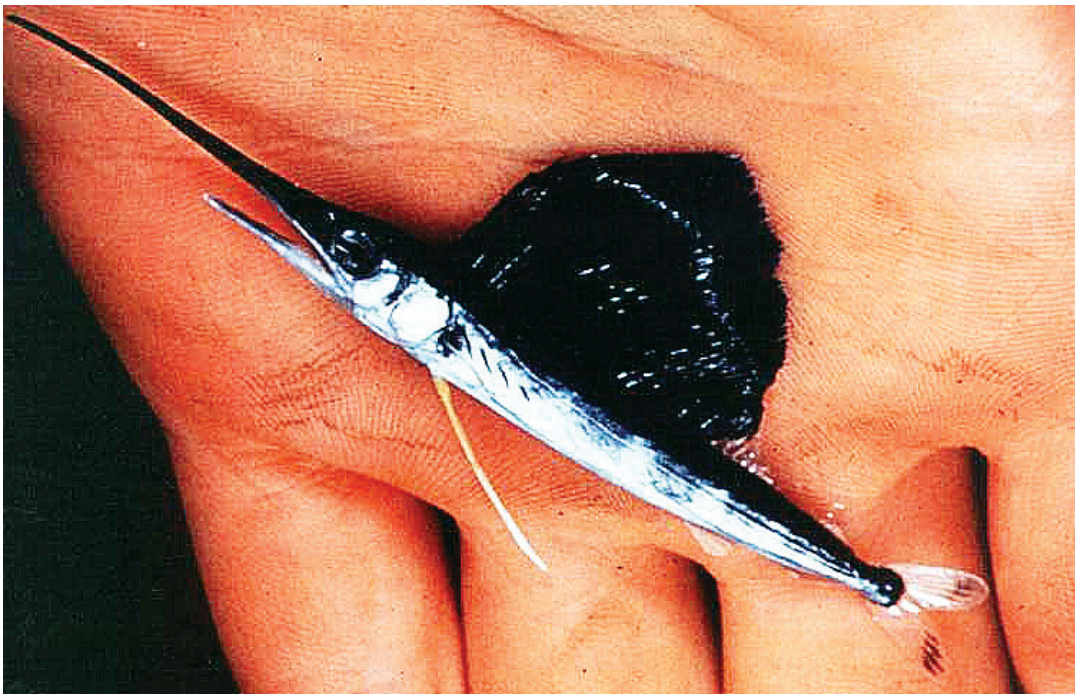
# Pacific Highly Migratory Pelagic Fisheries



SEFSC Pascagoula Laboratory

Unit
18

**JOHN CHILDERS**

**GARY SAKAGAWA**

NMFS Southwest Fisheries Science Center

La Jolla
California

**KEITH BIGELOW**

NMFS Pacific Islands Fisheries Science Center

Honolulu
Hawaii

Photo above:
Very young sailfish collected on a NMFS research cruise.

## INTRODUCTION

Adult fishes in this group are large pelagic predators found primarily in oceanic waters across the Pacific Ocean, from the tropics to temperate latitudes. Many of these fishes routinely travel great distances performing trans-Pacific migrations, crossing the waters of several nations and the high seas in their pursuit of forage and ideal habitat for reproduction. Collectively referred to as highly migratory species, these fishes include yellowfin tuna, skipjack tuna, bigeye tuna, albacore, blue marlin, swordfish, dolphinfish (mahi mahi), large pelagic sharks, and others. Many are valuable and highly prized by both commercial and sport fishermen. The status of most tuna stocks is relatively well known, while the status of many stocks of the other species is either uncertain or unknown (Table 18-1).

Fleets belonging to coastal and distant-water fishing nations target highly migratory species throughout the Pacific Ocean. Some of the fleets are capable of operating across the Pacific as well as in other oceans during a single fishing season. These fleets use larger purse-seine nets or longline gear, and the vessels have fish-holding capacities of several hundred to 2,000 metric tons (t) each. Other small fleets operate only in coastal waters with handline, troll, gillnet, harpoon, and longline gears and produce fresh fish for local economies and for subsistence use. Several Pacific Island communities and nations also depend on highly migratory species for income, largely from the sale of fishing access licenses to foreign tuna fishermen.

**Table 18-1**
Productivity in metric tons (t) and status of Pacific highly migratory pelagic fisheries resources.

| Species/stock | Recent average yield (RAY)[1] | Current yield (CY) | Sustainable yield (MSY) | Stock level relative to $B_{MSY}$ | Harvest rate | Stock status |
|---|---|---|---|---|---|---|
| **Tropical tunas** | | | | | | |
| Bigeye tuna | | | | | Overfishing | Not overfished |
| Eastern Pacific[2] | 109,987 | 103,322 | 81,350 | Below | | |
| Central Western Pacific[3] | 130,836 | 114,247 | 87,000 | Above | | |
| Skipjack tuna | | | | | | |
| Eastern Pacific[4] | 274,974 | 322,004 | Unknown | Unknown | Not overfishing | Not overfished |
| Central Western Pacific[5] | 1,494,421 | 1,538,112 | 2,700,000 | Above | Not overfishing | Not overfished |
| Yellowfin tuna | | | | | | |
| Eastern Pacific[6] | 252,412 | 174,780 | 285,000 | Near | Overfishing | Not overfished |
| Central Western Pacific[7] | 399,378 | 399,828 | 554,000 | Above | Not overfishing | Not overfished |
| Subtotal, tropical tunas | 2,662,008 | 2,652,293 | 4,029,354 | | | |
| **Temperate tunas** | | | | | | |
| Albacore | | | | | | |
| North Pacific[8] | 74,013 | 67,541 | Unknown | Near | Unknown | Unknown |
| South Pacific[9] | 37,602 | 32,108 | 117,000 | Unknown | Not overfishing | Not overfished |
| Pacific bluefin tuna (Pacific)[10] | 25,100 | 24,196 | Unknown | Unknown | Unknown | Unknown |
| Subtotal, temperate tunas | 136,715 | 123,845 | 208,737 | | | |
| **Billfishes** | | | | | | |
| Black marlin (Pacific) | 1,705 | 1,705 | Unknown | Unknown | Unknown | Unknown |
| Blue marlin (Pacific) | 17,369 | 17,369 | 17,369 | Near | Not overfishing | Not overfished |
| Sailfish (Pacific) | 5,153 | Unknown | Unknown | Unknown | Unknown | Unknown |
| Striped marlin (CWP)[11] | 8,065 | 8,065 | Unknown | Unknown | Unknown | Unknown |
| Swordfish (North Pacific)[12] | 33,000 | 57,000 | 57,000 | Above | Not overfishing | Not overfished |
| Subtotal, billfish | 65,292 | 89,292 | 89,292 | | | |
| **Oceanic sharks** | | | | | | |
| Bigeye thresher (North Pacific) | 4 | Unknown | Unknown | Unknown | Unknown | Unknown |
| Blue shark (North Pacific) | 37,386 | 70,000 | Unknown | Above | Not overfishing | Not overfished |
| Pelagic thresher (North Pacific)[13] | 2 | Unknown | Unknown | Unknown | Unknown | Unknown |
| Shortfin mako (North Pacific) | 69 | Unknown | Unknown | Unknown | Unknown | Unknown |
| Thresher shark (North Pacific)[14] | 323 | Unknown | Unknown | Unknown | Unknown | Unknown |
| Subtotal, oceanic sharks | 37,784 | 70,398 | 70,398 | | | |

