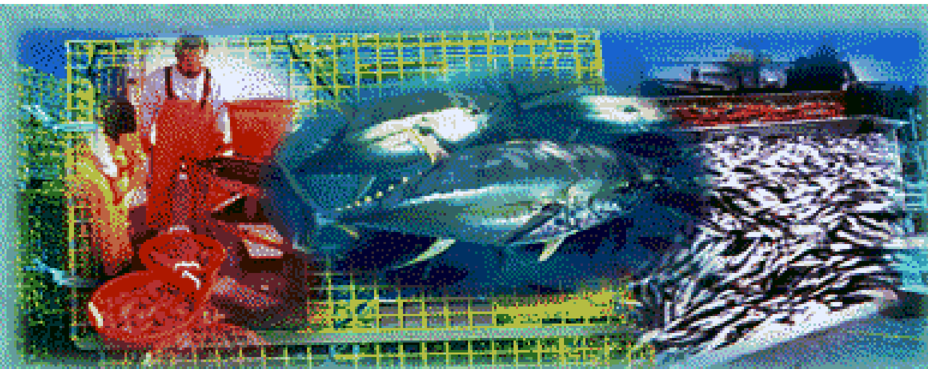
POPULATIONS OF HARVESTED FISHES & INVERTEBRATES



The outlook for the general welfare of the Nation's living marine resources is "guarded" with vigilance needed. The decline in Northeast groundfish, the precarious state of some West Coast salmon runs, and the reduced populations of sharks and other marine species are but a few areas that require special attention. Although many of our living resources remain healthy, the pressures and demands placed on them will continue to increase. Therefore, we must continue to improve our scientific understanding of marine species, habitats and processes so that we can develop effective fishery management strategies. The challenge is to maintain the long-term viability of the natural system, while at the same time addressing the social and economic needs of the fisheries.

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The following reference format is suggested:

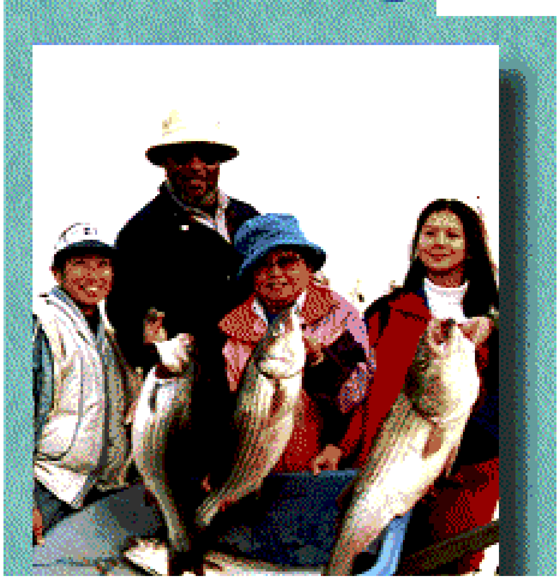
National Oceanic and Atmospheric Administration (NOAA). 1998 (on-line). "Populations of Harvested Fishes and Invertebrates" by A.M. Shimada, V.G. Wespestad, L.L. Low, and D.M. Nelson. NOAA's State of the Coast Report. Silver Spring, MD: NOAA.

URL: http://state_of_coast.noaa.gov/bulletins/html/lmr_07/lmr.html

INTRODUCTION

Marine fish populations are a self-sustaining ocean heritage; one that provides commercial, recreational, subsistence and aesthetic benefits to the American people. With proper stewardship, living marine resources will continue to provide these benefits to our Nation. Since 1990, the United States has consistently ranked fifth in world fisheries catch by weight (NMFS, 1997a). The U.S. catch was 5% of the world's total production of marine and freshwater products in 1995 (Figure 1). However, overutilization is causing many species that sustain these U.S. fisheries to fall below the levels required to produce long-term potential yield, and restoring these populations will require careful management and monitoring.

Photo 1. Lobster pots and fishermen's cooperatives symbolize the fishing tradition in New England states.



Harvested species include fishes, mollusks and crustaceans with a diversity of life histories and habitats (NOAA, 1995b). Ocean pelagic species include swordfish, marlins, tunas, and some sharks, which occur in offshore waters. Coastal pelagic species include Atlantic and Pacific herring, the mackerels, and menhaden. Demersal groundfish, such as Atlantic cod and Alaska walleye pollock, live near the bottom in the marine waters of the Continental Shelf. Snappers, groupers and spiny lobster inhabit coral reefs of the southeast Atlantic and Gulf of Mexico. Many species are estuarine-dependent, living in shallow nearshore habitats for all or part of their life cycles. Oysters and other sessile invertebrates, for example, spend their entire life cycle within estuarine waters. Anadromous fishes such as salmon, shad and striped bass spend much of their life at sea and migrate through estuaries to spawn in fresh water. Many species of shrimp, crabs and fishes spawn in marine waters near inlets and depend on tidal currents to carry eggs, larvae or juveniles into protected estuarine nursery areas.

Photo 2. A successful building effort in the Chesapeake Bay has enabled a re-opening of the sport fishery for Atlantic Striped bass.

Fisheries management within the 200-mile U.S. Exclusive Economic Zone (EEZ) is the responsibility of the federal government and Regional Fishery Management Councils (Figure 2). Nearshore fisheries (within the 0- to 3-mi territorial sea) are under the management of coastal states and interstate marine fisheries commissions. In the open ocean beyond the federal EEZ, fisheries are regulated by international laws and multilateral treaties.

Photo 3. Retail seafood markets are popular destinations for both consumers and tourists.

Fisheries managers not only must regulate fishing activities, but also must conserve essential habitat. Although fishing directly affects the abundance of adult fish and juveniles, the growth and survival of fish in their early life stages depend on the presence of necessary ocean, coastal, estuarine and riverine habitats. For example, Gulf of Mexico estuarine wetland habitat provides juvenile fish, shrimp and crabs with protection from predator species and abundant food sources that support rapid growth (Boesch and Turner, 1984). In the Pacific Northwest, salmon and steelhead require freshwater stream habitat for migration, spawning and rearing (Roper et al., 1997).

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NATIONAL PICTURE

A "fishery" is the act, process and industry of catching fish, crustaceans, mollusks or other aquatic animals for commercial, recreational, subsistence or aesthetic purposes. A "stock" is a biologically distinct population within a species, often one that has a particular migration pattern, specific spawning grounds (i.e. reproductively isolated), and may be subject to a directed fishery. Because populations often intermix in the marine environment, some fisheries intentionally or inadvertently catch more than one stock and are, therefore, known as "mixed stock" or "mixed species" fisheries.

Photo 4. A mixed species catch includes rockfish, flatfish, sablefish and Pacific whiting in the West Coast bottom trawl fishery.

Assessments of living marine resources are based on scientific analyses of their current and potential biological productivity and utilization by the fisheries. Some 275 nationally significant fish and shellfish species and stock groups have been identified for reporting purposes (NOAA 1996). Of this total, the coastal states and interstate marine fisheries commissions manage 74 nearshore stock groups; the federal government manages 201 through eight Regional Fishery Management Councils. Several of these stocks also fall under some international law or multilateral arrangement.

Three abundance measures characterize resource productivity: (1) long-term potential yield (LTPY), the maximum long-term average catch that can be derived from a stock; (2) current potential yield (CPY), the catch that can be taken consistent with current abundance; and (3) recent average yield (RAY), a three-year running average of reported catch (NOAA, 1996). Comparing current abundance to the level that would produce the maximum long-term average catch that could be achieved from the resource indicates the resource status. "Fishery utilization" is the relationship of the levels of current abundance and potential yield to observed fishing effort. Landings data are reported in metric tons, termed as "ton" (1 metric ton equals 2,200 pounds).

Photo 5. Levels of catch and fishing effort relative to levels appropriate for current abundance and long-term potential yield greatly affect subsequent resource health.

Measures of resource productivity, status of stocks and utilization are not independent of each other, but are interrelated. Stock groups that have been overutilized (e.g., Northeast groundfish such as Atlantic cod, haddock, yellowtail flounder) tend to have both a recent average yield and current potential yield well below their long-term potential yield (Table 1). Stock groups that are relatively underutilized (e.g., Northeast pelagics such as Atlantic mackerel, Atlantic herring) tend to have a recent average yield below the long-term potential yield, and a current potential yield equal to or greater than long-term potential yield. Stock groups that are fully utilized (e.g., Atlantic and Gulf of Mexico menhaden) tend to have a recent average yield close to their current potential yield and long-term potential yield.
(top)

Resource Productivity

The largest U.S. fisheries by landed weight include the Bering Sea/Aleutian Island groundfish complex (1.9 million tons), Southeast menhaden (900,000 tons), Alaska salmon (364,000 tons), Pacific Coast groundfish complex (262,000 tons), Gulf of Alaska groundfish complex (249,000 tons), Pacific highly migratory pelagic species (240,000 tons), and the Northeast groundfish complex (146,000 tons) (Table 1).

Photo 6. The West Coast fleet (CA, OR, WA) accounts for 9% of the national catch, about the same as the fleet in the Northeast region.

The estimated long-term potential yield of all U.S. fishery resources is 10.3 million tons (Table 1). By region, the percentage distribution of U.S. long-term potential yield is 10% for the Northeast; 18% for the Southeast, including the Gulf of Mexico; 54% for Alaska; 14% for the Pacific Coast; and 4% for the Western Pacific Ocean (Figure 3).

Nationwide, the recent average yield (1992-1994) was 7.2 million tons or 30% below the long-term potential yield (NMFS, 1996). However, the range of some stock groups extends well beyond the U.S. EEZ. Considering only the U.S. share of these resources, recent average yield is 8.1 million tons or 21% below the total long-term potential yield (Figure 4) (Appendix A). The total national yield is not being realized because some stock groups are underutilized, while some have been overexploited and currently are well below their long-term potential yield. By region, the percentage distribution of U.S. recent average yield is Northeast, 9%; Southeast, 23%; Alaska, 54%; Pacific Coast, 9%; and Western Pacific Ocean, 5% (Figure 5).
(top)

Status of Stocks

Stock status is known for 66% of the 275 stock groups identified as nationally significant, and these known status stocks make up more than 95% of the U.S. catch. Of the stock groups with known status, 30% are below the abundance levels that would produce long-term potential yield, 27% are near and 9% are above. Of the 201 federally managed stock groups, 36% are below that level, 30% are near it and 13% are above it, while the level is unknown for 21% (Figure 6).

Photo 7. Fishery-independent resource surveys provide critical stock assessment data.

There are 158 stock groups of known status that occur in the U.S. EEZ. Of these, 38% are near and 16% are above the levels that would produce long-term potential yield. Assuming that stock groups near or above these levels are in healthy condition, 85 (54%) of the 158 known status stocks can be considered at healthy abundance levels. The remaining 73 (46%) groups that are below these levels include the 19 stock groups of Northeast demersal species, nine stock groups of Atlantic and Gulf of Mexico reef fish, and six stock groups of Pacific Coast groundfish. Less severe cases of low abundance can be found in all regions, including Alaska.

Alaskan fisheries for some major groundfish (e.g., Greenland turbot) are substantially below the long-term potential yield levels. Other species, such as the smaller flatfish (e.g., yellowfin and rock sole, arrowtooth flounder), are relatively abundant. Walleye pollock and Pacific cod populations are at much lower levels than their recent (1980s) high levels, but are still close to levels of long-term potential yield. Off the West Coast, all five species of Pacific salmon are depressed. This is partly due to ocean conditions that have been generally unfavorable for salmon since the late 1970s, but is primarily the result of habitat losses, hydropower development and overharvest. Of the 15 highly migratory stock groups of tunas, billfishes, swordfish and sharks in the Western Pacific, 12 are near levels that would produce long-term potential yield, two are below that level, and one is of unknown status.

