previous page). Removal would restore 225 km (140 mi) of habitat that historically supported 50% of salmon returning to the Columbia River Basin, but would also eliminate substantial social and economic benefits that result from irrigation, electricity, and river navigation services that the dams provide.


NOAA

Above: Impacted and eroded marsh on Staten Island, New York.

ISSUE: FRAGMENTATION AND LOSS OF ESTUARINE AND SHALLOW MARINE HABITAT

Habitat loss occurs when habitat is destroyed or altered to the point that it can no longer provide the requisite ecological functions. Habitat fragmentation occurs when natural or human activities cause a habitat to become separated into isolated areas, disrupting migratory corridors, isolating local populations, and disrupting or preventing access to portions of habitat necessary for food, growth, or reproduction.

Habitat Impacts

A wide range of human activities in coastal watersheds causes habitat loss and fragmentation. While the effects of individual projects may be relatively modest, the scale of human activities in the coastal zone is so great that there are substantial cumulative effects. Placing fill in wetlands or other aquatic habitats for development is a significant factor. Over-water, shoreline protection, and water-control structures can have serious impacts on local habitat, including removal of vegetation and natural substrates, and blocking the sunlight needed by aquatic plants. Dredging removes bottom habitat and degrades water quality through increased turbidity and siltation, release of oxygen-consuming substances and contaminants, and alteration of physical habitat and hydrographic regimes. Disposal of dredged material can have these same effects and can smother benthic habitats. Additionally, predicted climate-related sea level rise threatens shallow marine habitats such as mudflats and salt marshes.

Wetland loss is widely recognized as a significant environmental problem (Dahl, 2006). For example, the average annual loss of wetlands in Connecticut between 1880 and 1970 was about 28 hectares (70 acres) per year, leading to a 30% loss of wetlands state-wide over this period. More than 70% of the estuarine wetlands have been lost or degraded in the Pacific Northwest and California. Since the 1930's, Louisiana has lost from 38 to 108 km^2 (15 to 42 mi^2) of wetlands per year due to land subsidence, sea-level rise, and erosion from tropical storms. Flood-control levees on the Mississippi River channel the river's drainage directly into the Gulf of Mexico. This prevents the annual floods that previously deposited new sediments and detritus on the adjacent wetlands and marshes.

Impacts to Living Marine Resources

The loss or fragmentation of habitat reduces the ecological services that habitat provides. The species most affected are those that depend on habitats where humans are most active, i.e. habitats located in watersheds, estuaries, or near the coast. As shown previously in Figures 2 and 3, the great majority of the fishery and protected-species stocks that NOAA manages use estuarine and shallow-marine habitats, with the percentage that use freshwater habitats varying by region. Even species that spend most of their lives far out at sea, such as some anadromous fishes, marine mammals, and seabirds, depend on these heavily-impacted habitats for certain key aspects of their life histories, such as spawning, larval or juvenile growth, calving, or nesting. Also, state-managed stocks, which occur primarily in state waters inside the 3-mile limit, all depend on these habitats.

Solutions

Solutions to habitat loss and fragmentation include conserving and protecting existing habitat, and restoring or enhancing lost, fragmented, or degraded habitat to recover ecological function. Creating or restoring habitat is usually much more expensive and less effective than protecting habitat that already exists and is functioning. The science of creating and restoring habitats is relatively new, so more research is needed to develop and evaluate restoration methods.

Understanding the relationships between species and habitats, and knowing where habitat exists, are the first steps toward habitat protection and conservation. Thus a key ingredient for conserving habitat is developing and providing information to resource managers and the public about habitat status, function, and relationship to various species. An example is Chesapeake Bay, from which most of the submerged aquatic vegetation, an important habitat that supports key species such as the blue crab, has been lost due to centuries of poor land use practices and declining water quality. The public has supported extensive regional efforts to improve water quality. There has been a rebound from the low point of 1984, such that vegetated areas have roughly doubled. However, the total vegetated area only covers approximately one-third of the 2010 restoration goal of 75,000 hectares (185,000 acres) (Chesapeake Bay Program, 2008).

One successful approach to prevent habitat loss is to provide legal protection. More than 1,000 areas within U.S. waters are granted some level of special protection by Federal or state governments. However, only about 1% of the ocean within U.S. jurisdiction qualifies as marine protected area, and only about 10% of that carries the highest level of protection, where fishing and other extractive activities are precluded.