United States fishermen have a long history of fishing for Pacific highly migratory species. In American Samoa, Guam, Hawaii, and the Commonwealth of the Northern Mariana Islands, handline fisheries for highly migratory species have operated since antiquity. Immigrants established pole-and-line and longline fisheries for tuna in Hawaii and southern California in the late 1800's and early 1900's. Pole-and-line fishing was the dominant fishery in Hawaii through the 1970's, but in the late 1980's longline fishing for tunas expanded rapidly and diversified to include swordfish in the 1990's. A sizable longline fishery for albacore has developed in American Samoa since 1995. Currently, U.S. fisheries targeting highly migratory species include commercial purse-seine fisheries in the eastern and western tropical Pacific; troll fisheries in the North and South Pacific; longline fisheries operating out of American Samoa, California, and Hawaii; troll and handline fisheries operating in the Exclusive Economic Zones (EEZ's) of U.S. Pacific Islands; and drift gillnet and harpoon fisheries in the West Coast EEZ.

Recreational fishermen in the 1920's were instrumental in drawing attention to the seasonal availability of highly migratory species off Califor-

**Table 18-1**
Continued from previous page.

| Species/Stock | Recent average yield (RAY)[1] | Current yield (CY) | Sustainable yield (MSY) | Stock level relative to $B_{MSY}$ | Harvest rate | Stock status |
|---|---|---|---|---|---|---|
| **Other Migratory Species** | | | | | | |
| Dolphinfish (Pacific)[15] | 23,742 | 23,742 | Unknown | Unknown | Unknown | Unknown |
| Wahoo (Pacific)[16] | 831 | 831 | Unknown | Unknown | Unknown | Unknown |
| Subtotal, other migratory species | 24,573 | 24,573 | 24,753 | | | |
| Total | 2,926,372 | 2,960,401 | 4,442,354 | | | |
| U.S. subtotal | 145,596 | | | | | |

[1]2004–06 average.
[2]U.S. portion of the RAY is 1,504 t. Status determinations are made for the entire Pacific region.
[3]U.S. portion of the RAY is 9,928 t. Status determinations are made for the entire Pacific region.
[4]U.S. portion of the RAY is 1,726 t.
[5]U.S. portion of the RAY is 55,588 t.
[6]U.S. portion of the RAY is 1,749 t.
[7]U.S. portion of the RAY is 55,588 t.
[8]U.S. portion of the RAY is 13,166 t.
[9]U.S. portion of the RAY is 3,950 t.
[10]U.S. portion of the RAY is 148 t.
[11]Central Western Pacific stock.
[12]U.S. portion of the RAY is 1,625 t.
[13]U.S. portion of the RAY is 1 t.
[14]U.S. portion of the RAY is 179 t.
[15]Also commonly known as dorado or mahi mahi.
[16]Average includes U.S. yield of 444 t and FAO Pacific yield of 387 t.

nia. Since then, sportfishing has grown in popularity and now supports important recreational fisheries for marlins, yellowfin tuna, dolphinfish, albacore, pelagic sharks, and other species in locations such as San Diego, California. Recreational highly migratory species fisheries also developed in other locations in the United States, such as Kona, Hawaii. Sportfishing participants contribute several million dollars annually to local economies.

The largest contemporary U.S. commercial fishery for highly migratory species started off the U.S. West Coast and Baja California, Mexico in the 1930's. At that time, U.S. fishermen targeted Pacific bluefin tuna and albacore for the emerging canned tuna market. The fishery rapidly expanded southward and westward with the development of new purse-seine fishing gear and discovery of large stocks of tropical tunas (yellowfin, skipjack, and bigeye tunas). During 1976–80, expansion of the fishery was concentrated in the eastern tropical Pacific. The U.S. fleet dominated the fishery until the 1980's, when fishing became less profitable owing to declining catch rates and increased costs associated with domestic regulations to reduce dolphin mortality. Many U.S. fishermen quit the fishery or moved their fishing operations to the central western Pacific. The U.S. fleet in the eastern tropical Pacific declined to about eight vessels by 2003. Simultaneously, the fleets of Mexico and other Latin American nations expanded and quickly filled the void. In 2006, 226 large purse seiners were active in the eastern tropical Pacific tuna fishery. In 2006, Ecuador (with 85 vessels) and Mexico (with 57 vessels) were leaders in the fishery.

Pacific tuna fisheries east of 150°W longitude have traditionally been managed in accordance with recommendations made by the Inter-American Tropical Tuna Commission (IATTC), to which the United States is a party. The IATTC historically has managed the fisheries with a focus on maintaining the tuna stocks at levels associated with maximum sustainable yield (MSY). The principal conservation measures have been catch quotas for yellowfin tuna. However, the IATTC has broadened the scope of its management program to include consideration of bycatch (including undersized fish), fleet capacity limits, and most recently, time–area closures for purse-seine fishing. Also, for the


Scott Landis, F/V MIDDLEPOINT

A SWFSC albacore troll observer. Observers collect data on catch, effort, and various special projects aboard commercial U.S. troll vessels that operate throughout the North Pacific.


Russell Ito, PIFSC

Unloading tunas from the longline vessel *Gail Ann* to the Honolulu fish auction.

2005–07 fishing seasons, the IATTC agreed to a management scheme of time–area closures for purse-seine gear and national catch quotas for longline gear to reduce fishing mortality on yellowfin and bigeye tuna. For the 2008 fishing season the IATTC parties were not able to reach agreement on management measures to correct overfishing of yellowfin and bigeye tunas. The IATTC has begun monitoring North Pacific albacore catches as well to ensure that the total level of fishing effort is not increased beyond current levels. In addition, under the Agreement on the International Dolphin Conservation Program (AIDCP), the parties to that agreement continued implementation of an overall dolphin mortality limit of 5,000 animals for the fishery by distributing individual vessel quotas to qualified vessels. Furthermore, all large tuna purse seiners operating in the eastern Pacific Ocean are required to carry an observer to collect data on compliance with AIDCP requirements.

In 1988, the United States and 16 South Pacific Island nations concluded a 5-year tuna fishing access agreement called the South Pacific Regional Tuna Treaty. This treaty gave the U.S. tuna purse-seine fleet fishing access to a 26 million km$^2$ area of the central western Pacific Ocean in exchange for fees. In 1993, the treaty was extended for 10 years, and in 2003 it was extended again for 10 years. The 2003 extension limits the fleet to a maximum of 40 licenses (one per vessel), plus 5 additional licenses for joint venture arrangements with the island parties. The annual industry license fee is $3 million. An additional $18 million is provided annually by the U.S. government for economic assistance to the island parties. In 2007, 18 U.S. purse seiners were licensed to fish under the treaty.

Following 5 years of negotiations involving 24 nations, 19 Pacific nations[1] adopted the Convention on the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific (WCPFC) on 4 September 2000, in Honolulu, Hawaii. By 19 December 2003, 13 nations[2] had ratified the convention, triggering its entry into force on 19 June 2004 and creating the Western and Central Pacific Fisheries Commission. The U.S. domestic procedures for ratification of the Convention were completed in 2007, and the United States actively participates in the WCPFC as a member. The WCPFC has authority to manage catch, bycatch, fishing capacity, and effort in order to achieve its goal of conserving the stocks and managing the fisheries for tuna and tuna-like species in the central and western Pacific Ocean west of 150°W longitude and between temperate waters in the North and South Pacific. Means for monitoring and compliance include a vessel register, vessel monitoring systems, an observer program, port monitoring, and reporting of landings, fishing effort, catch, and transshipment. A Scientific Committee was formed when the WCPFC entered into force to provide scientific advice to the Commission for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific.