Most stock groups classified as being of unknown status are nearshore species (50 of 74). These 50 stock groups accounted for only 4.7% of U.S. recent average yield (238,000 tons of 5.06 million tons) during 1992-1994. Of the 201 federally managed stock groups, 43 (21%) are of unknown status. These are generally of low abundance and contributed only 2.7% of the U.S. recent average yield.
(top)

Utilization

The status of utilization, or the level of resource use by fisheries, is reported as underutilized, fully utilized, overutilized, or unknown (Appendix B). This measure compares existing fishing effort with the appropriate levels necessary to achieve long-term potential yield. Of the 275 recognized stock groups, 12% are underutilized; 34%, fully utilized; 23%, overutilized; and 31%, unknown. Of the 201 federally managed stock groups in the U.S. EEZ, 15% are classified as underutilized; 35%, fully utilized; 28%, overutilized; and 22%, unknown (Figure 7). Of the 201 federally managed stock groups, 157 have known utilization status. Of these, 36% are overutilized. The majority of these are made up of 18 stock groups of Northeast demersal fish and 10 stock groups of Atlantic and Gulf reef fish. The remaining stock groups have been classified as 20% underutilized and 44% fully utilized.

By means of an alternative methodology that recognizes 737 marine species and stock groups, it has been estimated that 86 (12%) stock groups are "overfished," 10 (1%) are approaching an overfished condition, and 193 (26%) are not overfished; the utilization of 448 (61%) is unknown (NMFS, 1997b). However, the criteria used to define "overfished" are quite different from those used to define "overutilized."

Photo 8. Forty-four percent of federally managed stock groups are fully utilized in the U.S. Exclusive Economic Zone.

Stocks that are overutilized include some of the Nation's most valuable fishery resources, such as New England groundfish, Atlantic sea scallops, Gulf of Mexico shrimp, several highly migratory pelagic stocks (e.g., Atlantic bluefin tuna and swordfish), some Pacific salmon stocks, some rockfish off Alaska, and Alaska king crab. Many nearshore stocks, including several oyster populations, bay scallops, abalone and Pacific Coast striped bass, are also overutilized. A few abundant resources, such as some pelagic stock groups in the Northeast, jack mackerel off California and some flatfishes off Alaska, are currently underutilized.

Of the 74 nearshore state-managed species, three stock groups are underutilized; 24, fully utilized; seven, overutilized; and 40, of unknown status. Significant crab, oyster and shrimp fisheries in every region are all fully utilized. The unknown category includes newly developed fisheries for sea urchins, squids and other lesser known invertebrates.

Twenty-two percent of federally managed stock groups (44 of 201) have an unknown utilization status. The majority of these are in the Southeast and include coastal migratory species, reef fishes and invertebrates. This category also includes seven stock groups in the Western Pacific region where highly migratory tunas and billfishes move long distances across many national jurisdictions, making accurate assessments difficult.
(top)

REGIONAL CONTRASTS

The status of national fisheries can vary dramatically between regions. For example, there are great differences between the historically significant Northeast Region and the vast, but geographically remote, Western Pacific Region.

Northeast Region

Four major marine areas lie in the Northeast Region, extending from Maine south to North Carolina: the Gulf of Maine, Georges Bank, the waters off southern New England, and the Middle Atlantic Bight (NOAA, 1995b). Of the 275 stock groups surveyed nationally, more than 55 are in these Northeast Region waters.

Many Northeast stock groups are overutilized. These resources have a total long-term potential yield (LTPY) of 1.29 million tons over their entire range, which is shared by the United States, Canada and other Atlantic countries. The LTPY in U.S. waters is 845,000 tons (Appendix C). The U.S. recent average yield (RAY) (1992-1994) has totaled only 450,000 tons, or 53% of potential, because 33 stock groups, principally groundfish, were overutilized (as of 1995).

The mixed species groundfish (Atlantic cod, haddock, pollock, redfish, hakes and flounders) have traditionally been the most valuable, followed by American lobster and Atlantic sea scallop. Recreational fisheries for cod, winter flounder, mackerel, striped bass, bluefish and bluefin tuna also contribute greatly to the region's economy. Commercially significant groundfish and flounders have been severely overfished; in 1994, their estimated overall abundance was the lowest on record, with an abundance index only one-fifth that reported in 1963 (NOAA, 1996). Stringent management regulations introduced in 1994 (e.g., closure of portions of Georges Bank, limitations on days fished, trip limits for certain species) have sharply reduced fishing mortality and allowed some rebuilding of some groundfish stocks. Other stock groups remain in an overfished condition, however, thus warranting continued strict limits on the commercial fisheries. Dogfish and skates, which began to increase in abundance during the 1970s as groundfish and flounder populations declined, currently comprise about 75% of the total fish biomass on Georges Bank and have supported increased catches in recent years. Since 1990, however, they have become less abundant. Other groundfish (e.g., goosefish, scup, hake) have become increasingly important in recent years as preferred species (e.g., cod, haddock, yellowtail flounder) became scarce.

In 1997, 14 Northeast species are considered not overfished (NMFS, 1997b). The combined current potential yield (as estimated in 1995) for the two most abundant of these species, Atlantic mackerel and herring, is nearly 522,500 tons higher than their recent annual catch, primarily because of the low market demand and the consequently low fishing effort. The anadromous striped bass, driven to very low levels of abundance in the

Photo 9. The low abundance of Northeast groundfish has prompted fishery closures and moratoriums in recent years.

early 1980s, was declared fully restored in early 1995 (Field, 1997). The region's valuable crustaceans and bivalve molluscs, both offshore (American lobster, sea scallop, surfclam, ocean quahog, squid) and inshore (blue crab, oyster, blue mussel, hard and softshell clam) are nearly all exploited fully or excessively.

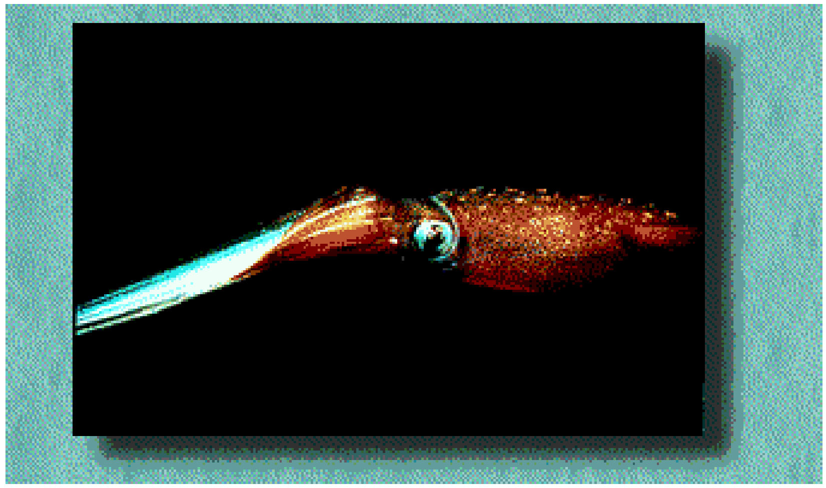

Photo 10. Increased catches and dockside prices of squid in the Northeast are leading to concern about the potential effects of the catch not only on the squid populations, but also on other species that depend on squid.

(top)

Western Pacific Region

The tropical and subtropical marine waters of the Western Pacific Region host a rich diversity of species, but sustainable yields are low because of limited nutrients. Local fisheries target reef and bottom fishes, several highly migratory species, seamount fishes, spiny and slipper lobsters, and precious corals.

Stretching across the central and western Pacific Ocean, this vast region includes the Hawaiian Islands and the U.S. territories of American Samoa, Guam and the Northern Marianas (Figure 2). Although these islands have only 17,870 sq km of emergent land, their isolation enables the United States to claim more than 5.18 million sq km of ocean. The magnitude of catch is small (U.S. LTPY is only 283,000 tons and U.S. RAY is 243,000 tons), but seafood and fisheries are important cultural components of the island communities. Additionally, certain transboundary fisheries have considerable international importance and value to Pacific Rim countries and the U.S. fleet fishing within and beyond the U.S. EEZ.

The highly migratory stocks (e.g., tunas, billfishes, sharks) roam the seas and often travel through areas beyond the jurisdiction of U.S. fisheries management. Pacific tunas, the major target species, migrate across multiple international jurisdictions in the Pacific. Their combined LTPY throughout their migratory range exceeds 2 million tons, while the prorated U.S. portion is only 279,000 tons. Of the 15 stock groups, 12 are near the levels that would produce their LTPY, two are below this level, and one is of unknown status.

Photo 11. Tuna migrate through U.S. waters, allowing domestic fisheries to capture only a portion of these species' long-term potential yield.

Western Pacific bottomfishes (deepwater snappers, jacks, grouper, emperors) are harvested from a variety of rock and coral habitats around Hawaii and Western Pacific island territories. About 90% of the catch comes from the main Hawaiian islands, where stock assessments indicate that some important species (e.g., squirrelfish and longtail snappers) are at only 10% to 30% of original stock levels, and overutilization is a serious concern. Across the entire region, however, the U.S. LTPY of 2,700 tons is seven times higher than the U.S. RAY because of the underutilization of stocks in the northwestern Hawaiian Islands, American Samoa and the Marianas.

The pelagic armorhead, which occurs on the northern Hawaiian and Emperor seamounts, exemplifies seamount fisheries that are vulnerable to overexploitation. This fishery peaked in 1972 with catch rates of greater than 60 tons per hour, but the catch rate dropped to 0.3 tons per hour, or 0.5% of the 1972 catch rate, by the early 1980s. The United States declared a six-year moratorium on the fishery in its waters in 1986. Recruitment improved in 1990-1993, but resulting increased catches were short-lived and populations of armorhead have not yet returned to their former levels.

Spiny and slipper lobsters are the most valuable invertebrates in the Western Pacific. The northwestern Hawaiian Islands are the primary fishing areas for these species. Begun in 1977, this fishery reached its peak during the mid-1980s, but has since declined. Since 1991, emergency closures, a limited entry regime, and a closed season have been among the measures adopted to rebuild the stocks. Lobster yields are now much lower than during the 1983-1989 period, but the stock is recovering.

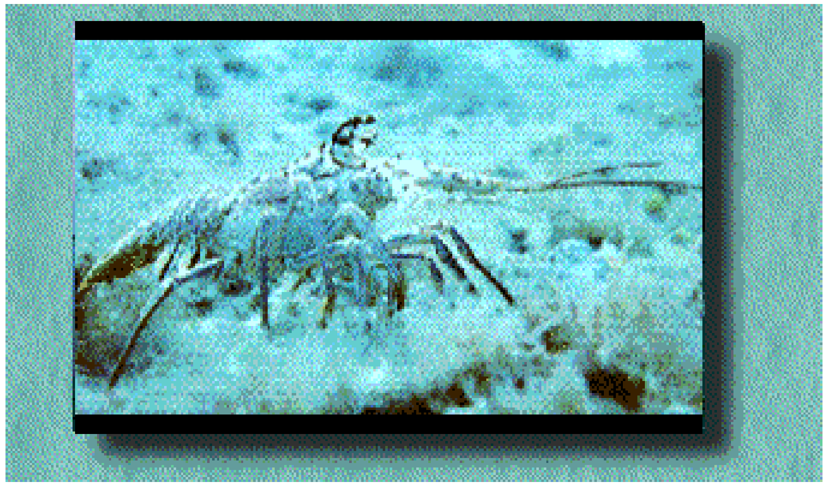

Photo 12. The implementation of new management measures in the Hawaiian spiny lobster fishery in 1991 is helping to rebuild stock abundance.

Precious corals represent another unique resource, having been harvested at the northern Hawaiian seamounts and on island slopes in the main and northwestern Hawaiian Islands. Sustainable harvest depends on selective fishing techniques, but the prohibitive costs of these techniques has discouraged precious coral harvests in U.S. waters since 1988.
(top)

CASE STUDIES

Following are descriptions of two regionally significant species: (1) walleye pollock (*Theragra chalcogramma*), a member of the cod family (Gadidae) in the marine waters of Alaska, and (2) red drum (*Sciaenops ocellatus*), a member of the drum family (Sciaenidae) in marine and estuarine waters of the Gulf of Mexico.