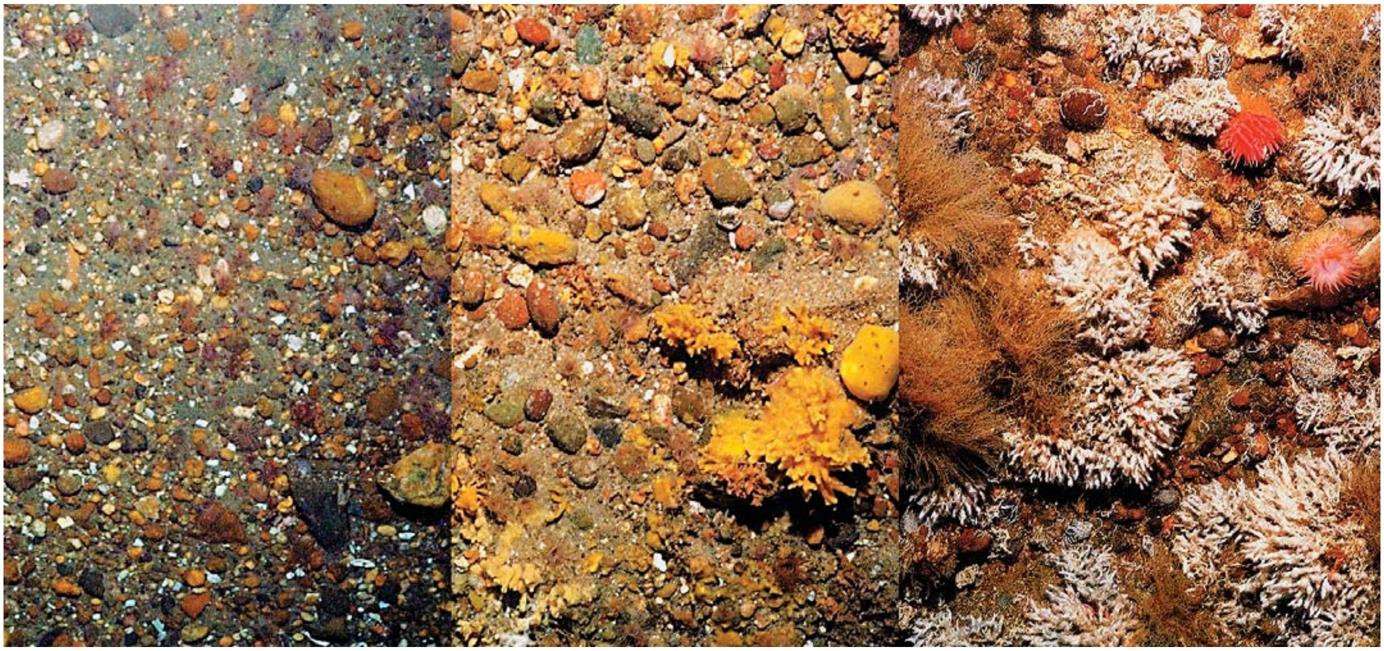
NOAA and partners designated protected status to three significant areas of the U.S. EEZ in 2006[1]. Marine waters totaling 388,500 km^2 (150,000 mi^2) off the U.S. West Coast were designated as Essential Fish Habitat for commercially valuable fish. The Aleutian Islands Habitat Conservation Area encompasses over 950,000 km^2 (366,795 mi^2), an area approximately the size of Texas and Colorado combined. The Papahānaumokuākea Marine National Monument contains nearly 362,600 km^2 (140,000 mi^2) of emergent and submerged lands and waters of the Northwestern Hawaiian Islands, including over 13,200 km^2 (5,100 mi^2) of coral reefs and over 7,000 marine species. It is home to almost the entire population of endangered Hawaiian monk seals and is the breeding ground for over 90% of the Hawaiian green sea turtle population.

The task of conserving and protecting habitats goes well beyond the abilities and funding of state and Federal agencies. Individual citizens and their organizations at the local, regional, and national levels are the key to successful actions. It is through education and consciousness raising that many harmful actions can be avoided or corrected.

Both photos © Peter Bergstrom

Local groups of concerned citizens can take an active role in conserving and restoring habitat. Here, members of the Magothy River Association are planting seagrass in a small tributary on the western shore of Chesapeake Bay, which has been heavily impacted by development, declining water quality, and habitat loss.

[1]On 6 January 2009, President George W. Bush designated three new National Monuments in the tropical western Pacific, with a total area of over 505,000 km^2 (over 195,000 mi^2) (White House, 2009). The largely uninhabited areas contain pristine coral reefs, volcanic ecosystems, and the Mariana Trench, which, at some 11,000 m (36,000 ft) depth, is the deepest region in the oceans. Protections include bans on fishing and shipping.



Page Valentine, USGS

Substrate at Northeast Peak in Georges Bank, off the Massachusetts coast, which is subjected to fairly high levels of natural physical disturbance due to storms and strong tidal currents.

Left: Gravel habitat heavily impacted by mobile fishing gear. Note that the gravel is clean, and that sand shows between the pebbles.

Middle: Recovering seafloor community that has been closed to trawling for 2.5 years. Note that there is some cover by attached organisms, primarily sponges.

Right: Unfished gravel habitat on the Canadian side of Georges Bank. Note the nearly full cover provided by attached organisms.