While WCPFC nations negotiated terms for an overall conservation and management convention for highly migratory species west of 150°W longitude, two informal, international scientific arrangements have been in place in the North

[1]Australia, Canada, Cook Islands, Federated States of Micronesia, Fiji, Indonesia, Kiribati, Marshall Islands, Nauru, New Zealand, Niue, Palau, Papua New Guinea, Philippines, Samoa, Solomon Islands, Tuvalu, United States, and Vanuatu; Japan and Korea voted against, and China, France, and Tonga abstained.

[2]Australia, Cook Islands, Federated States of Micronesia, Fiji, Kiribati, Marshall Islands, Nauru, New Zealand, Niue, Papua New Guinea, Samoa, Solomon Islands, and Tonga.

Pacific for a number of years. The North Pacific Albacore Workshop was established in 1974 for exchange of scientific information useful for assessing the status of North Pacific albacore. Scientists from Canada, Japan, Taiwan, and the United States have participated in this arrangement. The second arrangement, the Interim Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean[3] (ISC), was formed in 1995 to enhance scientific research and cooperation for conservation and rational utilization of highly migratory species resources of the North Pacific. The ISC also establishes the scientific groundwork for any future management regime. Scientists from Canada, Japan, Korea, Mexico, Taiwan, the United States, the IATTC, the Secretariat of the Pacific Community, and the North Pacific Marine Science Organization are active in this arrangement, with collaborative scientific studies and sharing of fishery data. In this regard, a central database and website have been established by the ISC. At the ISC's 2004 meeting in Honolulu, Hawaii, participants concluded that the ISC should continue as an independent body and be available to provide scientific stock advice to other bodies (e.g. WCPFC, IATTC) as needed. The ISC also decided to invite the North Pacific Albacore Workshop to become part of the ISC. With the addition of the albacore workshop in 2005 as the ISC Albacore Working Group, the ISC's primary focus is now on the North Pacific stocks of albacore, bluefin tuna, swordfish, striped marlin, and blue shark.

In 1981, the United States and Canada entered into an agreement, the U.S.–Canada Albacore Treaty, which allows for reciprocal fishing in each party's EEZ and landing privileges at selected ports for albacore fishing vessels of both countries. In 2002, that access agreement was amended to limit access of each party's vessels fishing for albacore in the waters of the other party. Over a period of 3 years, the effort-limitation regime requires by the third year no more than 125 vessels with 4 months fishing for each, or 500 vessel-fishing months regardless of the number of vessels involved, will be allowed by each party in each other's EEZ. In 2007, Canadian vessels fished 339 vessel months in the U.S. EEZ, while U.S. vessels fished 22 vessel months inside the Canadian EEZ. The agreement also had a provision that if at the end of the third year no new agreement was reached, fishing limits would be reduced to 94 vessels for 4 months or 376 vessel-fishing months in each party's EEZ. This provision was implemented for 2006 and 2007.

While international mechanisms for conservation and management of Pacific highly migratory species throughout their range are being developed, the United States has proceeded with managing its domestic fisheries for highly migratory species. Lead management authority for highly migratory species rests with the Western Pacific Fishery Management Council (WPFMC) for the U.S. EEZ in the central western Pacific and with the Pacific Fishery Management Council (PFMC) for the U.S. EEZ along the West Coast. The WPFMC has had a Fishery Management Plan (FMP) for pelagic fisheries since 1986. The most significant provision of that plan is a maximum limit of 164 permits for longline vessels operating from ports in Hawaii and 60 permits for longliners operating from American Samoa. In addition, an amendment to the plan in 2001 prohibited targeting swordfish in the North Pacific with longline gear and imposed time and area closures for longline gear targeting tuna in order to reduce sea turtle interaction and mortality. In 2004, the swordfish-directed component of the Hawaii-based fishery was re-opened but subject to restrictions on the types of hooks and bait to be used, annual fleetwide limits on turtle interactions and fishing effort, and other mitigation measures. The first complete year in which the Hawaii-based longline fishery was allowed to target swordfish was 2005. In the following year, the shallow-set longline fishery reached the annual interaction limit of 17 loggerhead sea turtles and the fishery was closed 20 March 2006. The vessels that targeted swordfish converted to deep-set longline and targeted tunas for the remainder of the year. In 2007, the Hawaii-based shallow-set longline fishery stayed below the annual sea turtle interaction limit and remained open throughout the entire year.

The PFMC began developing an FMP for West Coast highly migratory species in 2000 and approved the FMP in June 2003. The National Marine Fisheries Service (NMFS) approved the

[3]Name was changed in 2005 to the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean.

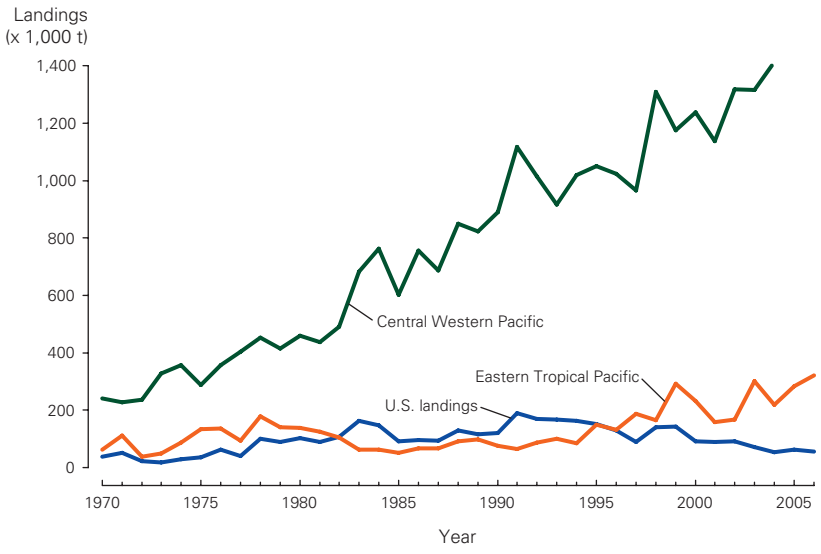



**Figure 18-1**
Landings in metric tons (t) of skipjack tuna in the Pacific Ocean region, 1970–2006.

FMP in February 2004 and implemented the plan beginning in 2005. Vessels immediately affected most by the plan were those using drift gillnet and longline gear. The plan prohibits shallow setting of longline gear (used largely to target swordfish) west of 150°W longitude because of concerns for sea turtle and seabird interactions. In a separate action, NMFS implemented regulations to prohibit targeting swordfish east of 150°W longitude to prevent jeopardy to sea turtles. Regulations protecting sea turtles from adverse impacts of the drift gillnet fishery had previously been announced and were continued under the FMP; certain new closures within the EEZ off Washington and Oregon have been implemented by the plan.