Alaska Walleye Pollock

Much attention has been focused on the collapse of major fisheries and the failure of their management bodies to ensure sustainable production. In contrast, the walleye pollock fishery of the eastern Bering Sea has been a management success for more than 20 years (Megrey and Wespestad, 1990). Rapid development in the domestic groundfish industry off Alaska produced such an economic boom that between 1978 and 1995, the ex-vessel value of the Alaskan groundfish landings grew from nearly zero to more than $590 million. The harvesting capacity of the U.S. fleet has undergone a similar expansion. In 1995, the U.S. fleet was able to harvest about 1.2 million tons in 71 days; in the past, joint venture arrangements between U.S. and foreign vessels took eight to nine months to harvest a similar quantity, and in the original Alaskan pollock fishery, foreign vessels took almost all year to harvest an average of 1.2 million tons.

Photo 13. The harvest of Alaska groundfish, which include walleye pollock, fueled the development of the industry, now worth more than $590 million.

Despite the rapid, substantial growth in the domestic fishery and the rise of economic problems associated with overcapitalization, the tight restrictions on annual groundfish quotas have prevented overfishing of the underlying pollock resource since the implementation of the Magnuson Act in 1977. Decisions by the North Pacific Fishery Management Council rest on

Photo 14. The Alaska walleye pollock was the largest single-species harvest in the world during the 1980s.

information provided by an extensive fishery observer program, as well as fishery-independent surveys. Both programs provide data essential for monitoring the effects of fishing efforts during the season. The Council's first action was to hold the allowable pollock harvest below 1 million tons because of the uncertainty surrounding early resource status. For the entire Bering Sea groundfish complex, the Council has maintained a 2 million ton quota ceiling year-to-year even though underlying resource abundance has warranted catches of 2.2 to 2.9 million tons since the mid-1980s. This conservative, precautionary approach has enabled a successful fishery to continue, while preventing overfishing.

Walleye pollock was the largest single-species harvest in the world during most of the 1980s and into the early 1990s. This dominance was due to its high stock abundance and the rapid development of high seas fisheries in the international waters of the central Bering Sea ("Donut Hole") and Central Okhotsk Sea ("Peanut Hole"). This international fishery has greatly affected resource status. In recent years, Russia has both opened its EEZ to foreign vessels and purchased modern factory trawlers that have a higher catching and processing capacity than the vessels in the traditional Russian fleet. Abundance levels have been declining in the major stocks, and international agreements now curtail the high seas fisheries.

The entire walleye pollock harvest in 1997 will likely exceed 4 million tons, comprising 1.3 million tons from North America and nearly 3 million tons from Asia. In U.S. waters, a slight decline in pollock abundance is likely to continue until 1999-2000, when a strong 1996 year class is likely to recruit into the fishery. In Russian waters, scientists anticipate a continued decline for most stocks through the end of the century, followed by an increase from strong 1995 and 1996 year classes.

Photo 15. The Nation's largest factory trawler fleet, with home port in Seattle, targets Alaska's walleye pollock.

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Gulf of Mexico Red Drum

The red drum, or redfish, spawns in marine waters, but depends on estuarine habitats during its larval and juvenile life stages (Murphy and Taylor, 1990; Wilson and Nieland, 1994; Pattillo et al. 1997). Fishermen have targeted red drum in the Gulf of Mexico and off the southeastern U.S. since the 1700s, and commercial fishery statistics have been recorded from the 1880s. Consumer demand for red drum increased dramatically in the 1980s because of a popular recipe for "blackened redfish." At the same time, improved purse seine technology and spotter planes facilitated the capture of high numbers of large adult fish in offshore waters (NOAA, 1995a). The commercial fishery in the Gulf of Mexico escalated to meet the market demand, reaching a peak in 1986 with total landings over 4,000 tons at a value of over $6 million. This species is also prized by coastal

Photo 16. A popular recipe for "blackened redfish" in the 1980s contributed to the overutilization of red drum.

anglers, and sport harvest has greatly exceeded commercial harvest in the 1990s.

The increased catch of spawning adult fish raised concerns that the stock was being overfished. These concerns prompted new stock assessment studies and a fishery management plan for the Gulf of Mexico (NMFS, 1986). The studies showed that the fishing mortality of inshore juveniles and offshore adults was too high to maintain sufficient spawning stocks (GMFMC, 1992). Consequently, commercial and recreational fisheries for red drum in federal waters were banned in 1988, and fisheries in inshore state waters were managed to protect juvenile red drum.

Although the red drum is still considered overutilized, assessment studies suggest that the Gulf of Mexico spawning stock can be restored if recruitment continues to increase and harvest restrictions remain in effect (Goodyear, 1996). Recovery will be a long-term process, however, because juvenile fish enter the spawning stock at age 4 and are not fully sexually mature until age 7 (GMFMC, 1992; Wilson and Nieland, 1994). The loss and degradation of estuarine habitats essential to red drum early life stages may also affect the rate of recovery.

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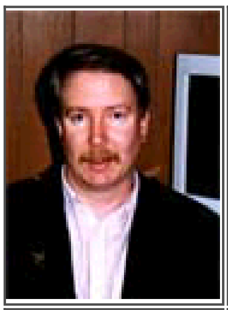
EXPERT INTERPRETATION

The four individuals below are experts in the topic of Populations of Harvested Fishes and Invertebrates. Here they voice their opinions on two questions relevant to that topic.

Question 1 – Are we measuring or assessing the right attributes of exploited marine populations? Will new or incremental improvements in scientific information make a difference?

Question 2 – Can you identify new technologies, any fundamental or applied science initiative(s), or evolving institutional arrangements that hold the promise of materially advancing our current capabilities in assessing and predicting the status of living marine resources?

Experts

			
Michael Fogarty	**Don Gunderson**	**Pamela Mace**	**Carl Safina**

Michael Fogarty

Associate Professor, Chesapeake Biological Laboratory, University of Maryland Center for Environmental Science

For the past 20 years, Dr. Fogarty has worked on problems related to fish stock assessment and in fisheries ecology. His research focuses on fishery recruitment dynamics of exploited marine populations, and on multi-species interactions.

Response to Question 1

Response to Question 2

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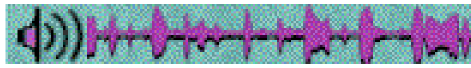
Question 1. Are we measuring or assessing the right attributes of exploited marine populations? Will new or incremental improvements in scientific information make a difference?

 Click here for audio response

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The general strategy of monitoring catch, fishing effort, relative abundance, demographic characteristics and ecological interactions of marine populations through a combination of fishery-dependent observations and fishery-independent measurements is fundamentally sound. We must recognize, however, that the precision of our estimates is limited by the logistical difficulties and expense of making measurements in the ocean. This, coupled with our incomplete understanding of population and ecosystem dynamics, virtually assures uncertainty in resource management. We need to confront this uncertainty directly, and treat management as a problem in risk and decision analysis. New or incremental improvements can make a difference by reducing uncertainty and by providing fundamental new insights into population and ecosystem processes. However, we also need to confront the twin problems of open access fisheries, in which rights and responsibilities are ill-defined, and the perceived conflicting goals and objectives among conservation, social and economic needs, if we are to improve fishery management. Many current problems in fishery management stem from institutional failures attributable to unbridled competition and conflicting objectives among different segments of society.
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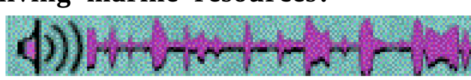
Question 2. Can you identify new technologies, any fundamental or applied science initiative(s), or evolving institutional arrangements that hold the promise of materially advancing our current capabilities in assessing and predicting the status of living marine resources?

 Click here for audio response

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Technological advances in remote sensing, *in situ* oceanographic monitoring devices, and biological samplers (e.g., multi-frequency hydroacoustics, optical devices etc) all hold the promise of revolutionizing the way we measure marine ecosystems and the physical/chemical environment. Advances in computational ability have been essential to the effective utilization of this wealth of information. Worldwide research initiatives, such as GLOBEC (Global Ecosystem Dynamics Program), which are intended to develop and use new technologies in the service of multidisciplinary approaches to understanding marine ecosystem dynamics, are now under way and hold considerable promise. A realistic and essential objective of these programs is to develop a mechanistic understanding of the linkage between environmental variability and population fluctuations, with a focus on variation on intermediate time scales (five to 10 years or longer). We need to identify and predict persistent environmental changes that directly or indirectly affect the productivity of living marine resources, and to adjust harvest strategies as necessary. Institutional arrangements fostering collaborative work between government and academic scientists have been integral to the success of the National Science Foundation/NOAA U.S. GLOBEC program and the NOAA Coastal Ocean

Program. This pooling of talent and capability should be encouraged.
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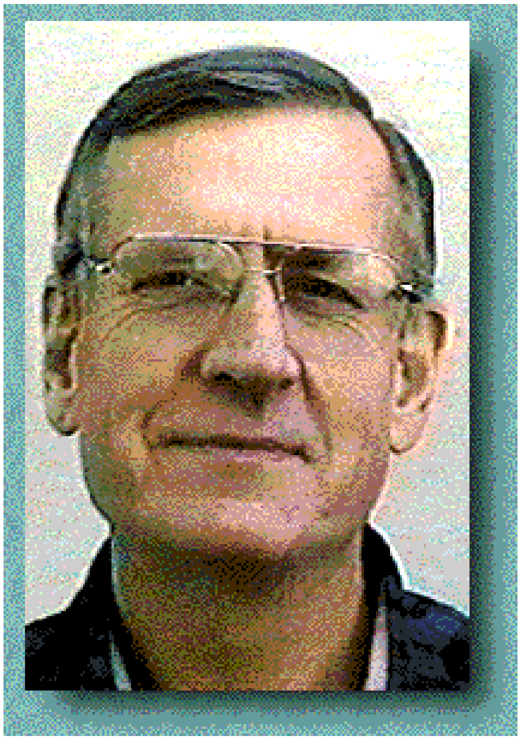


Donald R. Gunderson

Professor of Fisheries, College of Ocean and Fisheries Sciences, University of Washington.

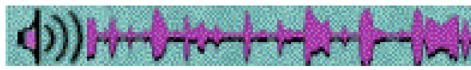
Dr. Gunderson's research and teaching span more than 30 years, during which he has concentrated on the biology, population dynamics, and management of marine fisheries. He has served 11 years with state and federal natural resource agencies, and for the past 20 as a professor of fisheries. His textbook, *Surveys of Fisheries Resources* , has been used widely both in the United States and abroad.

Response to Question 1

Response to Question 2

(top)

Question 1. Are we measuring or assessing the right attributes of exploited marine populations? Will new or incremental improvements in scientific information make a difference?

 Click here for audio response

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While a variety of ecosystem properties need to be examined in managing exploited populations, it is absolutely imperative that three of these be monitored accurately: abundance, annual removals (including discards and individuals killed incidental to fishing operations), and availability of critical habitat. At present, there are few cases in which these three elements are monitored adequately, and it is political will, rather than additional technology or scientific information, that can remedy this.
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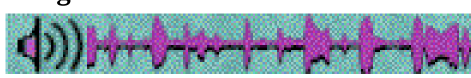
Question 2. Can you identify new technologies, any fundamental or applied science initiative(s), or evolving institutional arrangements that hold the promise of materially advancing our current capabilities in assessing and predicting the status of living marine resources?

