

Seafood Watch

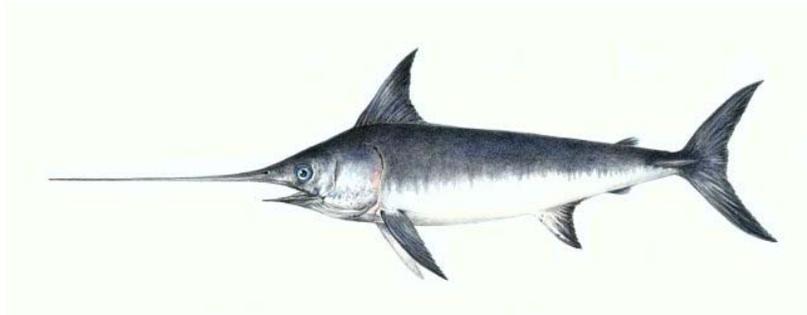
Seafood Report



MONTEREY BAY AQUARIUM®

Swordfish

Xiphias gladius



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All Regions

Original Report Published July 9, 2007
Stock Status Updated January 7, 2011

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About Seafood Watch® and the Seafood Reports

Monterey Bay Aquarium's Seafood Watch® program evaluates the ecological sustainability of wild-caught and farmed seafood commonly found in the United States marketplace. Seafood Watch® defines sustainable seafood as originating from sources, whether wild-caught or farmed, which can maintain or increase production in the long-term without jeopardizing the structure or function of affected ecosystems. Seafood Watch® makes its science-based recommendations available to the public in the form of regional pocket guides that can be downloaded from the Internet (seafoodwatch.org) or obtained from the Seafood Watch® program by emailing seafoodwatch@mbayaq.org. The program's goals are to raise awareness of important ocean conservation issues and empower seafood consumers and businesses to make choices for healthy oceans.

Each sustainability recommendation on the regional pocket guides is supported by a Seafood Report. Each report synthesizes and analyzes the most current ecological, fisheries and ecosystem science on a species, then evaluates this information against the program's conservation ethic to arrive at a recommendation of "Best Choices", "Good Alternatives" or "Avoid". The detailed evaluation methodology is available upon request. In producing the Seafood Reports, Seafood Watch® seeks out research published in academic, peer-reviewed journals whenever possible. Other sources of information include government technical publications, fishery management plans and supporting documents, and other scientific reviews of ecological sustainability. Seafood Watch® Fisheries Research Analysts also communicate regularly with ecologists, fisheries and aquaculture scientists, and members of industry and conservation organizations when evaluating fisheries and aquaculture practices. Capture fisheries and aquaculture practices are highly dynamic; as the scientific information on each species changes, Seafood Watch's sustainability recommendations and the underlying Seafood Reports will be updated to reflect these changes.

Parties interested in capture fisheries, aquaculture practices and the sustainability of ocean ecosystems are welcome to use Seafood Reports in any way they find useful. For more information about Seafood Watch® and Seafood Reports, please contact the Seafood Watch® program at Monterey Bay Aquarium by calling 1-877-229-9990.

Disclaimer

Seafood Watch® strives to have all Seafood Reports reviewed for accuracy and completeness by external scientists with expertise in ecology, fisheries science and aquaculture. Scientific review, however, does not constitute an endorsement of the Seafood Watch® program or its recommendations on the part of the reviewing scientists. Seafood Watch® is solely responsible for the conclusions reached in this report.

Seafood Watch® and Seafood Reports are made possible through a grant from the David and Lucile Packard Foundation.

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I. Executive Summary

Swordfish (*Xiphias gladius*) is a highly migratory species (HMS) distributed throughout the world's oceans. While some swordfish is caught by U.S. fisheries, the majority of the swordfish in the marketplace is imported. In this report, the worldwide fleets catching swordfish other than the U.S. fishery are referred to as "international."