ISSUE: FISHING EFFECTS ON HABITAT

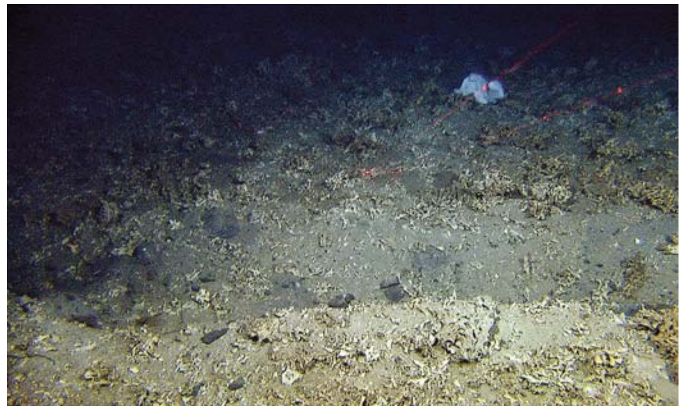
The impacts of fishing on habitat can be very significant, potentially resulting in ecosystem shifts that include altered species composition, changes in trophic structure, and reduced biodiversity. Because of these concerns, the Magnuson-Stevens Reauthorization Act requires that fishery management councils assess fishing impacts to EFH and minimize the impacts of fishing to the extent practicable. Congress was aware this could lead to fishing gear restrictions and time/area closures.

Habitat Impacts

The effects of fishing gear on habitat can be direct and indirect, and act over both short- and long-term scales (Barnes and Thomas, 2002). The impacts resulting from both fixed (longlines, gillnets, traps, and pots) and mobile (trawls and dredges) gear depend on the spatial extent of operations, level of effort, type of gear, and the sensitivity of the particular habitat. Mobile fishing gear is of particular concern and may have a greater effect on a regional scale, but other fishing practices (such as traps and gill nets) may have a more significant ecological effect in local areas, depending on the nature of the fishery and habitat. Most studies of the effects of fishing on habitat have only looked at local spatial scales, making it difficult to apply results to management efforts on an ecosystem level.

In addition to impacts from fixed and mobile types of gear, destructive fishing methods such as the use of poison or explosives cause major damage to marine habitats. These methods are often used in coral reef habitats, killing or breaking apart the living substrates these reefs provide. Such practices are banned in the United States, but may still occur in U.S. island territories.

Habitats vary in their sensitivity. Fauna that live in habitats with a low level of natural disturbance are generally more vulnerable. Such habitats often have large, slow-growing structures like deep corals, which are likely to take many years to recover from the damage caused by mobile gear (Lumsden et al., 2007). Habitats that normally experience high levels of natural physical disturbance (e.g. high-energy sandy bottoms) tend to be less vulnerable to the impacts of mobile gear (Link et al., 2005).



© Both photos courtesty of Mareano, Institute of Marine Research, Norway

Left: The deepwater coral *Lophilia* in its natural state.

Right. A *Lophilia* coral reef after bottom trawling.

Impacts to Living Marine Resources

The significance to fisheries productivity of gear impacts on habitat is generally not well known. The vulnerability of habitats to gear impacts may be greater when fishing is combined with other habitat stressors. Short-term effects are usually directly observable and measurable. While the impacts may be immediate, it may take years before the damage is repaired. Of the greatest concern are the impacts of trawling and dredging on habitat complexity. By directly damaging or removing living, structure-building components of habitat such as corals and burrowing species, repeated trawling and dredging can reduce productivity of benthic habitats and result in discernible changes in benthic communities. Removal of reef-building species will cause large changes to the species assemblages associated with the reef structure itself. For example, repeated dredging of oyster reefs reduces not only the oyster population, but the populations of all the species that use them for foraging or shelter.

The longer-term effects of fishing may be indirect and are more difficult to quantify. Fishing operations in an area can cause changes that linger long after the often immediate and measurable reductions in the densities of both target and non-target organisms. Excess removal of species can disrupt ecological function and balance, change habitats, and allow undesirable species to increase in abundance. For example, in Jamaica, removal of herbivorous fishes through over-harvest initiated a massive ecosystem shift from a coral-dominated reef community to a less productive algae-dominated system.

Solutions

Although fishing can have substantial impacts on aquatic habitats, there are a number of ways to reduce those impacts. Prohibiting or limiting fishing through time/area closures, allowing time for living habitats to regenerate, and restricting gear have been successful in protecting critical or sensitive habitats. More limited measures can also have profound impacts. The Aleutian Islands Habitat Conservation Area, designated by NOAA in 2006, has enforced several fishing closures in the Aleutian Islands and Gulf of Alaska to protect deep sea corals and other fragile parts of the ecosystem (e.g. rockfish habitat, seamounts) from bottom trawling. An area this large has a complex set of regulations intended to protect undisturbed or sensitive habitat, while allowing economically valuable fishing to continue. For example, bottom trawling is allowed in areas that have supported the highest catches of groundfish in the past, and is prohibited in all other areas to protect relatively undisturbed habitats.

More research is needed to further reduce the impacts of fishing gear on habitat. This includes research to better understand the ability of habitats to sustain fishing impacts; research on habitat restoration, especially for fragile biological habitats, such as corals; and research to develop less damaging fishing gear.