 Click here for audio response

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New technologies and science initiatives will no doubt increase our effectiveness in assessing and predicting living marine resource status, but our main problem is that we have yet to implement current technology for many species and areas. We need to be sure that the bricks and mortar are in place before we worry about interior decoration! The expertise and manpower that exist within state agencies and universities are underutilized at present, largely due to budgetary limitations. Any institutional arrangements that would remedy this would be a step in the right direction.
(top)

Pamela Mace

Fisheries Scientist, National Marine Fisheries Service, NOAA, Woods Hole, Massachusetts

Dr. Mace's primary research during the last decade includes investigations into the population dynamics of marine fish stocks and analysis of alternative fisheries management strategies. Prior to her work with the National Marine Fisheries Service, she was involved in fisheries science and management in New Zealand, Australia and Canada.

Response to Question 1

Response to Question 2

(top)

Question 1. Are we measuring or assessing the right attributes of exploited marine populations? Will new or incremental improvements in scientific information make a difference?

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The overall objective in assessing the status of harvested marine populations is to estimate optimal long-term sustainable rates of harvest and to compare these to observed rates of harvest, to determine whether the observed rates need to be decreased, or should be allowed to increase. Therefore, the "right attributes" of these populations that need to be measured are those related to the harvest rates, population size, life history characteristics, and the social and economic characteristics of the fishing fleets that exploit or otherwise value the fish stocks.

With respect to measuring these attributes, the United States is a world leader. We collect catch statistics for most of our important fisheries. We have some of the longest, consistent time series of relative abundance data in the world, and have conducted considerable research on growth, mortality and spawning dynamics for many species.

New or incremental improvements in scientific information will certainly improve the credibility of the science; however, the validity of the science is not the major problem impeding the long-term sustainability of existing fisheries. The greatest impediment to the long-term sustainability of natural fishery resources is the lack of recognition of the limits of natural marine systems to provide both livelihoods and recreational opportunities to unlimited numbers of participants.
(top)

Question 2. Can you identify new technologies, any fundamental or applied science initiative(s), or evolving institutional arrangements that hold the promise of materially advancing our current capabilities in assessing and predicting the status of living marine resources?

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The United States is actively involved in many high-tech research endeavors related to fisheries research and management. In terms of evolving institutional arrangements, the United States has also been a pioneer in implementing a far-reaching public participation process for the development of fisheries management plans, and the integration of science into those plans. But unfortunately, the current institutional arrangements for fisheries management are still subject to immense political pressure, resulting from a reluctance to accept the fact that harvest rates of marine resources are already at or beyond the ability of many of our fishery resources to support such extraction rates on a sustainable basis. The task of NOAA's National Marine Fisheries Service, which provides both the science, and together with the Fishery Management Councils, the management strategies, has become very difficult. We need to balance many divergent opinions on what the overall objectives should be in

managing our natural resources, and how best to attain those objectives.
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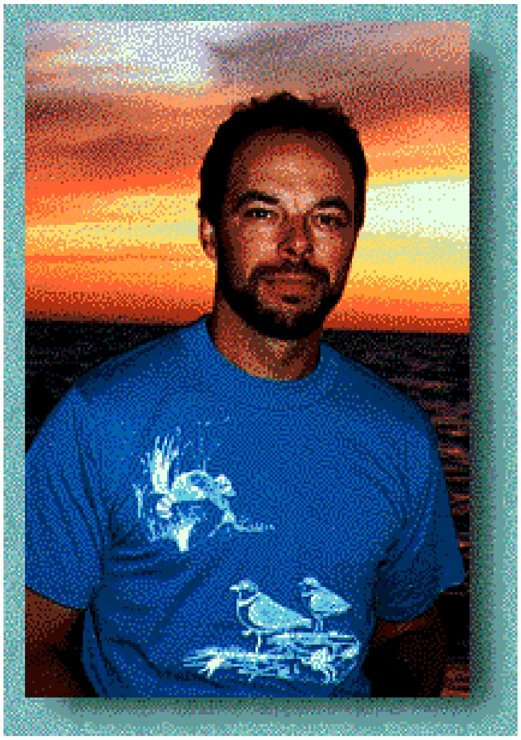

Carl Safina

Director, Living Oceans Program, National Audubon Society

Dr. Safina has authored 90 scientific and popular publications on the ecology and conservation of marine fishes. His book *Song for the Blue Ocean* , will be published in January 1998. He has served on the Mid-Atlantic Fishery Management Council, the Atlantic Tuna Commission, and the Smithsonian Institution's Ocean Planet Advisory Board. Dr. Safina is a lecturer at Yale University and a recipient of the Pew Charitable Trusts' Scholars Award in Conservation and the Environment.

Response to Question 1

Response to Question 2

(top)

Question 1. Are we measuring or assessing the right attributes of exploited marine populations? Will new or incremental improvements in scientific information make a difference?

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I believe we are measuring appropriate things like age structure and population trends. This information is enough to allow us to adapt and adjust our activities. With the information we've had, we could have managed much better than we have. But short-term political pressures and denial of the problems have overridden the prudent use of scientific information. Numerous times we have erred more in selfishness than ignorance, and in many cases we have paid a harsh price and inflicted a cost on young people coming of age in fishing communities.

We also have not done a good job of asking about the wider ecosystem effects of fishing. We have generally ignored the habitat damage done by certain fishing gear, such as bottom trawl nets. We have not asked how removing vast quantities of creatures like herring, mackerel and squid affects populations of predators, like tunas, that feed on them, and how these relationships should be factored into management. And we have hardly begun to appreciate these animals as the marvelous, highly evolved creatures that they are. I love fishing and I enjoy seafood, and I believe it's OK to use the ocean–but not to use it up. Will new improvements in scientific information make a difference? We have not really used what we already know, so new information will help only if we use what we learn because we have learned to care.
(top)

Question 2. Can you identify new technologies, any fundamental or applied science initiative(s), or evolving institutional arrangements that hold the promise of materially advancing our current capabilities in assessing and predicting the status of living marine resources?

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I do not believe our problems stem primarily from lack of information or insufficient knowledge. I know of no case in which a fishery problem took everyone by surprise. Many problems are a decade or two in the making and often subject to intense controversy, in which one side correctly warns of potential resource problems, and the other side dismisses them. We would benefit from better understanding of the population biology of exploited populations.

There is now increasing academic interest in marine communities and better tools. Recent advances in genetics and in high-tech, data-archiving and satellite-transmitting tags will allow us, for the first time, to really begin to understand the population structure of fishes over vast parts of their oceanic ranges, allowing us to make great strides in understanding how fish populations are configured and what the appropriate geographic scale of management needs to be for individual species and populations. Institutionally, there are more academic courses being taught that integrate biological understanding with the social and economic problems of management. And there is a growing awareness that concerted, creative synthesis of existing information will be a fertile avenue for research and analysis.

Changing awareness is also reflected in the overhaul of U.S. fisheries law in 1996, outlawing most overfishing and mandating recovery, and in the United Nation's high seas fisheries treaty, which is now in the process of ratification and which incorporates binding standards and formalizes the precautionary approach, instructing nations to be conservative when information is uncertain. Actually solving problems and restoring viable fisheries will remain quite difficult, but the formal recognition of the problems indicates a positive trend.
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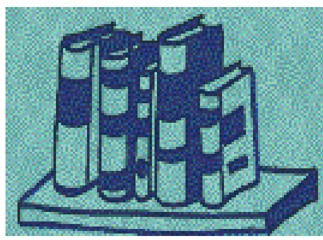

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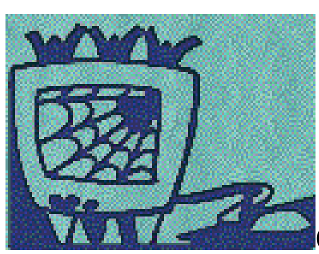

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Provides an economic overview of U.S. domestic fisheries. The principal focus is on commercial harvesting that targets wild stocks. Also included are sections describing recreational fisheries, commercial processing, international trade and retail sectors. Includes estimates of fishery stock productivity and status of resources through 1993. Assessments are drawn from results of field surveys, biological and physical studies, and independent monitoring of recreational, subsistence and commercial fisheries.

National Marine Fisheries Service. Fisheries of the United States 1996.

http://remora.ssp.nmfs.gov/fus/fus96/index.html

Preliminary annual report contains information on commercial and recreational fisheries of the United States and catches in both U.S. and foreign Exclusive Economic Zones. Includes U.S. commercial and recreational landings data, import/export data, employment data, prices, and production of processed products data.
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Internet Data Bases

National Marine Fisheries Service. Atlantic & Gulf Commercial Fishery Landings.

http://remora.ssp.nmfs.gov/commercial/landings/index.html

Provides access to weight and dollar value data of commercial fisheries landings. Searches by month, year, state and species can be made on a 1990 to 1996 data set. Annual landings can be searched by year, state or species on a 1950 to 1996 dataset. Additional searches by landing gear type and distance from shore can also be made.

Fisheries Status

Monterey Bay Aquarium. Fishing for Solutions: What's the Catch?

http://www.mbayaq.org/hp/hp_ffs1.htm

Provides succinct information and statistics about critical issues facing today's fisheries, including fishing pressure and effort, bycatch, and effects of population growth.
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The New Orleans Times-Picayune. Oceans of Trouble.

http://www.pulitzer.org/year/1997/public-service/works/

This comprehensive series of articles provides an examination of the conditions that threaten the world's supply of fish. Topics explored include overfishing, habitat destruction, fishing effort, effects of population, pollution and development, hypoxia, sport fisheries, aquaculture, and problems with regulation and fisheries management.

Fisheries Legislation

Congressional Research Service. Summaries of Major Laws Implemented by the National Marine Fisheries Service.

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The major laws implemented by NMFS organized into five categories: (1) ten laws for which Congress authorizes specific annual appropriations; (2) three laws for which Congress has permanently or indefinitely authorized appropriations; (3) ten laws implementing international treaties or agreements; (4) nine laws wherein NMFS provides consultation or acts as a trustee; and (5) five other laws. When the Secretary of Commerce is specifically authorized or directed to take action, NMFS has been delegated the authority to implement the provision or take specific action.

Northeast Region Fisheries

Northeast Fisheries Science Center Woods Hole Laboratory. Status of Fisheries Resources off Northeastern United States for 1994.

http://www.wh.whoi.edu/library/sos94/sos.html

Provides an overview of commercial and recreational fishery landing trends, aggregate resource trends, and fishery economic trends of the northeastern United States. Also includes detailed synopses of the status of the stocks of 39 species or groups of commercial and recreational harvested species from the fishery.

Western Pacific

Southwest Fisheries Science Center. Billfish Newsletter.

http://swfsc.ucsd.edu/billfish.html

Yearly newsletters (1995-1997) provide results of the International Billfish Angler Survey and the Cooperative Marine Game Fish Tagging Program. Included is information on total number of angler days, catch per unit effort, and catch rates. Emphasis is on billfish angling in the Pacific, Indo-Pacific and Indian Oceans. Also includes results of billfish tagging study.

Southwest Fisheries Science Center. Tuna Newsletter.

http://swfsc.ucsd.edu/tunanews.html

Quarterly newsletters (1995-1997) provide information on total receipts of tuna by U.S. canneries, broken down by region and species. Regional landings data and recent developments in tuna fisheries are also included.

National Marine Fisheries Service. Western Pacific Bottomfish and Armorhead Fisheries.

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Overview of the Western Pacific bottomfish and armorhead fisheries status. Provides brief information about species range and occurrence, landings trends, catch rates and stock assessments.

Alaska Walleye Pollock

Alaska Fisheries Science Center. Preliminary Results from the 1997 NMFS Surveys of Walleye Pollock in the Bering Sea.

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This technical paper presents the findings of a field study conducted in May 1988 to estimate mortality rates of individual cohorts of larval walleye pollock *Theragra chalcogramma* in Shelikof Strait, Gulf of Alaska. Includes an introduction, methods, results, discussion and references.

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http://earth.agu.org/revgeophys/schuma01/schuma01.html

Provides overview and results of studies to understand natural fluctuations in year-class strength of pollock and to provide information to reduce uncertainty in status-of-pollock-stock models.