As a species with an early age at maturity and moderate longevity, swordfish is inherently resilient to fishing pressure. For stock assessment purposes, there are eight swordfish stocks in the world's oceans: the northeastern Pacific, southeastern Pacific, southwestern Pacific, northwestern Pacific, North Atlantic, South Atlantic, Indian Ocean, and Mediterranean Sea. Swordfish stocks are healthy in the northeastern Pacific and southeastern Pacific, as the stocks are not overfished and overfishing is not occurring and biomass is greater than the biomass at which maximum sustainable yield (MSY) is produced. Abundance trends are also increasing in these regions. In the North Atlantic, the swordfish stock has been declared "rebuilt" by The International Commission for the Conservation of Atlantic Tunas (ICCAT). Biomass is slightly above that at which MSY is produced, and overfishing is not occurring. However, if catch levels increase in the upcoming years, the stock could experience subsequent declines, so Seafood Watch recommends that this stock be monitored closely. For now, this stock is considered a low conservation concern. There is no robust stock assessment for swordfish in the northwestern Pacific, and there is a paucity of data concerning stock status in this region. Therefore, this stock is considered unknown and a moderate conservation concern. The southwestern Pacific stock is a moderate concern due to model uncertainty and declining CPUEs (catch per unit effort), and the south Atlantic stock is also a moderate conservation concern due to high uncertainty in the results of the stock assessment. Overfishing is occurring in the Mediterranean and is likely occurring in the Indian Ocean. Thus these stocks are considered of high conservation concern.

Swordfish is most commonly caught with longlines, although there is some catch with drift gillnets, handlines, and harpoons. The level of bycatch in the swordfish fisheries varies according to gear type. Pelagic longlines catch a number of incidental species, including endangered and threatened sea turtles, seabirds, marine mammals, sharks, and billfish. The Hawaii and U.S. Atlantic longline fisheries have observer data demonstrating that their fishery has declining bycatch trends, or evidence that bycatch levels are not contributing to the decline of the species, and are therefore considered to be of high conservation concern (rather than critical) for the bycatch criterion; all other pelagic longline fisheries are considered to have critical bycatch levels. Bycatch in the California drift gillnet fishery is a high conservation concern due to the take of protected species such as marine mammals; however, bycatch rates have declined in this otherwise well-managed fishery. Very high bycatch of leatherback sea turtles in the South American drift gillnet fishery is believed to be contributing to declines in the endangered sea turtle's population, making bycatch a critical conservation concern in this fishery. There are negligible bycatch concerns associated with the handline and harpoon fisheries.

All gear used to catch swordfish have minimal habitat effects, as they have no contact with the ocean bottom. However, the ecosystem effects of removing large predators such as swordfish are not understood. Combined with the benign habitat effects of swordfish gear, the uncertainty surrounding ecosystem effects of the swordfish fisheries results in a moderate conservation concern for pelagic longlines and a low conservation concern for handline, harpoon, and drift gillnet gear for the habitat and ecosystem impacts criterion.

International management bodies evaluate the status of highly migratory fish stocks (those that are found in international waters or cross national boundaries) and recommend management actions that are then enacted by the member nations for their own fleets. International management bodies for swordfish include the International Commission for the Conservation of Atlantic Tunas (ICCAT) in the Atlantic Ocean (including the Mediterranean Sea), the Inter-American Tropical Tuna Commission (IATTC) in the eastern Pacific Ocean, the Western and Central Pacific Fisheries Commission (WCPFC) in the western and central Pacific (WPCO), and the Indian Ocean Tuna Commission (IOTC) in the Indian Ocean. Regulations are generally based on recommendations by the staff or scientific committees of the commissions, and implemented by the member and cooperating countries. In the Atlantic, the U.S. fishery is managed under the Fishery Management Plan (FMP) for Atlantic Tunas, Swordfish, and Sharks under the Highly Migratory Species (HMS) division of the National Marine Fisheries Service (NMFS). In the U.S. exclusive economic zone (EEZ) around Hawaii and the U.S. Pacific Islands, swordfish is managed by the Western Pacific Fishery Management Council (WPFMC) under the Pelagics Fishery Management Plan. Swordfish on the U.S. west coast is managed by the Pacific Fishery Management Council under the Highly Migratory Species Fishery Management Plan. Management of swordfish is complicated by the fact that individual countries may have more or less stringent regulations than those of the international management bodies. U.S. and Canadian management of the swordfish fisheries is deemed highly effective due to adequate enforcement, reporting, and bycatch mitigation efforts. In the international swordfish fisheries, many nations have no comprehensive enforcement plan, and most have no comprehensive bycatch mitigation plan. The international fleets are thus characterized as only moderately effective management, with the exception of the Mediterranean. While there is a stock assessment in the Mediterranean, there is no evidence of a bycatch reduction plan, catches exceed F_{MSY} , and management has not maintained stock productivity. Therefore management in this region is a high conservation concern for the handline and harpoon fisheries and a critical conservation concern for the longline fishery.