The United States has also taken steps to manage sharks taken in commercial fisheries. Shark finning (the removal and retention of shark fins only and discarding the carcass at sea) is currently prohibited in all U.S. fisheries. Landing shark carcasses with fins, however, is allowed at U.S. ports. Harvest guidelines have been set for thresher shark and shortfin mako shark by the PFMC, and the white shark and megamouth shark have both been designated protected species under the plan.

## SPECIES AND STATUS

Highly migratory pelagic species are often grouped for convenience into tropical tunas (yellowfin, bigeye, and skipjack), temperate tunas (Pacific bluefin and albacore), billfishes (marlins and swordfish), oceanic sharks (thresher, blue, and mako), and other species (dolphinfish and wahoo). Most of these fishes are caught commercially and support large industries. Some, such as tropical tunas and dolphinfish, are important to subsistence fisheries of small Pacific Island nations and U.S. territories. Others, especially marlins, yellowfin tuna, and albacore, support important recreational fisheries.

### Tropical Tunas

Yellowfin, skipjack, and bigeye tunas are the principal tuna species categorized as tropical tunas. Their concentrations are highest in the tropics between latitudes 20°N and 20°S. The primary fishing gears used to catch these tunas commercially are longlines and purse seines. Other fishing gears of less importance include ring net, handline, troll, and pole-and-line. In 2002, more than 400 large purse seiners and more than 5,000 longliners participated in Pacific tuna fisheries.

Longline gear is used to catch yellowfin and bigeye tunas across the Pacific, whereas the purse seine is the primary gear used in the eastern and the central western Pacific. In the eastern Pacific, the largest purse-seine fleets are from Ecuador, Mexico, and Venezuela. In the central-western Pacific, Japan, the Republic of Korea, the Philippines, Taiwan, and the United States have major purse-seine fleets. Major longline fleets fishing for yellowfin and bigeye tunas are based in Japan, Korea, and Taiwan.

Skipjack tuna is the volume leader in the Pacific and is caught primarily with purse-seine gear. The catch is used primarily as raw material for canning. Recent average annual yield (2004–06) is 274,974 t for the eastern Pacific and 1,494,421 t for the central western Pacific (Table 18-1, Figure 18-1). The U.S. Pacific-wide catch of skipjack tuna has averaged about 57,314 t recently. The dockside ex-vessel revenue of the total Pacific catch is about $869 million annually. The skipjack tuna stocks are believed to be underutilized, with the MSY for the central western stock at 2.7 million t; MSY for the eastern Pacific stock is unknown.

Yellowfin tuna is another prized species used principally for canning. Recent average yield

is 252,412 t for the eastern Pacific fishery and 399,378 t for the central western Pacific fishery (Table 18-1, Figure 18-2). The U.S. catch has averaged 57,337 t in recent years. The ex-vessel value of the Pacific-wide catch is about $474 million. The eastern stock of yellowfin tuna is near the biomass that produces the MSY, but the stock is experiencing overfishing. The central western stock is slightly above the biomass for MSY.

Large-sized bigeye tuna are sold mainly as raw material for the high-priced restaurant trade, particularly sushi restaurants. However, landings by purse seiners of smaller sizes, or subadults, are largely used for canning. Recent average yield for the entire Pacific is about 240,824 t, up significantly from earlier yields owing to increased catches by purse seiners taking young fish with fish-aggregating devices (Figure 18-3). The ex-vessel revenue from the total bigeye tuna catch is about $1 billion annually. Most of the catch is taken by longline fleets of Japan, Korea, and Taiwan. The U.S. catch of about 11,432 t annually is taken mostly with purse seines. However, U.S. longliners catch about 4,000 t annually, valued at about $20 million that includes a significant catch by Hawaii-based longliners. The recent average yield for U.S. longliners is 317 t in the eastern Pacific.

The MSY and current yield for bigeye tuna are undergoing review. The stock structure of the Pacific-wide population is unclear. However, current best estimates of yield potential indicate that the stocks (especially the stock or stock portion in the eastern Pacific) are at full utilization, and overfishing may be occurring.

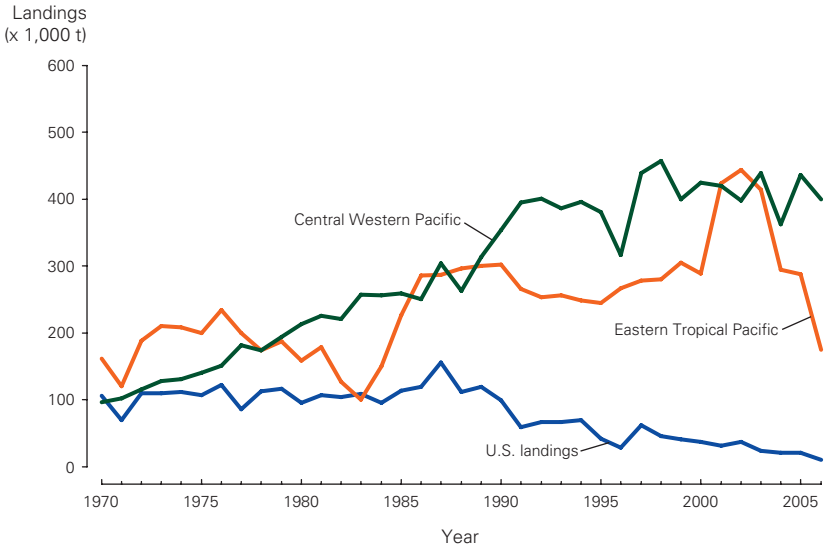



**Figure 18-2**
Landings in metric tons (t) of yellowfin tuna in the Pacific Ocean region, 1970–2006.

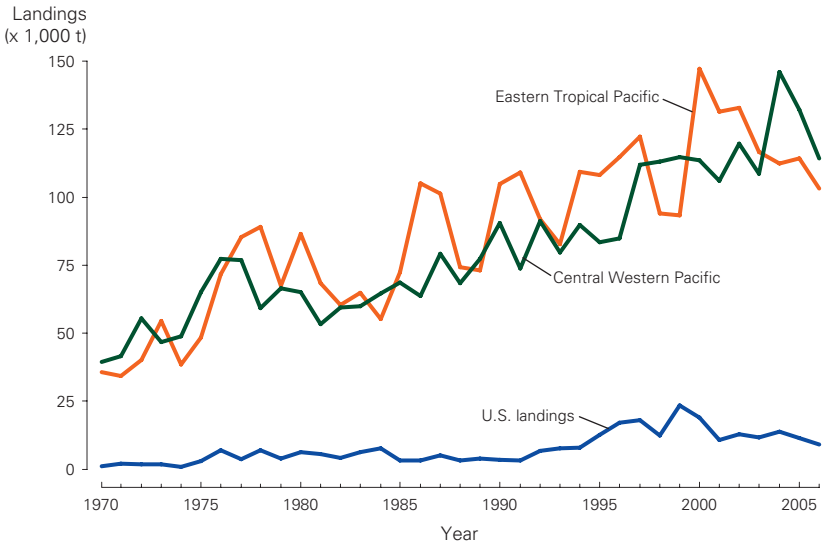



**Figure 18-3**
Landings in metric tons (t) of bigeye tuna in the Pacific Ocean region, 1970–2006.

## Temperate Tunas

Pacific bluefin tuna and North and South Pacific albacore are categorized as temperate tunas. They generally occur in large concentrations in higher latitudes of the North and South Pacific. Adults, however, seasonally migrate to tropical waters for spawning.