Red Drum

V. N. Stewart. Sea-Stats No. 15 - Red Drum/Redfish. Florida Department of Natural Resources Division of Marine Resources, Florida Marine Research Institute.

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Provides a thorough summary of information and statistics on red drum. Contains information on classification, habitat, distribution, life history, migration, feeding, parasites and diseases, fishing methods and regulations, farming potential and economic importance. Also includes a glossary and references.
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APPENDICES

Appendix A. Regional Productivity of Fisheries Resources Utilized by the United States

Appendix B. Status of Utilization Levels of U.S. Living Marine Resources, 1992-94

Appendix C. Productivity of Fisheries Resources by Region, 1992-94

Appendix A

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Regional Productivity of Fisheries Resources Utilized by the United States

Productivity indicators are expressed in metric tons by long-term potential yield (LTPY), current potential yield (CPY), and recent average yield (RAY, 1992-1994). Unknown row totals are substituted as in Table 1.

	ENTIRE RANGE OF STOCK			PRORATED WITHIN U.S. EEZ	
Region	**Total RAY**	**Total CPY**	**Total LTPY**	**U.S. RAY**	**U.S. LTPY**
Northeast	777,856	1,330,456	1,289,420	449,734	844,808
Southeast	1,168,531	1,169,346	1,474,344	1,168,531	1,474,344
Alaska	2,732,298	4,025,140	4,423,674	2,733,298	4,423,674
Pacific Coast	462,759	609,948	1,116,207	462,759	1,116,207
Western Pacific Oceanic	2,079,283	2,005,440	2,038,099	242,489	283,338
TOTAL	**7,220,727**	**9,140,330**	**10,341,744**	**5,056,811**	**8,142,371**

Source: National Oceanic and Atmospheric Administration (NOAA). 1996. *Our living oceans: Report on the status of U.S. living marine resources, 1995* . NOAA Tech. Memo. NMFS-F/SPO-19. 160 p.

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Appendix B

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Status of Utilization Levels of U.S. Living Marine Resources, 1992-94

	DEGREE OF FISHERIES UTILIZATION OF THE RESOURCE				
Unit/Fishery	**Under**	**Full**	**Over**	**Unknown**	**Total**
1. Northeast demersals	2	4	18	1	25
2. Northeast pelagics	4	1	1	0	6
3. Atlantic anadromous	0	2	3	0	5
4. Northeast invertebrates	0	3	2	1	6
5. Atlantic highly migratory pelagics	0	4	4	2	10
6. Atlantic sharks	0	1	1	1	3
7. Atlantic/Gulf of Mexico coastal migratory pelagics	1	2	1	3	7
8. Atlantic/Gulf of Mexico reef fish	0	2	10	16	28
9. Southeast drum and croaker	0	0	3	4	7
10. Southeast menhaden	0	2	0	0	2
11. Southeast/Caribbean invertebrates	0	7	2	5	14
12. Pacific coast salmon	0	3	2	0	5
13. Alaska salmon	0	5	0	0	5
14. Pacific coast and Alaska pelagics	1	6	0	0	7
15. Pacific coast groundfish	5	9	3	2	19
16. W. Pacific invertebrates	0	0	1	0	1
17. W. Pacific bottomfish and armorhead	3	0	3	0	6
18. Pacific highly migratory pelagics	4	2	2	7	15
19. Alaska groundfish	10	13	0	2	25

20. Alaska shellfish	1	4	0	0	5
21. Nearshore species	3	24	7	40	74
Subtotal of Units 1-20	**31**	**70**	**56**	**44**	**201**
% of Subtotal	**15%**	**35%**	**28%**	**22%**	
% of 157 "known" stock groups	**20%**	**44%**	**36%**		
Total of Units 1-21	**34**	**94**	**63**	**84**	**275**
% of Total	**12%**	**34%**	**23%**	**31%**	
% of 191 "known" stock groups	**18%**	**49%**	**33%**		

Source: National Oceanic and Atmospheric Administration (NOAA). 1996. *Our living oceans: Report on the status of U.S. living marine resources, 1995* . NOAA Tech. Memo. NMFS-F/SPO-19. 160 p.

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Appendix C

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Productivity of Fisheries Resources by Region, 1992-94

Northeast | Southeast, Gulf of Mexico, Caribbean | Alaska | Pacific Coast | Western Pacific Ocean

Productivity indicators are expressed in metric tons by long-term potential yield (LTPY), current potential yield (CPY), and recent average yield (RAY).[1]

Northeast Region

	ENTIRE RANGE OF RESOURCE			PRORATED WITHIN U.S. EEZ	
Unit/Fishery	**Total RAY**	**Total CPY**	**Total LTPY**	**U.S. RAY**	**U.S. LTPY**
1. Northeast demersals	185,535	183,735	479,335	145,900	402,365
2. Northeast pelagics	165,800	724,300	412,000	115,600	253,920
3. Atlantic anadromous	4,836	4,836	4,836	4,836	4,836
4. Northeast invertebrates	99,500	99,900	72,500	93,568	89,357
5. Atlantic highly migratory pelagics	246,955	242,455	245,519	14,600	19,100
21. Northeast nearshore species	75,230	75,230	75,230	75,230	75,230
Northeast Total	777,856	1,330,456	1,289,420	449,734	844,808

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Southeast/Gulf of Mexico/Caribbean Region

	ENTIRE RANGE OF RESOURCE			PRORATED WITHIN U.S. EEZ	
Unit/Fishery	**Total RAY**	**Total CPY**	**Total LTPY**	**U.S. RAY**	**U.S. LTPY**
6. Atlantic Sharks	9,324	9,213	10,240	9,324	10,240

7. Atlantic/Gulf of Mexico coastal migratory pelagics	17,884	20,127	26,236	17,884	26,236
8. Atlantic/Gulf of Mexico reef fish	31,225	30,750	43,158	31,225	43,158
9. Southeast drum & croaker	16,785	16,785	68,715	16,785	68,715
10. Southeast menhaden	890,000	890,000	1,140,000	890,000	1,140,000
11. Southeast/Caribbean invertebrates	112,483	111,641	95,165	112,483	95,165
21. Southeast nearshore species	90,830	90,830	90,830	90,830	90,830
Southeast Total	1,168,531	1,169,346	1,474,344	1,168,531	1,474,344

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Alaska Region

	ENTIRE RANGE OF RESOURCE			PRORATED WITHIN U.S. EEZ	
Unit/Fishery	**Total RAY**	**Total CPY**	**Total LTPY**	**U.S. RAY**	**U.S. LTPY**
13. Alaska Salmon	364,800	296,500	296,500	364,800	296,500
14. Alaska herring	52,900	55,200	55,200	52,900	55,200
19. Alaska groundfish					
Bering Sea/Aleutian Islands	1,902,402	3,025,385	3,483,785	1,902,402	3,483,785
Gulf of Alaska	249,582	492,240	451,440	249,582	451,440
Halibut (Alaska)	34,700	26,900	19,800	34,700	19,800
20. Alaska shellfish	125,744	125,745	113,779	125,744	113,779
21. Alaska nearshore species	3,170	3,170	3,170	3,170	3,170
Alaska Total	2,733,298	4,025,140	4,423,674	2,733,298	4,423,674

(top)

Pacific Coast Region

Unit/Fishery	ENTIRE RANGE OF RESOURCE			PRORATED WITHIN U.S. EEZ	
	Total RAY	Total CPY	Total LTPY	U.S. RAY	U.S. LTPY
12. Pacific coast salmon	22,957	33,312	33,312	22,957	33,312
14. Pacific coast pelagics	63,900	110,900	503,900	63,900	503,900
15. Pacific coast groundfish	262,657	352,491	465,750	262,657	465,750
19. Halibut (Pacific Coast)	200	300	200	200	200
21. Pacific coast nearshore species	113,245	113,245	113,245	113,245	113,245
Pacific Coast Total	462,959	610,248	1,116,407	462,959	1,116,407

(top)

Western Pacific Ocean Region

Unit/Fishery	ENTIRE RANGE OF RESOURCE			PRORATED WITHIN U.S. EEZ	
	Total RAY	Total CPY	Total LTPY	U.S. RAY	U.S. LTPY
16. W. Pacific invertebrates	143	106	135	143	135
17. W. Pacific bottomfish & armorhead	388	626	2,738	388	2,738
18. Pacific highly migratory pelagics	2,077,232	2,003,188	2,033,706	240,438	278,945
21. W. Pacific nearshore species	1,520	1,520	1,520	1,520	1,520

Western Pacific Total	2,079,283	2,005,440	2,038,099	242,489	283,338

[1]For row totals; where LTPY is unknown, CPY is substituted; where CPY is unknown, RAY is substituted.

RAY is generally for the latest 3-year average, 1992-94.

Source: National Oceanic and Atmospheric Administration (NOAA). 1996. *Our living oceans: Report on the status of U.S. living marine resources, 1995* . NOAA Tech. Memo. NMFS-F/SPO-19. 160 p.

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GLOSSARY

anadromous: pertaining to fish that spend most of their life in the sea and migrate to fresh water to spawn. Examples include Pacific and Atlantic salmon, American shad and striped bass.

catadromous: pertaining to fish that spend most of their life in fresh water and migrate to saltwater to spawn. The American eel is a noted example.

commercial fishery (*see also* **fishery):** the industry of catching a certain species for sale.

current potential yield (CPY): the current potential catch that can be taken, depending on the current resource abundance and prevailing ecosystem considerations. This term is analogous to the acceptable biological catch (ABC) that is specified in some fishery management plans.

demersal: pertaining to fish (also known as groundfish) that live near the bottom of an ocean, river or lake; also refers to eggs that are denser than water and sink to the bottom after spawning.

Endangered Species Act of 1973 (ESA): Federal law that provides for the conservation of endangered and threatened species of fish, wildlife, and plants. Several stocks of Pacific salmon (*Onchorhynchus* sp.) are now listed or are proposed for listing under the ESA.

estuarine dependent: pertaining to the many species of fish, crustaceans and mollusks that utilize estuarine habitats for all or part of their life cycle and, therefore, depend on estuaries to maintain stock productivity. Examples include the oyster, blue crab, penaeid shrimp and red drum.

estuary: a semi-enclosed body of water with an open connection to the sea. Typically, there is a mixing of sea and fresh water, and the influx of nutrients from both sources results in high productivity.

fishery: the act, process and industry of catching fish, crustaceans, mollusks or other aquatic animals. A fishery can be for commercial, recreational, subsistence or aesthetic purposes.

fishery management council (FMC): one of the eight regional fishery management councils were established by the Magnuson Act: New England, Mid-Atlantic, South Atlantic, Gulf of Mexico, Caribbean, Pacific, North Pacific, and Western Pacific.

fishery management plan (FMP): a plan developed by a regional fishery management council, or by the U.S. Secretary of Commerce under certain circumstances, to manage a fishery resource in federal waters of the U.S. EEZ.

groundfish: fish species that live on or near the bottom, also called bottomfish; includes many species in the cod family (Gadidae).

growth overfishing: a type of overfishing in which the loss in weight of a stock from mortality exceeds the gain in weight due to growth.

long-term potential yield (LTPY): the maximum long-term average catch that can be achieved from the resource. This term is analogous to the concept of maximum sustainable yield (MSY).