Overall, all harpoon and handline-caught swordfish from the U.S. Atlantic, Hawaii, Canada, North Atlantic and Eastern Pacific are recommended as **Best Choices**. Harpoon or handline-caught swordfish from the international fleets of the Indian Ocean, Southwest Pacific, Western and Central Pacific, Northwest Pacific, and South Atlantic are all recommended as **Good Alternatives**. All U.S. longline-caught swordfish and California drift gillnet-caught swordfish are also recommended as **Good Alternatives**. Swordfish from the Mediterranean (all gear types) is recommended as **Avoid** due to poor stock status and ineffective management. Swordfish from international longline fleets and the South American drift gillnet fleet is also recommended as **Avoid** because of concerns related to bycatch.

The North West Atlantic Canada haroon fishery has been certified as sustainable to the Marine Stewardship Council (MSC) standard. The MSC is an independent non-profit organization, which has developed an environmental standard for sustainable and well-managed fisheries. It uses a product label to reward environmentally responsible fishery management and practices (<http://www.msc.org/>).

This report was updated on January 7, 2011. Please see Appendix I for a summary of changes made at this time.

Table of Sustainability Ranks

Sustainability Criteria	Conservation Concern			
	Low	Moderate	High	Critical
Inherent Vulnerability	√			
Status of Stocks	√ • Eastern Pacific • North Atlantic	√ • NW Pacific • South Atlantic • SW Pacific	√ • Mediterranean • Indian Ocean	
Nature of Bycatch	√ • Harpoon • Handline		√ • Hawaii longline • U.S. Atlantic longline • California drift gillnet	√ • International longline • South Am. gillnet
Habitat & Ecosystem Effects	√ • Harpoon • Handline • Drift gillnet	√ • Longline		
Management Effectiveness	√ • U.S. • Canada	√ • International (EPO, NW Pacific, North Atlantic, South Atlantic) • Indian Ocean • SW Pacific	√ • Mediterranean (harpoon & handline)	√ Mediterranean (longline)

About the Overall Seafood Recommendation:

- A seafood product is ranked **Best Choice** if three or more criteria are of Low Conservation Concern (green) and the remaining criteria are not of High or Critical Conservation Concern.
- A seafood product is ranked **Good Alternative** if the five criteria “average” to yellow (Moderate Conservation Concern) OR if the “Status of Stocks” and “Management Effectiveness” criteria are both of Moderate Conservation Concern.
- A seafood product is ranked **Avoid** if two or more criteria are of High Conservation Concern (red) OR if one or more criteria are of Critical Conservation Concern (black).

Overall Seafood Recommendation

Seafood Watch® Recommendation	Where Caught and Gear Used
Best Choices 	Harpoon or handline (North Atlantic, eastern Pacific, U.S. Atlantic, Hawaii, Canada)
Good Alternatives 	California drift gillnet
	Harpoon or handline (Southwest Pacific, Indian Ocean, international western and central Pacific, international northwest Pacific, international South Atlantic)
	U.S. Atlantic and Hawaii longline
Avoid 	International longline
	South American drift gillnet
	Mediterranean (all gears)