U.S. catches of Pacific bluefin tuna have recently been relatively minor. This species is taken seasonally off southern California and Baja California, Mexico, primarily by purse seiners that normally target other species (anchovy, sardine, and mackerel) and by recreational fishermen. In the mid North Pacific, Pacific bluefin tuna are taken sporadically by the Hawaii- and California-based longline fleets targeting swordfish and bigeye tuna. Recent Pacific-wide average (2004–06) yield is about 25,100 t. Approximately 63% of the landings are taken by Japan, 7% by Taiwan, 24% by Mexico, 3% by Korea, and 2% by the United States. Stock status is uncertain and undergoing review.

In the North Pacific, albacore are fished primar-

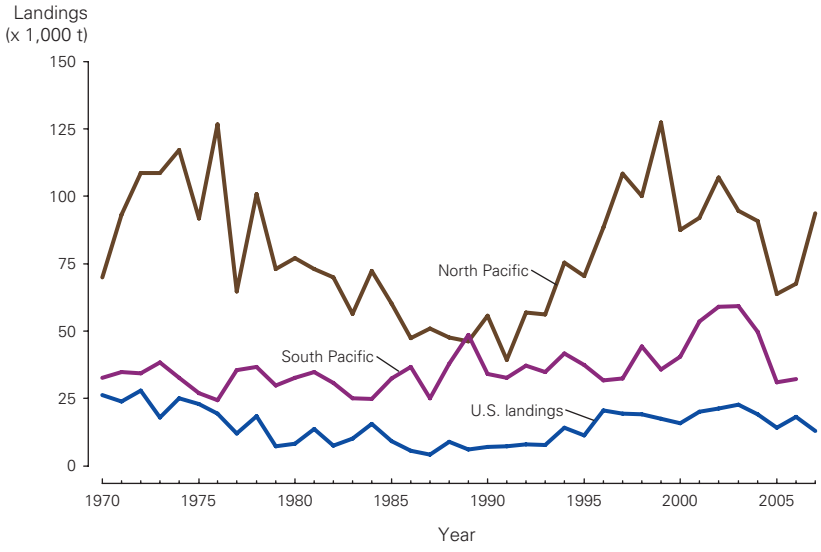



**Figure 18-4**
Landings in metric tons (t) of albacore in the Pacific Ocean region, 1970–2007.

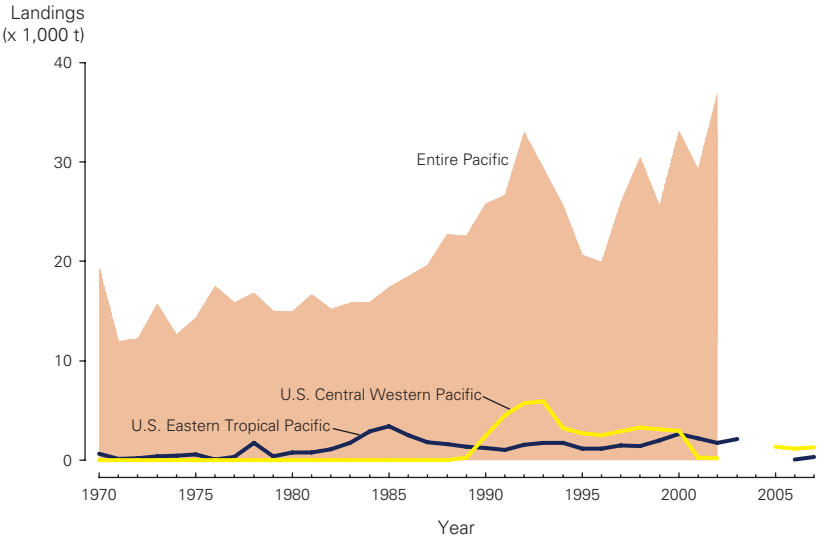



**Figure 18-5**
Landings in metric tons (t) of swordfish in the Pacific Ocean region, 1970–2007. Data are not available for some recent years.

ily by longline, pole-and-line, troll, and up until 1992, drift gillnet gears. Longline gear is used in the lower latitudes and off the Japanese archipelago and currently accounts for 35% of the catch. Pole-and-line and troll gears are used in the surface fisheries that operate in the North Pacific Transition Zone and higher latitudes. These gears account for 60% of the catch. The 2004–06 average yield was 74,013 t, and the U.S. yield was 13,166 t (Figure 18-4). Based on a dockside price of $1,973 per ton, the annual ex-vessel revenue of the 2004–06 average North Pacific albacore yield was about $142 million per year. The MSY is unknown. The status of the North Pacific albacore population is reviewed on an ongoing basis by an international team of scientists through the ISC's North Pacific Albacore Working Group. A comprehensive review was conducted in 2006. Although a stock assessment was conducted and a suite of candidate biological reference points have been documented, management bodies (e.g., PFMC and WPFMC) have not established formal harvest control rules to date.

In the South Pacific, fisheries for albacore are expanding with largely longline and troll gears. The 2004–06 average yield was 37,602 t (Figure 18-4). Longline fleets from Japan and Taiwan are the largest producers. Longline gear accounts for 86% of the catch and is the gear of choice for new vessels entering the fisheries. The newer vessels use a large reel with miles of monofilament main line. South Pacific Island countries (French Polynesia, New Caledonia, Fiji, and Samoa), for example, are rapidly building significant longline fleets for albacore. The U.S. fishery, which primarily consists of longliners and troll vessels, landed approximately 3,950 t of albacore in the South Pacific in 2004–06. The troll fishing season is the austral summer (November through April) in the higher latitudes (35° to 45°S) east of New Zealand.

## Billfishes

Billfishes, including swordfish, marlins, and spearfish, generally range from North America to Asia and between the North and South Pacific Convergence Zones. These fishes are more abundant near islands, continental slopes, seamounts, and oceanic fronts, and many are important to local economies. They are caught by foreign and U.S. recreational and commercial fishermen.

Swordfish are distributed throughout the temperate, subtropical, and tropical waters of the Pacific. Much of the Pacific-wide catch of swordfish is taken by the Japanese longline fishery as bycatch while targeting tunas. Other longline fleets target swordfish, particularly the longline fleets of the United States, Mexico, Chile, and Australia. Coastal swordfish fisheries occur off the United

States, Japan, Taiwan, Mexico, Chile, and Australia, using various surface gears, such as harpoons and driftnets. Yields increased throughout the 1980's and fluctuated in the 1990's (Figure 18-5), averaging about 33,000 t in recent years (Table 18-1).