Magnuson-Stevens Act: Federal Public Law 94-265, as amended through October 11, 1996. Also known as the Magnuson Act, Magnuson Fishery Conservation and Management Act, or MFCMA, it mandates a national program for conserving and managing fisheries to allow for an optimum yield on a continuing basis, and to realize the full potential of the Nation's fishery resources. It establishes eight regional fishery management councils that develop fishery management plans for harvested species.

marine fisheries commission: one of three interstate marine fisheries commissions (Atlantic States, Gulf States, Pacific States) that work cooperatively with individual states to manage fisheries in state territorial marine and estuarine waters. For example, the Gulf States Marine Fisheries Commission has published fishery management plans for the blue crab, oyster, gulf menhaden, black drum, striped mullet, and Spanish mackerel in the Gulf of Mexico.

mixed stock fishery (*see also* **fishery** *and* **stock**)**:** a fishery in which more than one stock, species or population of fishes and/or invertebrates are intentionally or inadvertently caught in significant numbers.

pelagic: pertaining to the water column; refers to fishes that live in the open sea, not near the bottom or shore.

recent average yield (RAY): equivalent to the recent average catch. Unless otherwise designated, RAY is the reported fishery landings averaged for the 3-year period, 1992-1994.

recreational fishery: a fishery undertaken by individuals as a leisure or sport activity, and not for profit. Catch-and-release practices may result in nonconsumptive use of the resource.

recruitment: the number of fish added to a fishable stock each year through reproduction, growth and migration; also refers to the number of fish entering the spawning stock, or the number of fish from a year class reaching a certain age.

recruitment overfishing: a type of overfishing that results in greatly reduced spawning stock, a decreased proportion of older fish in the spawning stock, and repeated years of low recruitment.

status of resource utilization: the level of fishery use of the resource (i.e., underutilized, fully utilized, overutilized, or unknown). It shows how the existing fishing effort compares with those levels necessary to achieve LTPY.

stock: a biologically distinct and interbreeding population within a species of aquatic animals, such as fish, crustaceans, or mollusks. Since stocks may intermix in the marine environment, some fisheries intentionally or inadvertently catch more than one stock, and are therefore known as "mixed-stock" or "mixed-species fisheries."

stock level relative to LTPY: a measure of stock status. The present abundance level of the stock is compared with the level of abundance that on average would support the LTPY harvest. This level is expressed as below, near, above, or unknown relative to the abundance level that would produce LTPY.

subsistence fishery: a fishery in which the harvested resource is used directly by the fisher without sale for profit; not considered a leisure or sporting activity.

Sustainable Fisheries Act (SFA): federal law enacted on October 11, 1996 to amend the Magnuson Fishery Conservation and Management Act (renamed the Magnuson-Stevens Fishery Conservation and Management Act). SFA amendments and changes to the Magnuson Act include numerous provisions requiring science, management and conservation action by NOAA's National Marine Fisheries Service (NMFS). NOAA/NMFS is mandated to implement these changes and amendments by December 1998.

threatened or endangered: terms defined under the Federal Endangered Species Act (ESA). A species is considered endangered if it is in danger of extinction throughout a significant portion of its range; it is threatened if it is likely to become an endangered species. Several stocks of Pacific salmon are listed under the ESA.

U.S. Exclusive Economic Zone (EEZ): a zone of marine waters extending from the U.S. territorial sea to 200 nautical miles offshore, considered federal waters.

U.S. territorial sea: a zone extending to 3 nm from the shoreline of most states, the exceptions being the Gulf coasts of Texas and Florida, where it extends 9 nm offshore.. These coastal waters are considered state waters, and fisheries within them are generally managed by individual states and cooperative interstate marine fisheries commissions.
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Acknowledgments

The work of countless scientists and technicians who collect the data, perform analyses, and report their findings provides the data bases and information sets that form the basis for much of the material presented here. Our thanks and appreciation to these unnamed contributors and their sponsoring institutions. Special thanks are due to Don Gunderson, Pamela Mace and Carl Safina for their review of this manuscript.
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Photo Credits

Many of the photos were gathered from NOAA archives or were generously provided from the personal collections of NOAA staff members.

Two were contributed from outside NOAA, and we gratefully thank the following individual and organization:

Photo 2. Ms. Moon T. Tran, U.S. Office of Management and Budget
Photo 9. Chesapeake Bay Foundation
(top)

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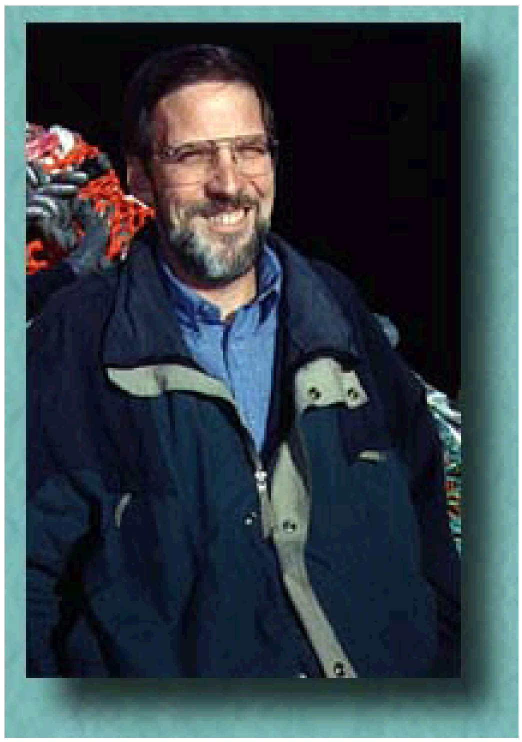
Allen Shimada is a second-generation fishery biologist with 20 years experience in stock assessment surveys and field research in Bering Sea and North Pacific waters. Now with the Office of Science and Technology, NOAA National Marine Fisheries Service, Mr. Shimada has been a principal editor of Our Living Oceans since 1991. He is a graduate of Northwestern University, and the Schools of Fisheries and Marine Affairs, University of Washington.

Vidar Wespestad is president of Resource Analysts, International, a consulting firm engaged in global marine resource assessment. From 1977 to 1997 he was a fishery research biologist with the Alaska Fisheries Science Center. At the time of his retirement from government service, Dr. Wespestad was leader of the Bering Sea stock assessment group. He is a recipient of the American Fisheries Society's Distinguished Service Award for organizing and co-chairing the First World Fishery Congress, and has held fellowships from the Norwegian Fishery Research Council, the Norwegian Marshall Fund, and the Rockefeller Foundation. He received his Ph.D. in fisheries from the University of Washington in 1990.



Loh-Lee Low has 23 years of government service with the National Marine Fisheries Service. He is a fishery research biologist and deputy division director at the Alaska Fisheries Science Center. Dr. Low chairs the Bering Sea/Aleutians groundfish plan team of the North Pacific Fishery Management Council and serves as a technical liaison between fishery science and its application in management. He also serves as a senior scientist-advisor on a number of international fisheries commissions, including the International Pacific Halibut Commission, the North Pacific Anadromous Fish Commission, and the Convention for the Conservation of Pollock Resources in the Central Bering Sea. He received his Ph.D. in fisheries from the University of Washington in 1974.

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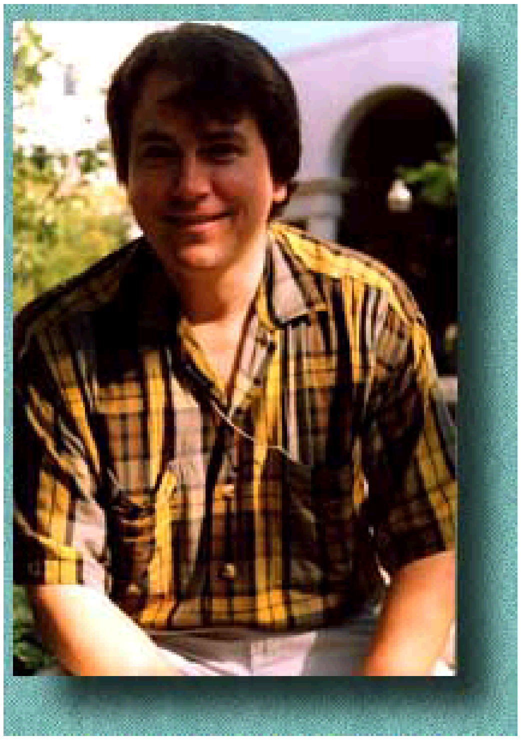

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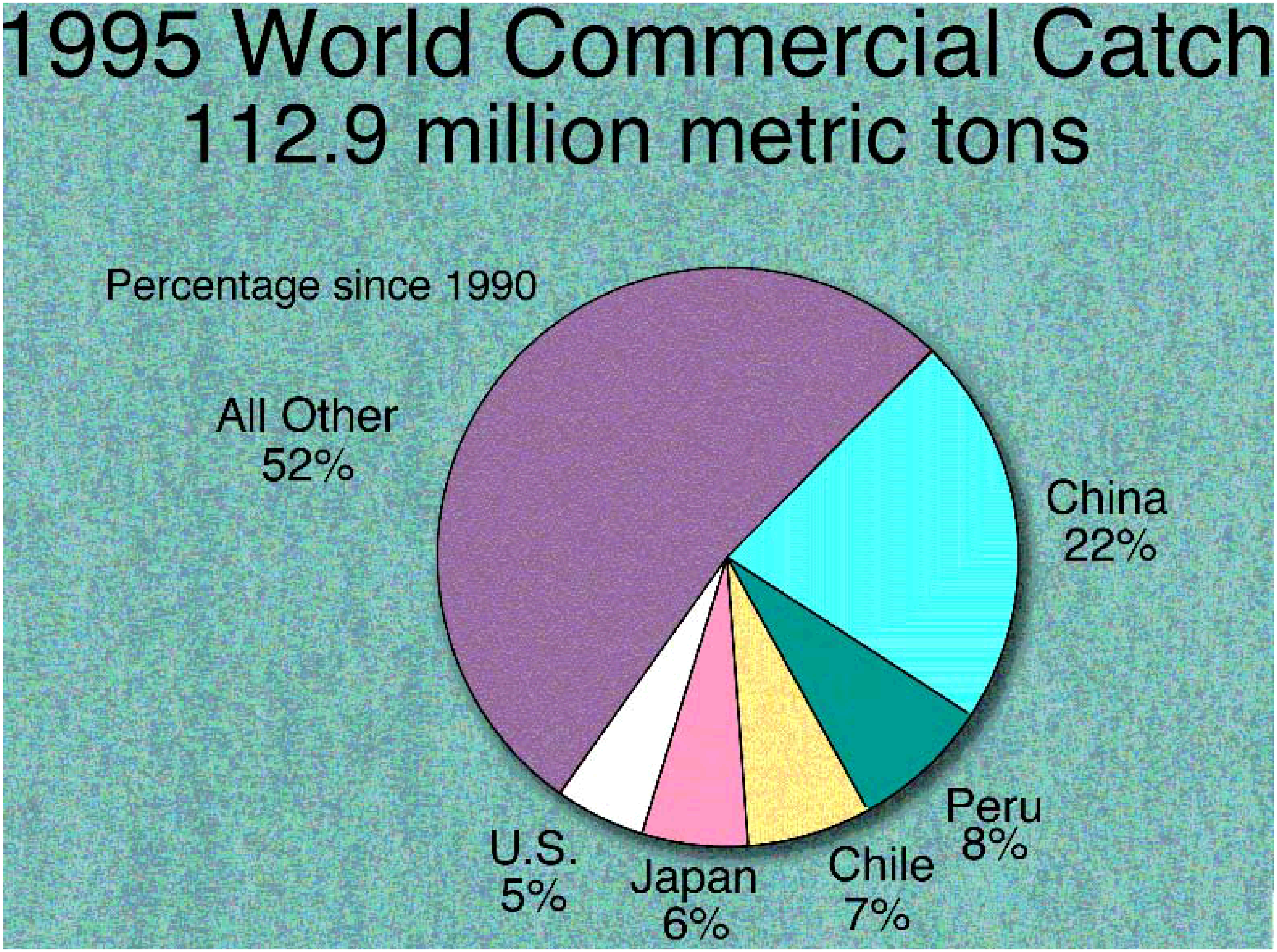

Figure 1. Top five countries in world commercial fisheries production.