Common acronyms and terms

CPUE	Catch per unit effort
EEZ	Exclusive Economic Zone
EPO	Eastern Pacific Ocean
ETBF	Eastern Tuna and Billfish Fishery
FFA	Forum Fisheries Agency
FMP	Fishery Management Plan
FR	Federal Rule
HMS	Highly Migratory Species
IATTC	Inter-American Tropical Tuna Commission
ICCAT	International Commission for the Conservation of Atlantic Tunas
IOTC	Indian Ocean Tuna Commission
IUU	Illegal, unreported, and unregulated
MSY	Maximum sustainable yield
NEI	Nowhere else included. These landings are mostly flag of convenience landings, which is when a vessel from one country flies a flag from another country.
NMFS	National Marine Fisheries Service
PFMC	Pacific Fishery Management Council
SCRS	Standing Committee on Research and Statistics
SPC	Secretariat of the Pacific Community
SBR	Spawning biomass ratio
WCPO	Western and Central Pacific Ocean
WPFMC	Western Pacific Fishery Management Council

Drift Gillnet: A gillnet is a large mesh net or curtain of netting that hangs vertically in the water column at various depths; it is attached to a weighted leadline at the bottom and a buoyed floatline at the surface. The netting is almost invisible to fish as they swim into it, and the mesh spaces are large enough for a fish's head (of target size) to pass through but not its body. As the fish tries to back out, its gills are entangled in net, giving the net its name. The gillnet is attached to a vessel at one end and a spar buoy affixed with a radar reflector and strobe light at the other. Drift gillnet trips range from one night to one month, and the net is deployed at sunset and hauled in at sunrise (Hanan et al. 1993; PFMC 2003).

Handline: In handlining, fishermen hold a fishing line in their hand, which can have one to several hooks attached to it. To attract fish, the fishermen use artificial lures or bait. Lines are pulled in as soon as a fish takes the bait, thus any unwanted fish can be released immediately, minimizing unwanted bycatch.

Harpoon: Harpooning is a traditional method for catching large, pelagic predatory fishes, such as bluefin tuna and swordfish, which is still used today. When a harpooner spots a fish, he or she thrusts or shoots a long aluminum or wooden harpoon into the animal and hauls it on board. Harpooning is an environmentally responsible fishing method as fishermen visually identify the species and size of a targeted fish before killing it; thus, this method does not result in bycatch of unwanted marine life.

Longline: Longlines consist of a main horizontal fishing line that can be 50 – 65 nautical miles long. Smaller vertical lines with baited hooks are spaced intermittently along the main line, and can be rigged to fish at various depths depending on the target species and fishing conditions. The longlines used to target tuna are pelagic longlines, and are fished in the upper water column.

II. Introduction

The sharp pointed bill that gives the swordfish its name has attracted human curiosity from the odes of Aristotle and Pliny to fishermen's tales of captured fish ramming into the sides of wooden ships (Tibbo et al. 1961; Junger 1997). There is only one species of swordfish, *Xiphias gladius* (Linnaeus 1758), for which both the generic and species names mean "sword": xiphos in Greek; and gladius in Latin. Swordfish is the only species in the family Xiphiidae (Nelson 1984 in Froese and Pauly 2006; Nakamura 1985; NOAA Fisheries 1997).

The sword is used for protection and for hunting their prey, leaving slash marks on the animals found in their stomachs (Tibbo et al. 1961; Nakamura 1985; Collette 1995 in Froese and Pauly 2006). Swordfish hunt from the surface to the murky bottom and from coast waters out to the open ocean. Their diet includes a variety of tunas, barracudas, squid, lancetfish, lanternfish, herring, and other fishes (Tibbo et al. 1961; Nakamura 1985). In eastern Australia, squid and various fishes have been found to be the most common prey items of swordfish (Young et al. 2006). Elucidating their feeding behavior can be used to identify important feeding and spawning grounds for different populations of swordfish.

Swordfish is globally distributed, and caught throughout its range (Table 1). The structure of different stocks within the Pacific Ocean is not completely understood (Grijalva-Chon et al. 1994). One recent study of mitochondrial DNA, however, distinguished between Northwest and Southwest stocks in the Pacific (Reeb et al. 2000). Fisheries data have been used to separate Northeast and Southeast stocks, and they are divided at approximately 5 degrees north latitude (Hinton 2003; IATTC 2004). In some studies, North Pacific or East Pacific stocks are lumped together. For management purposes, authorities recognize Northwest, Southwest, Southeast, and Northeast stocks in the Pacific Ocean.