Budd Christman, NOAA Corps

Above: A group of walrus hauled out on sea ice in the Bering Sea. As sea ice disappears due to climatic warming, so too does the ecosystem it supports and the habitat it provides.

ISSUE: CLIMATE VARIABILITY AND CHANGE

Natural climate variability can be seemingly random from year to year, may operate over several years, such as the 2- to 7-year cycle of the El Niño Southern Oscillation, over decades, such as the North Atlantic Oscillation, or even over millennia, such as the ice ages. Some species and populations can adapt to climate change, while others may virtually disappear or go extinct.

Superimposed on this natural variability is a new threat from human-induced (or anthropogenic) global warming, widely believed to be caused by emission of greenhouse gases, such as carbon dioxide from burning fossil fuels. Warming of about 0.74°C (1.5°F) has been observed over the last 100 years. The Intergovernmental Panel on Climate Change (IPCC, 2007) projects further global warming of 1.1–6.4°C (2.0–11.5°F) by the year 2100. NOAA paleoclimatological data show that the earth has not been as warm as the projection's lower bounds since the last interglacial period, 120,000 years ago (NOAA, 2006).

Habitat Impacts

Regional and local changes will differ from the global averages discussed here, and some habitats are more vulnerable to these changes.

Increases in ocean temperatures have been widely detected. Predicted impacts include more increases in water temperature, changes in ocean currents, and increased intensity of tropical storms. There have been major losses of polar ice in the last few decades, although the Antarctic changes are not uniform and tend to balance. Because of thermal expansion of the oceans and ice melting, global mean sea level has been rising at an average rate of 1–2 mm (0.04–0.08 in) per year over the past 100 years, significantly faster than the rate averaged over the last several thousand years. The projected increase in sea level by 2100 is anywhere from 0.18 to 0.59 m (7.1–23.2 in).

Another effect of carbon dioxide emissions that is only recently beginning to receive attention is ocean acidification. Approximately 30–50% of global anthropogenic carbon dioxide emissions are absorbed by the world's oceans, which is expected to increase surface ocean acidity by 0.14–0.35 pH units over the next century. Depending on emissions, the increase in ocean acidity over the next few centuries is expected to exceed the changes seen over the past few hundred million years.

Impacts to Living Marine Resources

Some species will be negatively impacted under most scenarios for human-induced climate change, while other species may benefit. Several potential negative impacts from global warming include accelerated loss of beaches and wetlands due to sea level rise, loss of habitat for cold-water and ice-dependent species, coral bleaching, changes in ecosystem productivity, and seasonal timing of physical and life-history events. Positive impacts may include decreased winter mortalities of some species and increased habitat availability for some warm-water species.

Coral bleaching is a symptom of environmental stresses such as diseases, sedimentation, pollution, and increased temperature. In a bleaching event, coral polyps expel the photosynthetic cells of unicellular algae, called zooxanthellae, which normally live symbiotically within their tissues and provide nutrients and a characteristic color. The remaining carbonate skeleton is light in color, and looks as if it were bleached.

In the bleaching event shown in adjoining photograph on the next page, over 89% of the live coral was bleached, including brain coral (in the foreground) and mountainous star coral (large colonies in the distance), which are the dominant reef builders in the western Atlantic. Certain fast growing taxa (lettuce coral and file coral) experienced extensive mortality, while long-lived species like those shown suffered partial mortality affecting up to 40% of their surface. From the fisheries perspective, loss of the living coral means that the habitat it provides for coral reef-dwelling fish will also be lost.

Ocean acidification likely will impact the ability of marine calcifiers, such as corals and mollusks, to make their shells and skeletons from the calcium carbonate dissolved in sea water. Ocean acidification may indirectly affect fish and marine mammals through reduced abundance of marine calcifiers that form the base of the food web and that provide habitat structure. Ocean acidification is an emerging concern and an important area for new research.