Until recently, a substantial fraction of the Pacific catch of swordfish was harvested by the U.S. longline fleet in the central western Pacific (Figure 18-5), and prior to prohibition of the gear in 1993, some of the catch was caught by high-seas drift gillnet vessels. The rest of the swordfish yield is largely taken by surface gears, such as harpoons, handlines, and coastal drift gillnets. From 1989 to 1993, production from the U.S. domestic longline fishery in Hawaii increased rapidly, reaching 5,925 t and an ex-vessel revenue of $26.1 million in 1993. Production from the Hawaii fishery accounted for about 14% of the total Pacific production in the 1990's. The swordfish production from the U.S. domestic gillnet and harpoon fisheries located primarily off California increased markedly between 1975 and 1985, when a peak yield of 3,400 t was landed. Production from these sources declined in the 1990's, while production increased from longline vessels based in California and with seasonal participation by vessels from the Hawaii-based fleet making landings in California. The U.S. eastern Pacific fishery has a recent average annual yield of about 1,400 t worth about $6 million in ex-vessel revenue. Both the U.S. longline and gillnet fisheries have recently been affected by concerns over interactions with protected species. In 2001, the Hawaii-based longline fishery was prohibited from using shallow-set fishing methods that target swordfish, due to high bycatch rates of primarily loggerhead and leatherback sea turtles. This fishery was reinstated in 2004 with new gear, fishing effort, and turtle take limitations. Annual catches in the Hawaii-based fishery during 2001 and 2002 declined to about 225 t due to the regulations prohibiting swordfish fishing. The catch and effort of the California gillnet fishery also plummeted owing to expansion of area and season closures to reduce pinniped and turtle interactions.

The stock structure and status of Pacific swordfish stocks are unclear. Several studies suggest more than one Pacific stock. A stock assessment of a North Pacific population indicated a decline in abundance in the northwest Pacific. The MSY, however, is estimated to be greater than the current yield.

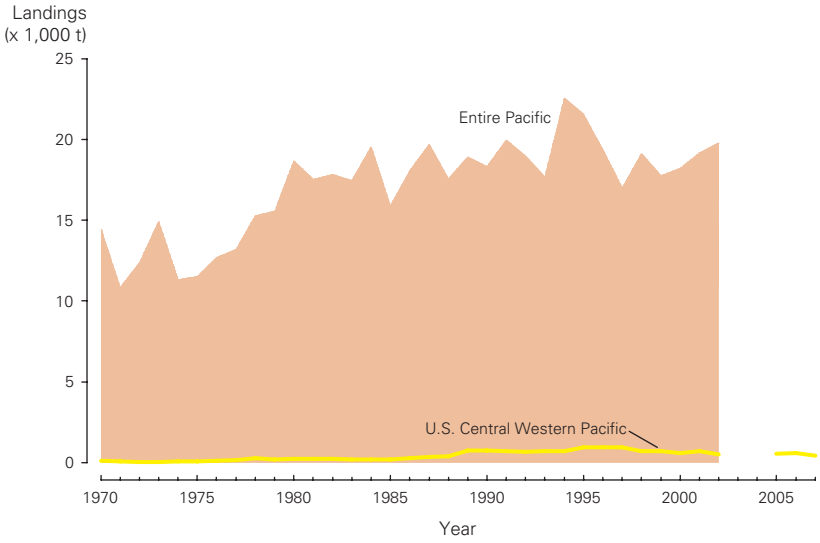



**Figure 18-6**
Landings in metric tons (t) of blue marlin in the Pacific Ocean region, 1970–2007. Some recent years of data are not available for all metrics.

Other Pacific billfish species include blue, black, and striped marlins; sailfish; and shortbill spearfish. U.S. commercial fishermen primarily use longline, troll, and handline gears to catch marlins and spearfish, while recreational fishing gears include rod-and-reel and handline. The U.S. catch of blue and striped marlin is worth about $2,500 per ton ex-vessel.

Blue marlin are one of the most important big game fish for recreational fishermen and are of great economic value to communities with charter fleets and fishing tournaments for this species. It is also an important commercial species. Pacific-wide commercial yields of blue marlin increased in the 1970's and fluctuated between 16,000 t and 22,000 t in the 1980's and 1990's (Figure 18-6). Annual U.S. Pacific fisheries yields of blue marlin increased in the 1970's and 1980's and leveled out in the 1990's at 700 to 900 t, comprising about 4% of the Pacific total. Concern over the status of blue marlin has prompted several recent efforts to assess the status of the Pacific-wide stock. Earlier, scientists had suggested that the stock might be overfished, as Pacific-wide fishing effort increased in the 1980's and yields remained level. However, the most recent assessment models indicate that effective fishing effort for blue marlin has not increased very much since the early 1980's, and at most, blue marlin are now thought to have a biomass close to the level


Anne Allen, SWFSC

Mako shark.

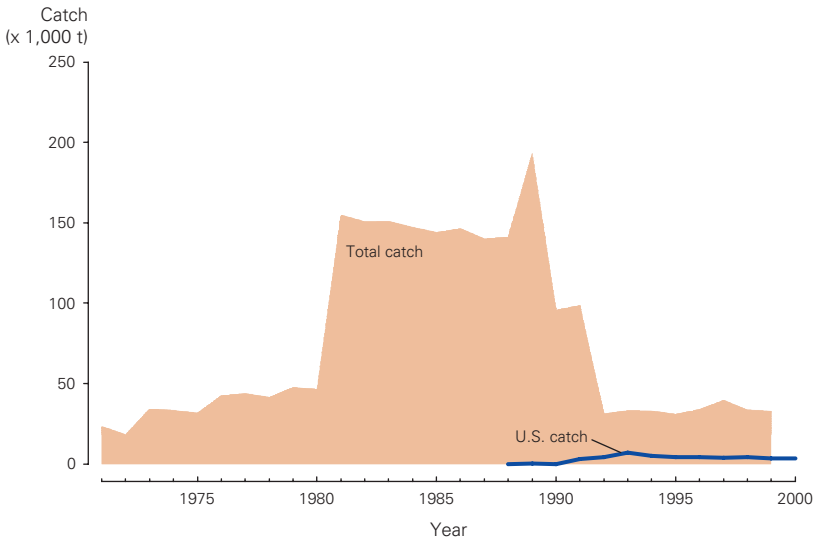



**Figure 18-7**
Landings in metric tons (t) of blue shark in the North Pacific Ocean region, 1970–2000.

Allen Shimada, NMFS

A freshly landed wahoo on the deck of a NOAA Fisheries Research Vessel.

that supports the MSY (Table 18-1). The status of most other billfish species stocks is unknown or uncertain, although earlier assessments using data through 1985 indicated that striped marlin were underutilized.

### Oceanic Sharks

Pacific oceanic shark species include requiem, thresher, and mackerel sharks. Sharks are taken by longline in the central North Pacific and by drift gillnet off the U.S. West Coast. Shark prices vary greatly by product form, and until recently most landings in U.S. fisheries were from the Hawaii-based longline fishery in the form of shark fins, selling for about $40,000 per ton. Shark finning with discarding of the carcass at sea is currently banned in all U.S. fisheries. Limits on non-blue shark landings are being considered for Hawaii-based longline vessels. In Hawaii, whole sharks are sold for about $1,400 per ton.

All pelagic longline fisheries catch appreciable numbers of sharks, but only a few nations report their shark catches. Most foreign longline fisheries collect shark fins to produce a dried product for making soup. The product is marketed primarily through Hong Kong. In some cases, shark finning is conducted by fishing crew members as a separate enterprise from the primary fishery. Because carcasses are discarded at sea, shark catches are often treated as discards and are seldom logged; hence, the total Pacific harvest of pelagic sharks is unknown.