Source: Food and Agriculture Organization

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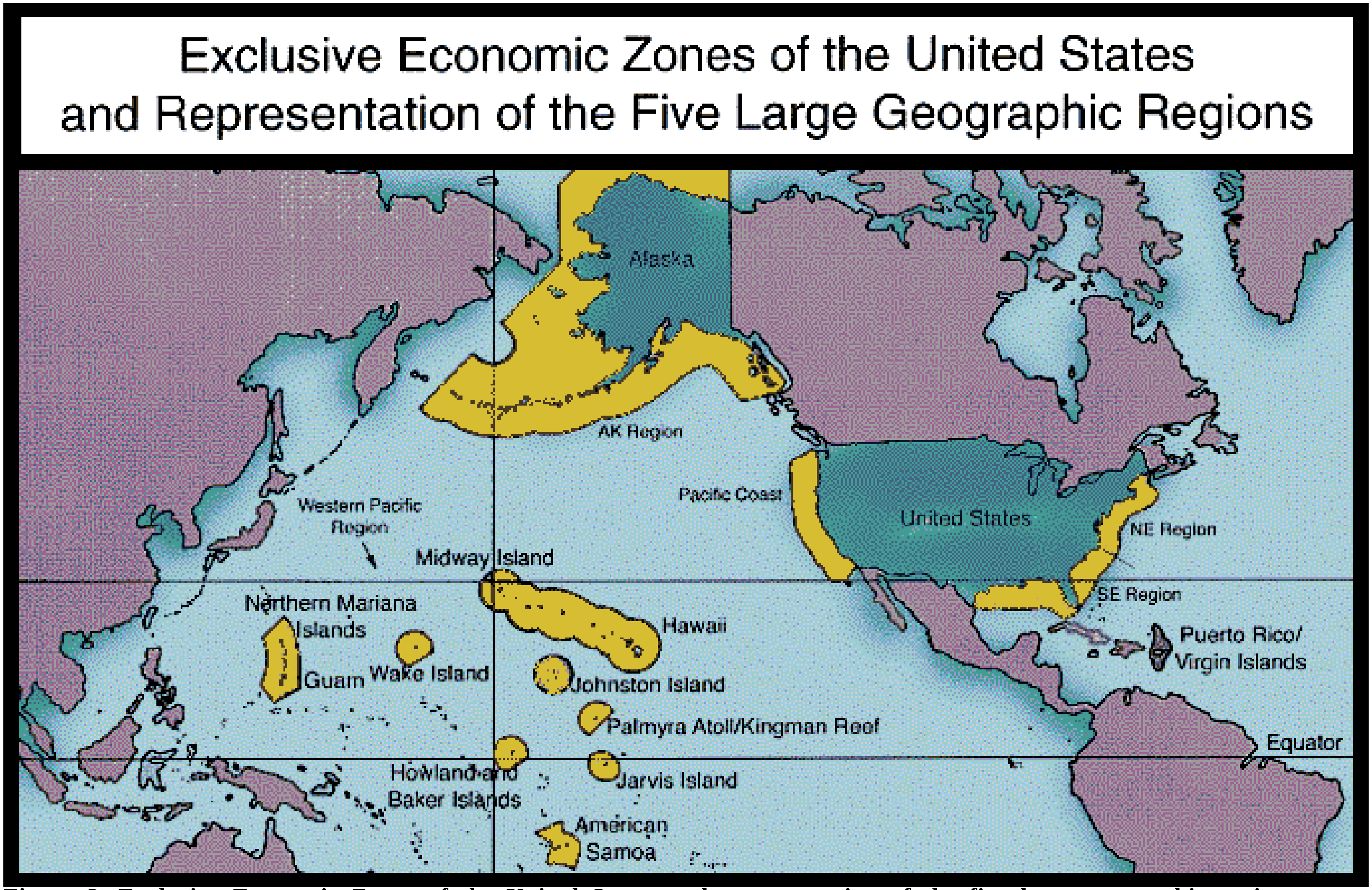

Figure 2. Exclusive Economic Zones of the United States and representation of the five large geographic regions.

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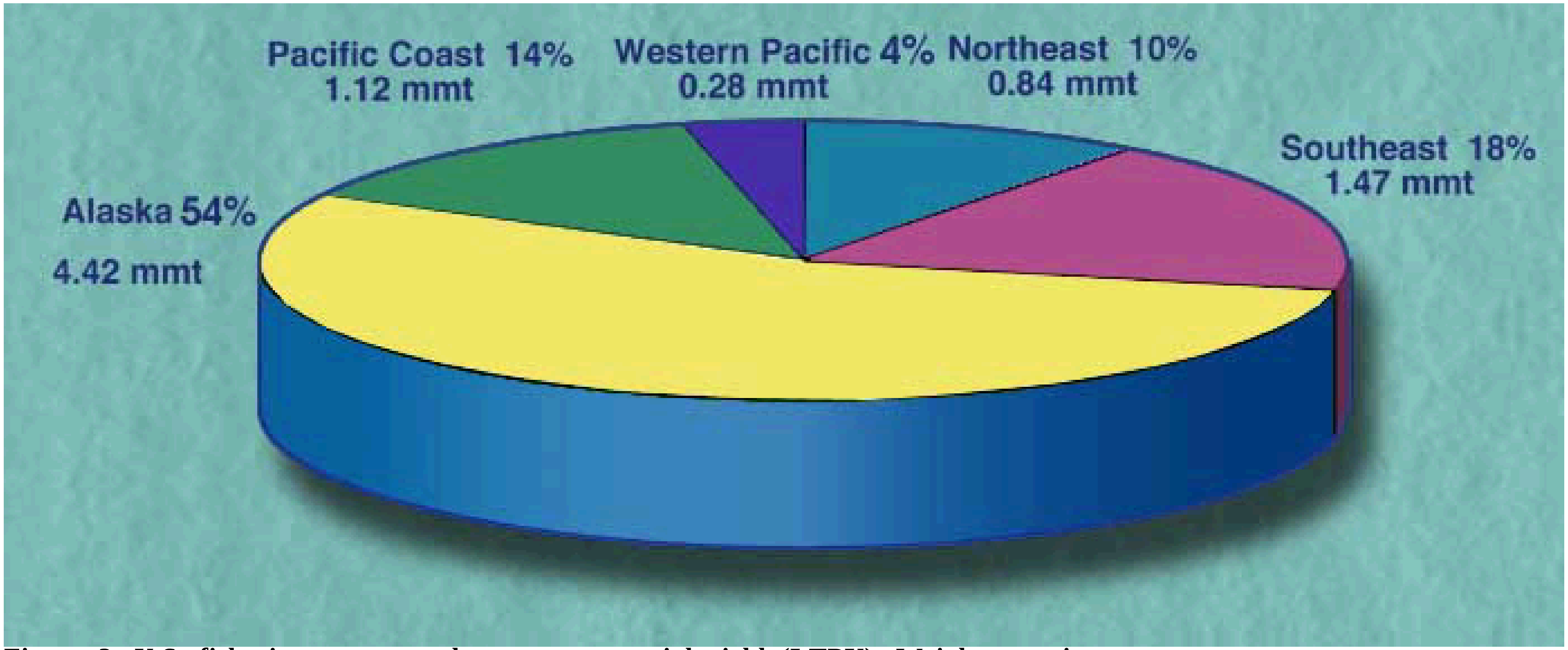

Figure 3. U.S. fisheries resources, long-term potential yield (LTPY). Weights are in million metric tons (mmt). U.S. long-term potential yield is 8.14 mmt.

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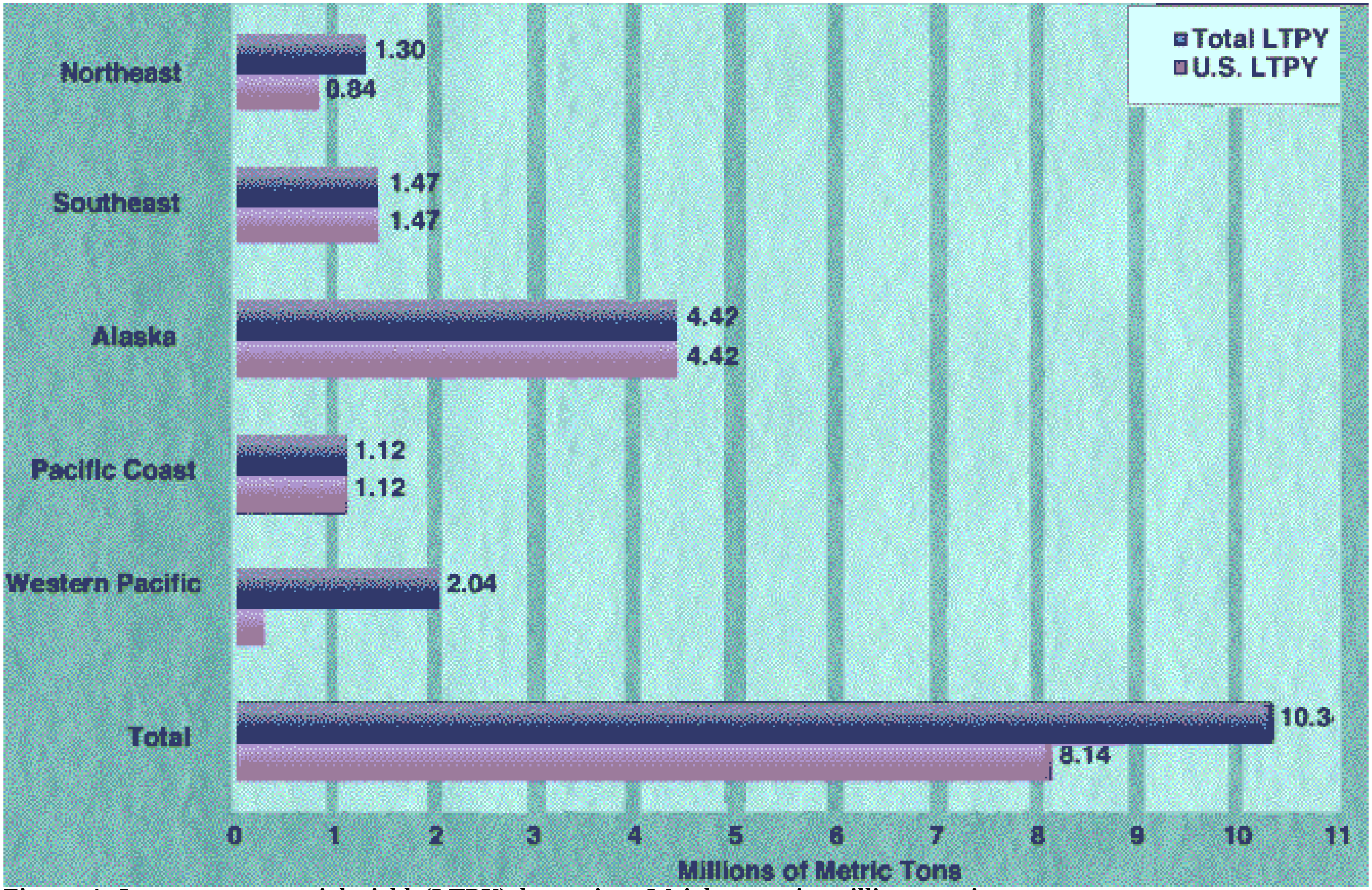

Figure 4. Long-term potential yield (LTPY) by region. Weights are in million metric tons. Total LTPY is the sum of U.S. and international LTPY.