Atlantic Ocean swordfish are separated into distinct stocks in the North Atlantic, South Atlantic, and Mediterranean (Alvarado-Bremer et al. 1996; Alvarado-Bremer et al. 1998; Chow and Takeyama 2000; Castro-Pampillon et al. 2002; Pujolar et al. 2002; Nohara et al. 2003). However, the exact location of the boundary between Mediterranean and North Atlantic stocks remains unclear (ICCAT Mediterranean 2003).

Pacific

In the eastern Pacific Ocean (EPO), swordfish is assessed separately for the North and South Pacific (Figure 1) (Hinton et al. 2005). Longliners catch the majority of swordfish in the Pacific (Figure 2) (IATTC 2004). In Japan, more than 90% of the catch is by longline (Uozumi and Uosaki 1998); in Australia, almost all swordfish are caught by longlining (AFMA 2003); and in Chile the industrial fleet for swordfish consists of 72% pelagic longliners (Barbieri et al. 1998). Total catches are less for drift gillnets, but their use continues throughout California, Mexico, and Chile. Artisanal gillnetters are able to fish year-round even in bad weather (Barbieri et al. 1998). Catches by drift gillnets and harpoons are minor compared to longline catches (IATTC 2004). The California driftnet fleet fishes close to shore primarily between San Diego and San Francisco from August through January (Holts and Sosa-Nishizaki 1998; Barlow and Cameron 2003).

Figure 1. Delineation of the North and South Pacific swordfish assessment in the EPO (Figure from Hinton et al. 2005).

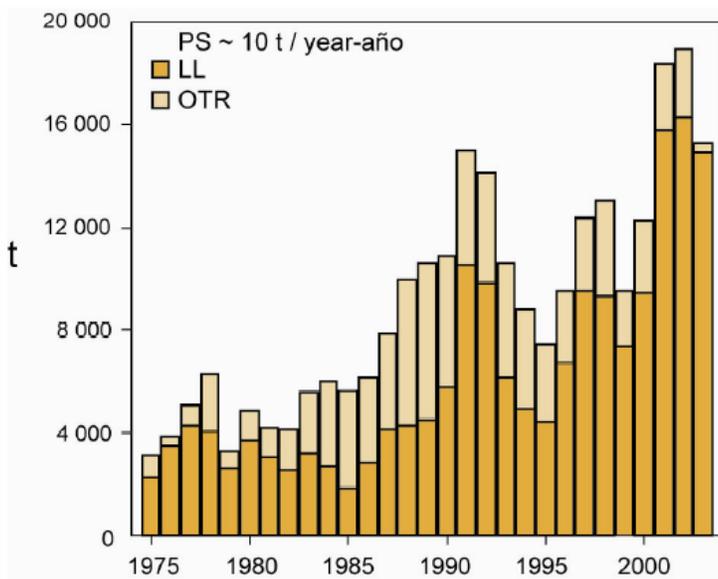
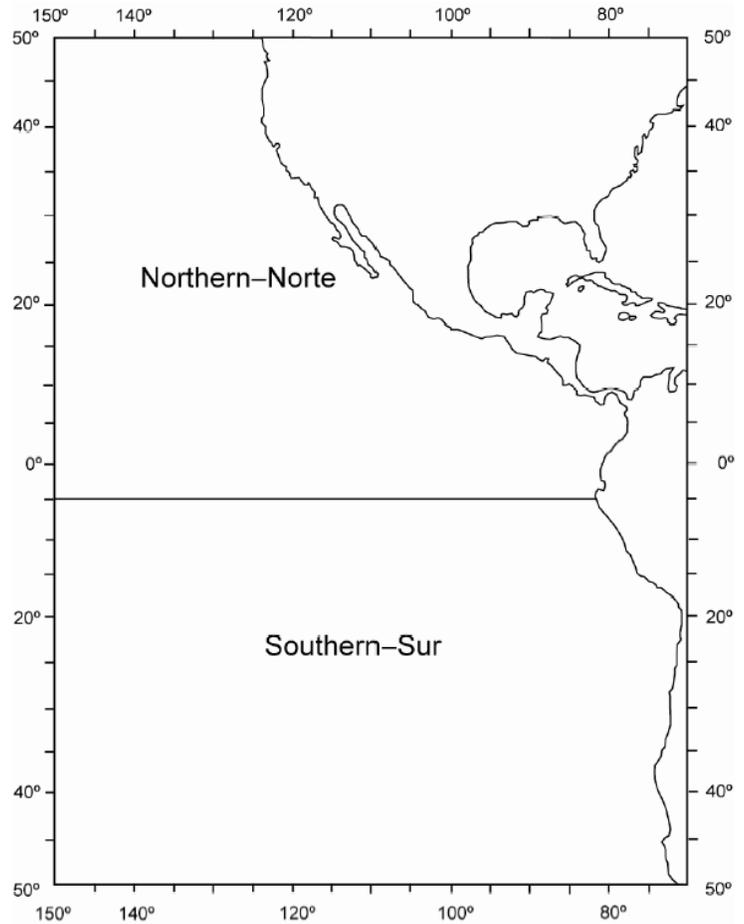