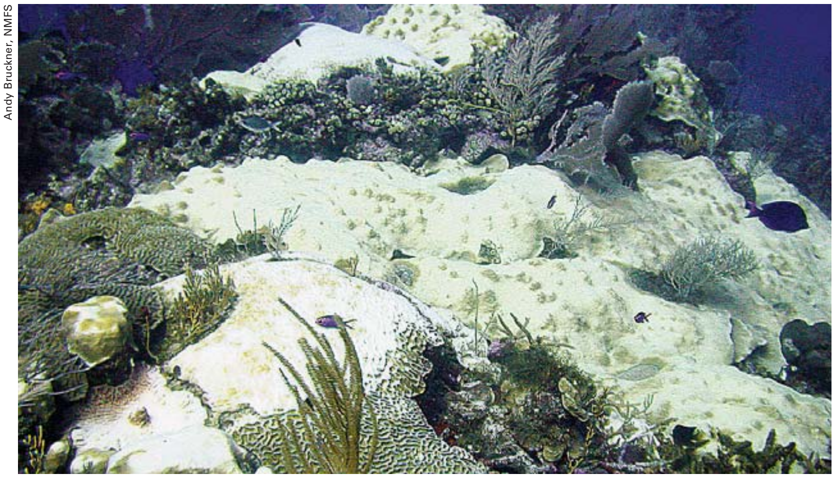
Solutions

Addressing the issue of anthropogenic climate change has two basic components: reducing emissions of the greenhouse gases that are causing global warming, and adapting to the changes that are already occurring. The first priority, reducing greenhouse gas emissions, will require reducing the release of carbon dioxide on a global scale. Among the approaches are development of alternate energy sources, such as solar, geothermal, wind, and ocean current, as well as increased development of nuclear power. Carbon sequestration is a different technical approach, in which the carbon dioxide produced from burning fossil fuels is sequestered underground instead of released into the atmosphere.

Energy conservation is an important component of reducing greenhouse gas emissions. This can be accomplished through many approaches. Some are technical, such as improving the fuel efficiency of automobiles, power plants, and industrial processes. Others combine technical and societal changes, such as expanding the availability and use of public transportation. There also are economic approaches to changing societal patterns of energy use, such as fuel taxes or selling permits for carbon dioxide release.

Because anthropogenic climate changes are already occurring, the science and management of living marine resources must adapt. Some of the science that will be required is basic research, such as improving the understanding of how climate changes are affecting watersheds, estuaries, and oceans, and the structure and function of the habitats, ecosystems, and species they contain. Improved monitoring that incorporates the latest research findings will enable scientists to better understand the changes that are occurring and their potential impacts on living marine resources. This will provide managers with greater lead times and give them better opportunities to respond to changing conditions. Applied research for restoring degraded habitats and establishing new ones also will provide managers with new and better options for adapting to climate change. Management can also adapt to the higher levels of uncertainty that will accompany climate change. Increasing the levels of protection of vulnerable habitats and more conservative fisheries management could help to ensure that stocks remain viable as their habitats change.

Andy Bruckner, NMFS



Coral reef bleaching off Desecheo Island, Puerto Rico, in December 2005.

© Linda Preskitt, Univ. Hawaii

Above: In Hawaii, invasive algal species have spread to become the dominant bottom cover in some reef and coastal areas. The invasive *Cladophora* algae in this photograph has overgrown and smothered the coral in this area off Maui.

**ISSUE:
INVASIVE SPECIES
AND MARINE DEBRIS**

The introduction of non-native species and the release of marine debris are both unintended consequences of human activities. Because of the lack of native predators or pathogens, some non-native species can invade new ecosystems into which they are introduced and become highly abundant. NOAA defines marine debris as "any persistent solid material that is manufactured or processed and directly or indirectly, intentionally or unintentionally, disposed of or abandoned into the marine environment or the Great Lakes" (NOAA, 2009). As human activity has increased in aquatic and coastal environments, rates of introduction of non-native species and marine debris have increased as well.

Impacts to Habitat and Living Marine Resources

Invasive species are prevalent in all aquatic habitat types and regions (EPA, 2008b). For example, about 240 invasive species have become established in San Francisco Bay alone. Some of these species are responsible for reducing native food supplies, eliminating native species, reducing fisheries productivity, and causing substantial habitat alterations. The invasive sea squirt, *Didemnum*, is proliferating on gravel bottoms on Georges Bank, in highly productive scallop habitats. There is concern that the infestation could disrupt food chains and interfere with the settlement of scallop larvae (NEFSC, 2006). Non-native species can also carry novel diseases. MSX, a devastating parasitic oyster disease now widespread in the Mid-Atlantic, is thought to have arrived in oysters brought from Japan in the 1950's. This disease kills oysters, and has been a significant factor to the drastic decline in oyster harvest in Delaware and Chesapeake Bays. Loss of the oysters also degrades the reef habitat they provide.

Non-native species are introduced into aquatic habitats through both intentional and accidental release. Since the 1800's, few bodies of water have been immune to deliberate introductions of species by government agencies and citizens. These have included various trout and salmon, clams, oysters, and carp, for recreational, food, or other purposes. Ballast water, taken onboard at one location to stabilize ships for transit and then released at the destination port, may contain millions of alien eggs, larvae, and microorganisms. Recreational boaters may also introduce alien species into waterways when they move their pleasure craft between areas without proper precautions. The aquarium trade and accidental releases from aquaculture operations are additional pathways of non-native introductions.

Marine debris is widely distributed (EPA, 2008c). For example, even in the largely uninhabited Northwestern Hawaiian Islands (NWHI), it is estimated that about 1,600 metric tons (t) of debris litter the shorelines. Marine debris results from numerous sources, including at-sea dumping and land-based littering or illegal dumping. It can cause significant physical damage to fragile habitats like coral reefs, introduce toxic substances and pathogens, and cover salt marshes, wetlands, and shallow water habitats, making them inaccessible to species that use them and vulnerable to invasive species.