Blue sharks are the most numerous shark species in the North Pacific, and research to estimate yield based on data reported by a subset of fishing vessels has recently allowed an assessment of blue shark to be completed. Estimated yield of sharks (including discards) reached high levels during the era of the North Pacific drift gillnet fishery, which ended in the early 1990's (Figure 18-7). After an international ban on high-seas drift nets, the annual shark yield (mostly by longliners) stabilized at around 33,000 t (weight estimated from number caught multiplied by an assumed average weight of 45 kg per shark). The U.S. North Pacific yield (estimated round weight, including discards) was taken mainly by Hawaii-based longliners and peaked at about 6,800 t in 1993. Yields subsequently declined as the fleet altered its fishing strategy in the mid 1990's, but shark landings continued to increase through 1999 (Figure 18-7) because an increasing fraction of the yield was landed in the form of fins (landings expressed as round weight regardless of product form). The recent North Pacific blue shark stock assessment estimated an MSY of about twice the recent annual yield and indicated that the stock is underexploited. In 2003, a regional MSY and optimum yield were calculated for the U.S. Pacific Coast stock of thresher shark, with harvest guideline established at 340 t per year. The condition of other pelagic shark stocks remains unknown.

### Other Migratory Species

Other Pacific highly migratory species include wahoo and dolphinfish (mahi mahi). These species are primarily caught commercially using longline, troll, and handline gears; recreational fishermen use mainly rod-and-reel and handlines. The U.S. catch of dolphinfish and wahoo is worth about $4,200 per ton. The MSY and status for these stocks is unknown, but both species are thought to be near the biomass level that would produce the MSY.

## ISSUES

### Management Concerns

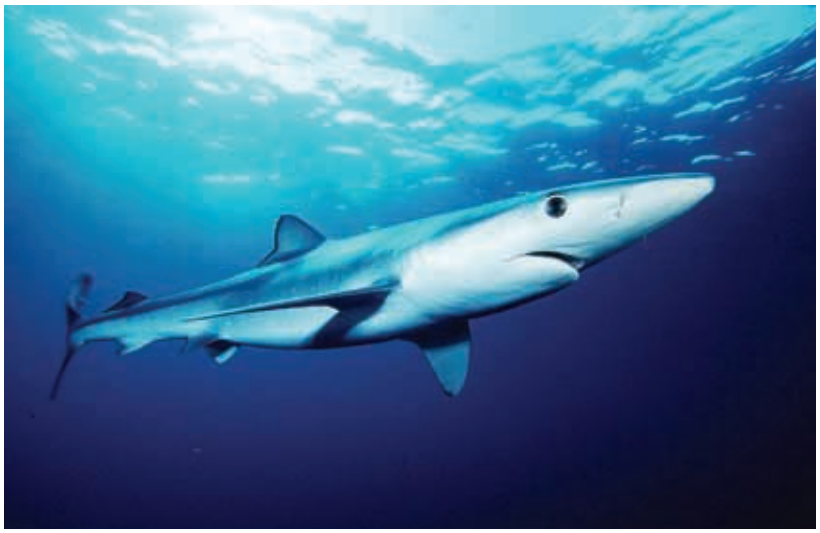
Growth of total fleet fishing capacity for highly

migratory species in the Pacific is of increasing concern to fishery managers, because many of the target species are already fully harvested or harvested above sustainable levels. In addition, the economic impacts of high capacity are becoming more apparent. Regional fishery management organizations and nations are increasingly considering management and limitation of fishing capacity as a major component of a rational fishery conservation and management program. The paradigm is that if fishing capacity can be managed effectively, the need for more restrictive, complicated, and costly management measures (e.g. limitations on fishing effort, catches, sizes, seasons, and area closures) would not be necessary. Therefore it is prudent to manage capacity rather than to limit efficiency. In recent years, the IATTC has been working on limiting purse-seine fishing capacity in the eastern Pacific, and parties involved in developing the WCPFC consider limitation of fishing capacity as a priority topic for consideration.

Closely aligned with fishing capacity is the problem of illegal, unreported, and unregulated (IUU) fishing by vessels that operate outside the control of regional management regimes. In June 2001, the U.N.'s Food and Agriculture Organization Council adopted an international plan of action to prevent IUU fishing. The IATTC has been actively addressing this issue, and the emerging WCPFC deliberated on this issue as part of the groundwork for establishing the Commission for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific.

Another issue in the Pacific is the high fishing mortality (and subsequent reduction in future spawning biomass) being exerted on juvenile bigeye and yellowfin tuna with increasing use of fish aggregating devices by purse seiners and domestic fisheries of the Philippines and Indonesia. The WCPFC, in collaboration with the Secretariat of the Pacific Community, has initiated a program to document the level of mortality, particularly that caused by the Philippine and Indonesian fisheries, for highly migratory species. The IATTC has also been addressing this issue with proposed measures to limit the catch of bigeye tuna and to prevent overall fishing effort from increasing, but conservation measures for 2008 to address overfishing have not been adopted.

Mark Conlin, NMFS



Blue shark in the Southern California Bight, an important nursery area for young blue sharks.

### Bycatch and Multispecies Interactions

Of continuing concern is the bycatch of seabirds, sea turtles, and marine mammals by fisheries for Pacific highly migratory species. NMFS has been and will continue to be a strong proponent for accurate reporting of catches of bycatch species as well as for adoption of preventative and mitigative gear and procedures. In this regard, NMFS is promoting the international adoption of fishing gear and techniques (i.e. large circle hooks and mackerel-type bait) developed in the Atlantic Ocean and currently being implemented in the Hawaii-based longline fishery to significantly reduce turtle bycatch in swordfish fishing. The IATTC and the Standing Committee on Tuna and Billfish have had a working group to address the problem of bycatch of protected species as well as incidental catches of fishes for a number of years. A similar working group was established by the WCPFC at its inaugural meeting in December 2004.

Participants in various fisheries under the WPFMC's jurisdiction continue to voice concern about the impacts of competing fisheries on their fishing success (for example, near-island troll and handliners complain about offshore longline and handline fishing, particularly now as handline fishing around privately deployed fish aggregating devices expands offshore into waters fished by longliners). Also, longline fishery participants object to the number and severity of management measures specific to

Allen Shimada, NMFS

Removing the hook from a freshly landed juvenile yellowfin tuna.

that fishery. In particular, regulations to protect sea turtles and seabirds are contested in the Hawaii-based longline fishery because the impact of that fishery is believed to be slight compared to that of other fisheries, particularly foreign longliners that continue to operate unhindered on the high seas.

### Transboundary Stocks and Jurisdiction

Although they fish the same resources as the Hawaii-based vessels and sometimes fish the same areas, longline vessels operating out of California have not been subject to the management regulations developed by the WPFMC. As noted earlier, however, in 2004 the PFMC approved and implemented a highly migratory species FMP to close this loophole. The plan requires California-based longline vessels fishing highly migratory species on the high seas to follow practices applied to longliners by the WPFMC for prevention of sea turtle and seabird interactions. Combined with a separate regulation issued by NMFS, the FMP results in a prohibition of all shallow swordfish longline sets by West Coast-based longline vessels. The PFMC is considering whether to amend its FMP to require the same gear and techniques as in the WPFMC's FMP and thus restore some swordfish fishing opportunity for the longline fleet. Other provisions of the PFMC's plan apply to conservation of shark resources and involve application of existing state regulations.