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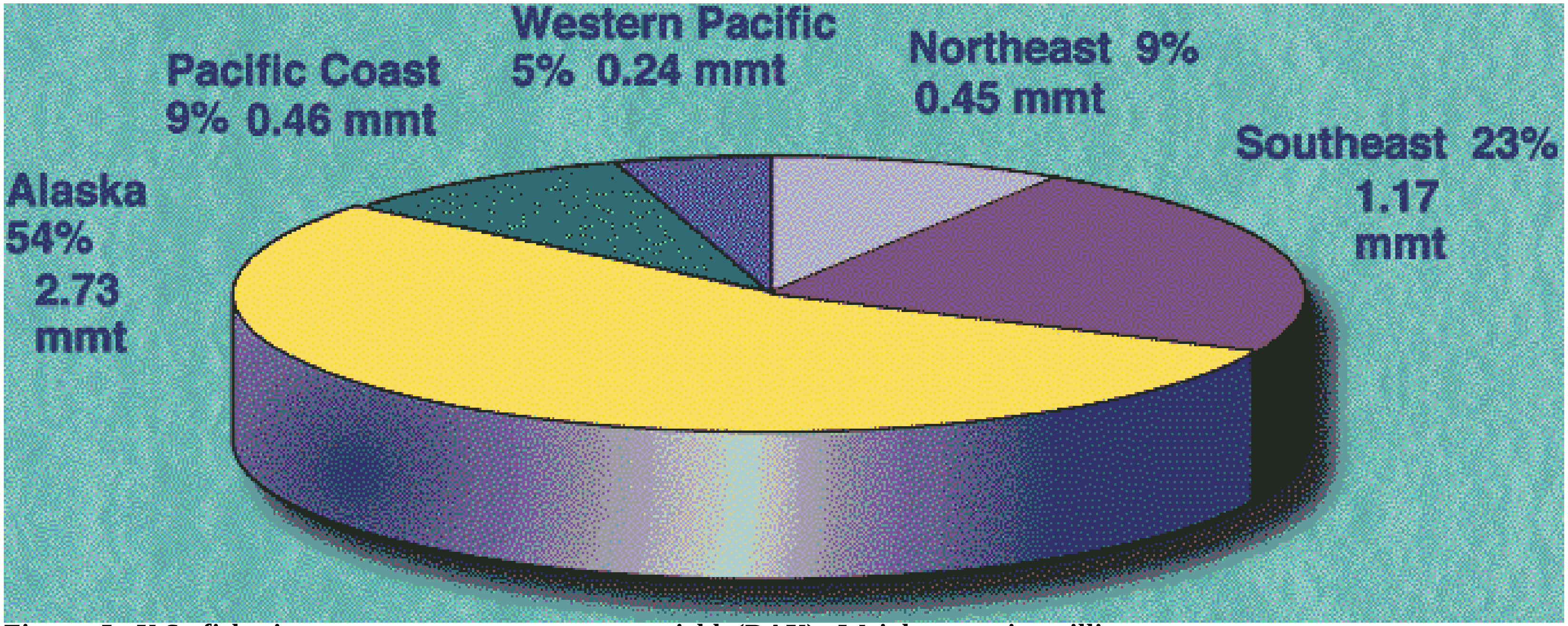

Figure 5. U.S. fisheries resources, recent average yield (RAY). Weights are in million metric tons (mmt). U.S. recent average yield (1992-1994) is 5.06 mmt.

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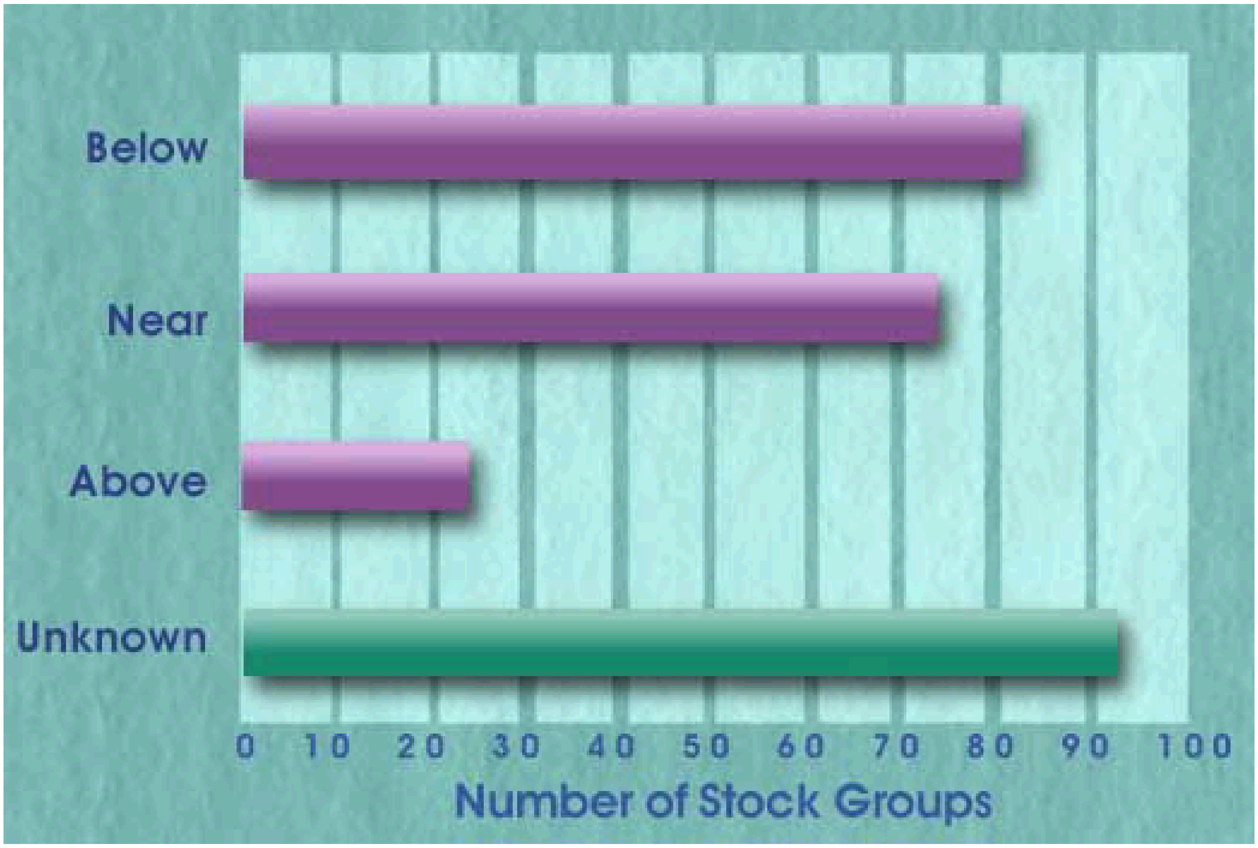

Figure 6. Status of U.S. fisheries stocks relative to their abundance that would produce long-term potential yield. Total number of stock groups is 275, including 74 nearshore (state-managed) and 201 offshore (federally-managed) stock groups.

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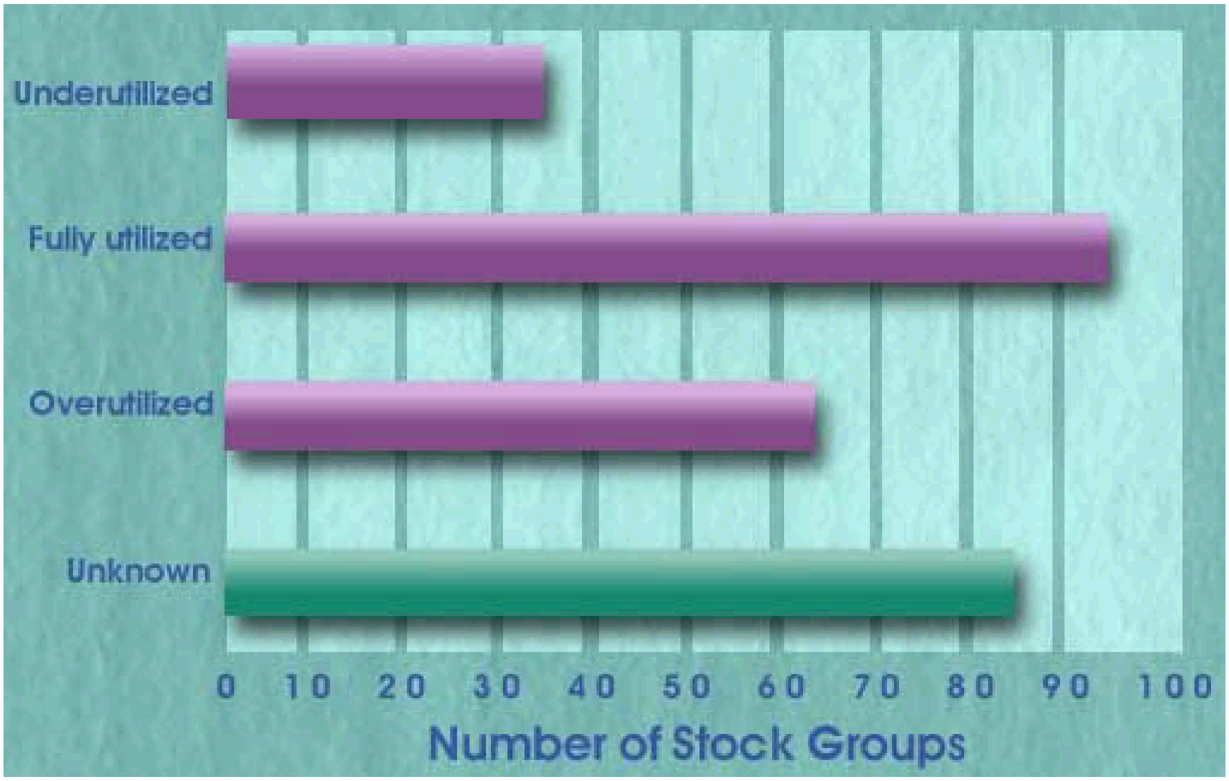

Figure 7. Status of utilization of U.S. fisheries resources. Total number of stock groups is 275, including 74 nearshore (state-managed) and 201 offshore (federally-managed) stock groups.

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Table 1. Productivity of Fisheries Resources Utilized by the United States

Productivity indicators are expressed in metric tons by long-term potential yield (LTPY), current potential yield (CPY), and recent average yield (RAY) [1]

	ENTIRE RANGE OF STOCK			PRORATED WITHIN U.S. EEZ	
Unit / Fishery	**Total RAY**	**Total CPY**	**Total LTPY**	**U.S. RAY**	**U.S. LTPY**
1. Northeast demersals	185,535	183,735	479,335	145,900	402,365
2. Northeast pelagics	165,800	724,300	412,000	115,600	253,920
3. Atlantic anadromous	4,836	4,836	4,836	4,836	4,836
4. Northeast invertebrates	99,500	99,900	72,500	93,568	89,357
5. Atlantic highly migratory pelagics	246,955	242,455	245,519	14,600	19,100
6. Atlantic sharks	9,324	9,213	10,240	9,324	10,240
7. Atlantic/Gulf of Mexico coastal migratory pelagics	17,884	20,127	26,236	17,884	26,236
8. Atlantic/Gulf of Mexico reef fish	31,225	30,750	43,158	31,225	43,158
9. Southeast drum & croaker	16,785	16,785	68,715	16,785	68,715
10. Southest menhaden	890,000	890,000	1,140,000	890,000	1,140,000
11. Southeast/Caribbean invertebrates	112,483	111,641	95,165	112,483	95,165
12. Pacific coast salmon	22,957	33,312	33,312	22,957	33,312
13. Alaska salmon	364,800	296,500	296,500	364,800	296,500
14. Pacific coast & Alaska pelagics	116,800	166,100	559,100	116,800	559,100
15. Pacific coast groundfish	262,657	352,491	465,750	262,657	465,750
16. W. Pacific invertebrates	143	106	135	143	135
17. W. Pacific bottomfish & armorhead	388	626	2,738	388	2,738
18. Pacific highly migratory pelagics	2,077,232	2,003,188	2,033,706	240,438	278,945
19. Alaska groundfish	2,186,684	3,544,525	3,955,025	2,186,684	3,955,025
20. Alaska shellfish	125,744	125,745	113,779	125,744	113,779

21. Nearshore species	283,995	283,995	283,995	283,995	283,995
Total	**7,221,727**	**9,140,330**	**10,341,744**	**5,056,811**	**8,142,371**

[1] For row totals; where LTPY is unknown, CPY is substituted; where CPY is unknown, RAY is substituted. RAY is generally for the latest 3-year average, 1992-94.

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