Marine debris poses a serious threat to the survival of some endangered or threatened sea birds, marine mammals, and turtles. For example, sea turtles will ingest plastic bags that closely resemble jellyfish (their typical food) in appearance and then eventually die of starvation due to blockage of their digestive tracts. Discarded or lost fishing gear such as gillnet panels, traps, crab pots, and longlines with hundreds of hooks may continue to fish ("ghost fishing") for many years.

PIFSC, NMFS, NOAA

NOAA

Above: Debris cleaned up from Midway Atoll, at the far western end of the Hawaiian Islands. Discarded fishing nets make up most of the debris shown.

Left: Emaciated northern fur seal entangled with a section of fishing net.

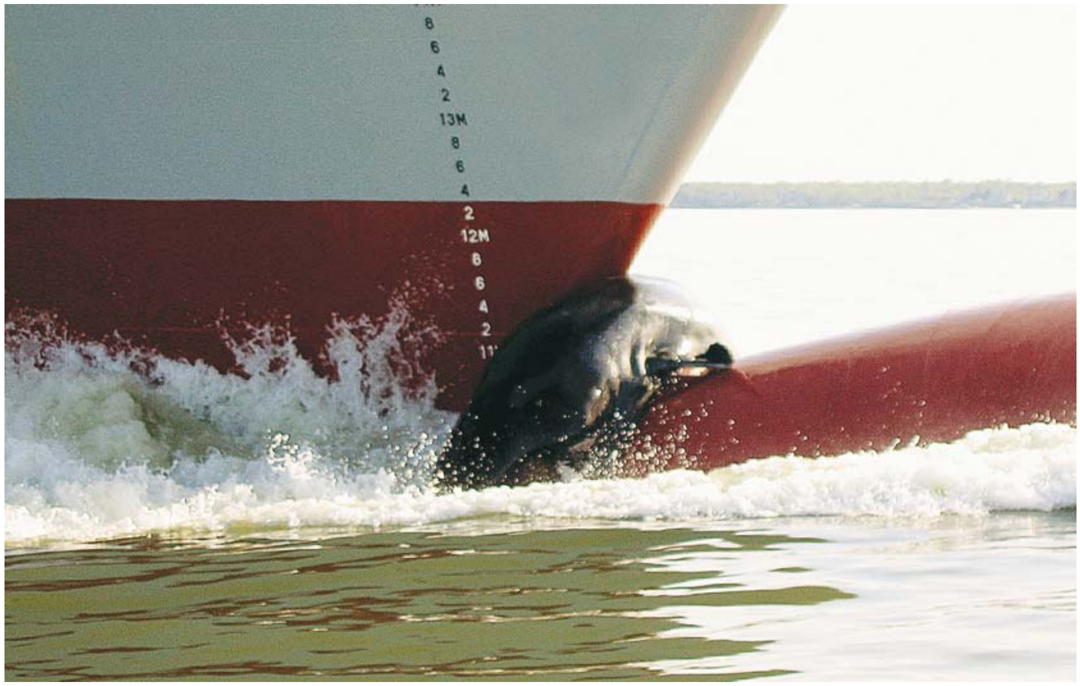
Solutions

Control of alien species is very difficult once they have become established in a new habitat, so preventing new introductions and responding rapidly to newly discovered introductions are very important. The Nonindigenous Aquatic Nuisance Prevention and Control Act, passed in 1990, aims to both prevent future introductions and control existing populations of non-native species. Technological advances, such as onboard use of biocides, filtration, and anti-fouling coatings, as well as development of shore-based treatment facilities, are making control of introductions from ballast water more effective.

More attention is being paid to deliberate introductions. For example, the Asian oyster may prove less vulnerable to the diseases that have devastated the native oysters in Chesapeake Bay, but the National Academy of Sciences recommended a complex research program with strict management controls prior to introduction to rigorously evaluate the potential benefits and risks of introducing this non-native species (NRC, 2004).

Strict regulations and enforcement efforts exist to restrict at-sea dumping; however, land-based sources of debris account for about 80% of inorganic waste found in U.S. coastal areas. Local civic actions such as litter removal and beach clean-ups have been effective at reducing the amount of debris in the marine environment. Increasing public awareness can also help. The Ocean Conservancy's International Coastal Cleanup program found a 48% decrease in the number of items found per mile during beach clean-ups between 1994 and 2000 (The Ocean Conservancy, 2002).

NMFS has been actively involved in marine debris removal from the NWHI since 1996. Over 511 t of derelict fishing gear has been removed as part of a multiagency partnership supported by the NOAA Coral Reef Conservation Program and the Marine Debris Program. A 5-year intensive effort removed much of the historical debris on the coral reefs of the NWHI. NOAA was able to collect 19 t in 2006 in the first year of the maintenance-level effort, but a recent study estimated the accumulation rate to be 52 t annually. NMFS is evaluating new technologies, such as remote sensing and unmanned aerial vehicles, to detect and remove debris at sea before it damages reef ecosystems and impacts protected species.