International cooperation and conservation measures are a growing management issue emerging for the highly migratory species FMP of the PFMC. If a tuna stock is experiencing overfishing or becomes overfished, FMP regulations could result in limits on the catch of U.S. fishermen, even when the regulations result in no significant advantage to the stock because of the relatively small amount of effort exerted by the U.S. fleet. The FMP regulations would have no effect on the substantial amount of foreign fishing that occurs on the high seas, although this sector of the fishery for highly migratory species may be the root cause of overfishing. United States fishermen would thus be disadvantaged. Efforts of the United States in establishing the WCPFC and strengthening the IATTC are designed to ensure that conservation measures would be equally applied to foreign and U.S. fishermen.

An administrative problem arising in all areas in the Pacific is the increasing need for vessel records and statistical documents for shipments of various tuna from nation or region to nation or region. Fish are easily shipped across regions, and all nations have a stake in ensuring that fishermen are not allowed to circumvent catch restrictions in one area by simply shipping fish to other areas and reporting they were caught there. While cumbersome, catch documentation requirements are increasingly needed to support effective conservation and management of important stocks in the Pacific Ocean.

### Scientific Advice and Adequacy of Assessments

The condition is unknown for populations of some of the billfishes, dolphinfish, wahoo, and most shark species, largely because of a lack of comprehensive data on these species, in particular fishery statistics from all fishing fleets. Many of the species with unknown status are not targeted in highly migratory species fisheries but are captured as incidental catch or bycatch. United States fishery data collection through logbooks and observer programs is comprehensive, but is not enough for performing stock assessments. These data represent only a small fraction of the total catch from the stocks. Data collection and exchange on an international scale are required. Recent as-

sessments undertaken for tuna species, swordfish, blue marlin, and blue shark have resulted from international collaboration. This collaborative approach also led to new stock assessment activities and a re-examination of stock structure for striped marlin in 2007. For other species, particularly bycatch species, international data collection must be significantly improved before credible stock assessments can be performed.

The take of protected species by U.S. fisheries is well monitored, and aggressive management measures have been taken to minimize the impacts of U.S. fisheries. However, the impacts of U.S. fisheries on protected species and bycatch in general are relatively minor compared to those of the much larger foreign fleets that fish across the Pacific, because they represent only a small fraction of total fishing effort. Further work on an international scale will be required to minimize these impacts.

The U.S. monitoring of landings (including estimation of total catches), collection of fishing effort and resulting catch data (logbooks), and size data for domestic coastal and high-seas fisheries provide the basis for preparing scientific advice on domestic fisheries. They also comprise a disproportionate amount of the data used by international bodies for stock assessments. At meetings of multinational management bodies, NMFS will continue to strongly advocate participation of all fishing nations to meet their obligations for monitoring their fleets commensurate with their fisheries production. Data collected ought to be shared and made available to international management bodies and scientific working groups tasked to conduct stock assessments and to provide advice on the condition of the highly migratory species stocks.

### Progress

Progress has been made on the stock assessment of several important fish stocks and in reducing U.S. fishery impacts on protected and endangered species. An updated blue marlin stock assessment indicates no overutilization. The status of several tuna stocks also has been updated. For central western Pacific tunas, the Secretariat of the Pacific Community annually convenes informal international scientific meetings to assemble fisheries statistics, evaluate fishery developments, and assess the condition of the western and South Pacific stocks. The recent assessments of North Pacific swordfish and blue shark were undertaken cooperatively under the sponsorship of the ISC. This organization now meets regularly to organize such research. The eastern Pacific stocks are assessed annually by the IATTC for providing fishing management advice.

Management of the domestic fisheries has been successful in reducing gear conflicts among longline, troll, driftnet, rod-and-reel, and handline fisheries and in reducing U.S. fishery impacts on Hawaiian monk seals, California sea lions, cetaceans, albatrosses, and sea turtles. Although the swordfish sector of the Hawaii longline fishery was closed between April 2001 and April 2004, the tuna harvest by the fishery continued to increase throughout the 1990's and early 2000's.

### FOR FURTHER READING

Boggs, C., P. Dalzell, T. Essington, M. Labelle, D. Mason, R. Skillman, and J. Wetherall. 2000. Recommended overfishing definitions and control rules for the Western Pacific Regional Fishery Management Council's pelagic fishery management plan. NMFS Southwest Fisheries Science Center, Honolulu Laboratory Administrative Report H-00-05, Honolulu, HI, 18 p.

Childers, J. 2001. Summary of the 2000 U.S. North and South Pacific albacore troll fisheries. NMFS Southwest Fisheries Science Center, La Jolla Laboratory Administrative Report LJ-01-05, La Jolla, CA, 42 p.

Crone, P. R., and R. J. Conser (Editors). 2002. Report of the eighteenth North Pacific Albacore Workshop, La Jolla, CA, 4–11 December 2002. NMFS Southwest Fisheries Science Center, La Jolla, CA, 92 p.

FAO. 2001. FAO yearbook of fishery statistics. Capture production 1999. Food and Agriculture Organization of the United Nations, FAO Fisheries Series Volume 88, Rome, Italy, 765 p.

Fournier, D. A., J. Hampton, and J. R. Sibert. 1998. MULTIFAN-CL. A length-based, age-structured model for fisheries stock assessment, with application to South Pacific albacore, *Thunnus alalunga*. Canadian Journal of Fisheries and Aquatic Sciences 55:2105–2216.

IATTC. 2001. Annual report of the Inter-American Tropical Tuna Commission, 1999. Inter-American Tropical Tuna Commission, Scripps Institution of Oceanography, La Jolla, CA, 183 p.

IATTC. 2008. The fishery for tunas and billfishes in the eastern Pacific Ocean in 2007. Report of the 9th Stock Assesment Review Meeting, Inter-American Tropical Tuna Commission, La Jolla, CA, 49 p. Internet site—http://www.iattc.org/PDFFiles2/SARM-9-04-The-fishery-in-2007.pdf.

Interim Scientific Committee. 2004. Report of the Plenary Session of the Fourth Meeting of the Interim Scientific Committee for Tuna and Tuna-like Species in the North Pacific, February 2004, Honolulu, HI. National Research Institute of Far Seas Fisheries, Shimizu, Japan. Internet site—http://isc.ac.affrc.go.jp/rep/ISC4PlenaryReport.pdf.

Ito, R. Y., and W. A. Machado. 2001. Annual report of the Hawaii-based longline fishery for 2000. NMFS Southwest Fisheries Science Center, Honolulu Laboratory Administrative Report H-01-07, Honolulu, HI, 61 p.

Kleiber, P., Y. Takeuchi, and H. Nakano. 2001. Calculation of plausible maximum sustainable yield (MSY) for blue sharks (*Prionace glauca*) in the North Pacific. NMFS Southwest Fisheries Science Center, Honolulu Laboratory Administrative Report H-01-02, Honolulu, HI, 10 p.

PFMC. 2003. Fishery Management Plan and Environmental Impact Statement for U.S. West Coast Fisheries for Highly Migratory Species. Pacific Fishery Management Council, Portland, OR. Internet site—http://www.pcouncil.org.

SCTB. 2004. Report of the 16th meeting, Standing Committee on Tuna and Billfish. Mooloolaba, Queensland, Australia, 9–16 July 2003. Internet site—http://www.spc.int/oceanfish/html/SCTB/index.htm.

WPRFMC. 2004. Pelagic fisheries of the western Pacific region. 2002 annual report. Western Pacific Regional Fishery Management Council, Honolulu, HI. Internet site—http://www.wpcouncil.org/pelagic-data.html.