Cindy Driscoll, Maryland Department of Natural Resources

Above: A ship-struck sei whale on the bow of a container ship in Chesapeake Bay.

ISSUE:
VESSEL TRAFFIC AND NOISE

Vessel traffic can affect marine habitats in a number of ways. Collisions between vessels and marine mammals or sea turtles, which occur when ships are transiting these animals' habitats, can have important impacts on fragile populations of these protected species. Noise is potentially the most pervasive pollutant in marine habitats.

Habitat Impacts

In addition to the introduction of non-native species from ballast water discussed previously, vessel traffic has several potential impacts to the habitats of living marine resources. Near ports, where deep-draft ocean-going ships frequently transit through relatively shallow navigational channels, the re-suspension of sediments by passing ships can reduce water quality by increasing turbidity and decreasing light penetration, and toxic chemicals in sediments may be released into the water column. An additional concern is the possibility of fuel or oil spills. In 1989, the *Exxon Valdez* ran aground in Prince William Sound, Alaska, and spilled approximately 260,000 barrels of crude oil, contaminating approximately 2,080 km (1,300 mi) of Alaskan shoreline.

Ocean noise is one of the most controversial and poorly understood habitat threats (U.S. Navy, 2006; Boyd et al., 2008). Noise comes from vessel traffic, geophysical exploration, active sonars, construction activities, and other sources. It is ubiquitous in the marine environment, and is increasing throughout the oceans by an average of 3 decibels per decade (essentially doubling). High-intensity underwater sound production from research, military, or other activities can reach over 235 decibels, as loud as an underwater earthquake. Sound of this magnitude can travel great distances and is detected at high levels even hundreds of miles from its source.

Impacts to Living Marine Resources

For some species, such as the highly endangered northern right whale, collisions with vessels are a key factor preventing their recovery. Between 1970 and 1994, vessel encounters were implicated in 7% of injuries and 28% of known right whale deaths (Jensen and Silber, 2003).

Spills from ships have both acute and chronic effects. Because oil floats, the most observable impacts of oil spills are to animals that frequent the surface, such as sea birds and marine mammals. When it reaches the shore, spilled oil is deposited primarily in the intertidal and shallow subtidal zones. Following the *Exxon Valdez* spill, the largest deposit of oil was in the upper and middle intertidal zones on sheltered rocky shores. Some of the species affected by that spill included sea otters, harbor seals, and killer whales. Pacific herring, which spawn in shallow coastal habitats, and salmon, which transit these areas as spawning adults and out-migrating juveniles, were also significantly affected. Fourteen years after the *Exxon Valdez* spill, residual oil was still present in some habitats. It continues to be a problem for species that spawn or forage in these areas. This persistence of oil may delay for many years the complete recovery of some habitats or species (Peterson et al., 2003).

Currently, the impacts of noise on marine mammals are receiving considerable attention. Recent mass strandings of beaked whales have occurred in close association (in time and space) with military exercises that used high-energy, mid-frequency (1–10 kilohertz [kHz]) sonars. Sonar has also been implicated in altering the singing of humpback whales, disrupting the feeding of orcas, and causing porpoises to leap from the water or panic and flee. There is currently no documented evidence of ocean noise being the direct physiological agent of any marine mammal deaths, but analysis of fresh, whole animals is rarely possible, and a definitive diagnosis of the cause of death is often problematic.

As with marine mammals, many species of fish use sound to follow migration routes, locate each other, find food, and care for their young. The potential impact of noise on fish is relatively unknown. It is clear that animals that use sound for communication and navigation can easily be affected, but it is less clear what levels will actually cause damage to animal tissues and hearing organs.

NASA

The U.S. Navy's Atlantic Undersea Test and Evaluation Center (AUTEC) range in the Bahamas, where a NOAA-led international team, funded primarily by the U.S. Navy, is studying the behavioral responses and relative sensitivities of several marine mammals to sonar (Boyd, et al., 2008). This high-altitude image shows Andros Island (center) surrounded by shallow (turquoise) water to the left side and very deep water to the right (a trench called Tongue of the Ocean). The AUTEC range is in the middle of the trench, and has 82 hydrophones deployed over 1,554 km² (600 mi²) of the sea floor.

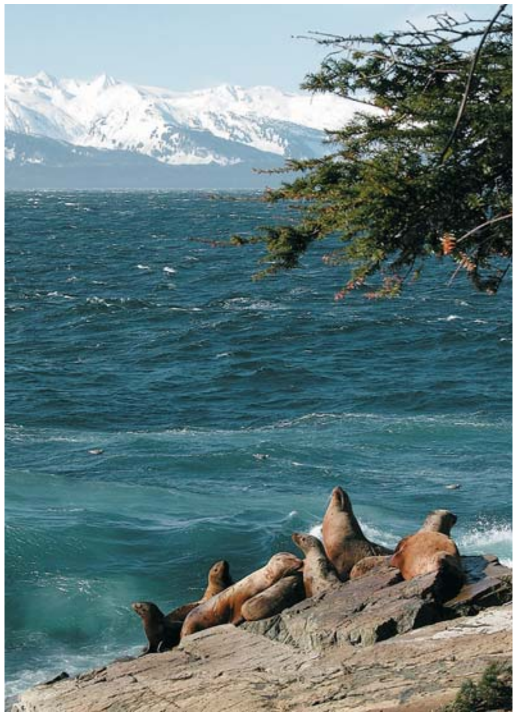
Solutions

Designating critical habitat areas for marine mammals vulnerable to vessel collisions, and restricting vessel traffic within those areas, has been successful at reducing vessel impacts, and will continue to help susceptible populations. Recent regulations limiting the speed of vessels 20 m (65 ft) or longer to 18.5 km/hr (10 knots) within 37 km (20 n.mi.) of major Atlantic ports are intended to protect the northern right whales that occur in this region (NOAA, 2008). The likelihood of spills and other impacts to habitat from passing ships can be minimized through improved navigation and port facilities.

Because the potential impacts of noise have become a concern only recently, research is needed to better define these impacts and to develop approaches to minimize the impacts that are documented.

Left: Steller sea lions hauled out on Benjamin Island, near Juneau, Alaska.

Right: Mangrove roots provide essential habitat for many species, such as in this mangrove habitat at Elliott Key in Biscayne Bay, Florida.



NMFS

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CONCLUSIONS

Managing habitat through conservation and protection is critical because of the living marine resources that habitat supports. An effective program requires components that protect and conserve remaining habitat, restore damaged or lost habitat, and build or enhance habitat where there are opportunities to do so. These actions require the engagement and support of an informed citizenry and government agencies with habitat-conservation mandates and the resources needed to carry them out.

Scientific information and the scientists that generate it are key to effectively managing habitat. Understanding the relationships between species and habitats, knowing where and how much habitat exists, and rigorously monitoring and assessing its condition can provide the scientific basis for managing habitat. However, this information can only be effective in informing public policy when it is communicated to resource managers, stakeholders, and the public in a timely manner and in forms that are appropriate to the specific audiences.

To prevent further impacts from habitat degradation, fragmentation, and loss, the habitats that remain can be conserved and/or protected through legislation and vigorous enforcement. Although more than 1,000 areas within U.S. waters are granted some level of special protection by Federal or state governments, only about 1% of the ocean within U.S. jurisdiction qualifies as a marine protected area, and only about 10% of that carries the highest level of protection, where fishing and other extractive activities are precluded. Clearly there is the potential to protect more area, and to provide high-priority areas with a greater level of protection. However, conserving and protecting habitat does not have to be accomplished only by setting aside large areas of habitat. Other management options also exist, such as fishery time/area closures, avoiding certain activities in sensitive areas (e.g. banning bottom trawling over deep-coral beds, but allowing fishing using other gears that do not contact the bottom), and developing alternative methods or new technologies that reduce or eliminate the most deleterious impacts.

Creating or restoring habitat is usually much more expensive and less effective than conserving

Biogeography Team, CCMA, NOS, NOAA

Mandy Lindeberg, NMFS

Left: Coral reef and fish in the Pacific Islands.

Right: Southeast Alaska wetland and estuarine habitat supports many fish species at critial times in their life cycles.

habitat that already exists and is functioning. The science of creating and restoring habitats is relatively new, so more research is needed to develop and evaluate restoration methods. When habitat is created or restored, it should be done with a valid scientific purpose and experimental design, so that effectiveness can be evaluated through monitoring and additional corrective actions undertaken if they prove necessary. To ensure restoration success, NOAA's Restoration Center employs technical staff to improve project design, advance restoration techniques, and use ongoing scientific monitoring to evaluate restoration projects and assure efficient use of restoration funds.

This *Policymakers' Summary*, and the complete *Our Living Oceans: Habitat* report from which it is derived, provide a comprehensive overview of the habitat issues that are affecting the living marine resources of the United States, and the state of the scientific information on these issues. The intent is to provide scientifically valid information in a form that can be used not only by scientists, but also by stakeholders, policymakers, students, and the general public.

The overall message in these reports is mixed. The United States still possesses a considerable amount of functioning habitat, which supports substantial harvests of fishery resources and populations of protected species. However, there has been substantial loss and degradation of habitat in many areas, especially where human activities occur. The cumulative impacts of these losses cannot readily be quantified, but they are undoubtedly considerable, especially on urbanized watersheds, estuaries, and coasts.

In order that our Nation can continue to benefit from abundant living marine resources, our society needs to place a high priority on managing habitat. Human populations and economic activities will continue to expand, placing ever-increasing demands on the environment and the habitats it contains. Gaps in the relevant scientific information must be filled, and the information communicated, such that our decisionmakers can be appropriately informed as policy is developed and implemented. The National Marine Fisheries Service has developed the *Our Living Oceans* series of reports to contribute to these vital processes.

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