Figure 2. Longlines are the most common gear used to catch swordfish in the EPO. OTR = other unknown gears (Figure from IATTC 2005).

Chile began a harpoon fishery for swordfish

in 1930 that continues to the present day alongside the more dominant longline and driftnet fisheries (Barbieri et al. 1998; Davenport et al. 1993). Traditional harpoon fishing also continues in coastal Japan despite declines in catches (Uozumi and Uosaki 1995). This technique requires good weather and an abundance of large female swordfish basking at the surface (Barbieri et al. 1998; Ward et al. 2000). Japan first developed a distant-water longline fleet for tuna and swordfish in the 1950s, and was followed by Taiwan and Korea in the 1960s and Spain in the 1980s (Ward et al. 2000). During the 1980s, monofilament longline and driftnets also gained popularity. The Chilean government provided incentives to switch gears and Japanese driftnets focused on the Central North Pacific. Concerns about bycatch led to a United Nations ban on driftnets in international waters in 1993, although this ban did not apply to exclusive economic zones (EEZs), the Baltic Sea, or the Mediterranean (Northridge and Hoffman 1999 in Reeves et al. 2005). Before their ban, high seas driftnets were responsible for high numbers of marine mammal and other protected species bycatch (Hall et al. 2000).

Southwest Pacific longlining grew more slowly (the Southwest Pacific is delineated at 0 - 50°S and 140°E - 175°W). In Australian waters, Japanese vessels represented the bulk of effort until access was restricted by a 1979 bilateral agreement, which lapsed in 1997. Since then access has been limited to the growing Australian domestic fleet (AFMA 2003). Both Australian and New Zealand catches have been increasing since the late 1990s (Figure 3) (Kolody et al. 2006a), and Australian effort has moved offshore as a result of declining catches in inshore waters (Campbell and Hobday 2003).

North Pacific fishing nations include Japan, Taiwan, Mexico, the Philippines and the United States (Ward et al. 2000). The Japanese longline fleet accounts for the largest catch in the Pacific, even though swordfish is its secondary target; tuna is the primary target of Japanese longliners (Nakano 1998). Canada does not have a commercial fishery for swordfish in the North Pacific (ISC 2004; L. Mijacika pers. comm.). Southeast Pacific fishing nations includes Chile, Peru, Spain, and Ecuador (Ward et al. 2000); from 1987 to 1994, 80% of the Southeast Pacific catch was taken by Chile (Barbieri et al. 1998).

The U.S. longline fleet fishes on the high seas and is based primarily in California and Hawaii. The Hawaii fleet sets only about 2.7 % of the longline hooks set in the entire Pacific each year, and California sets even fewer (Cousins et al. 2000). As of early 2004, shallow-set longlining for swordfish was prohibited on the high seas for vessels based on the West Coast, to protect endangered sea turtles (Federal Register 2004). The twenty-one affected vessels will likely relocate to Hawaii or modify their gear to target tuna.

Western and Central Pacific waters are fished by distant-water and domestic longliners from Japan, South Korea, Taiwan, Fiji, Australia, New Caledonia, New Zealand, Solomon Islands, and French Polynesia (AFMA 2003).

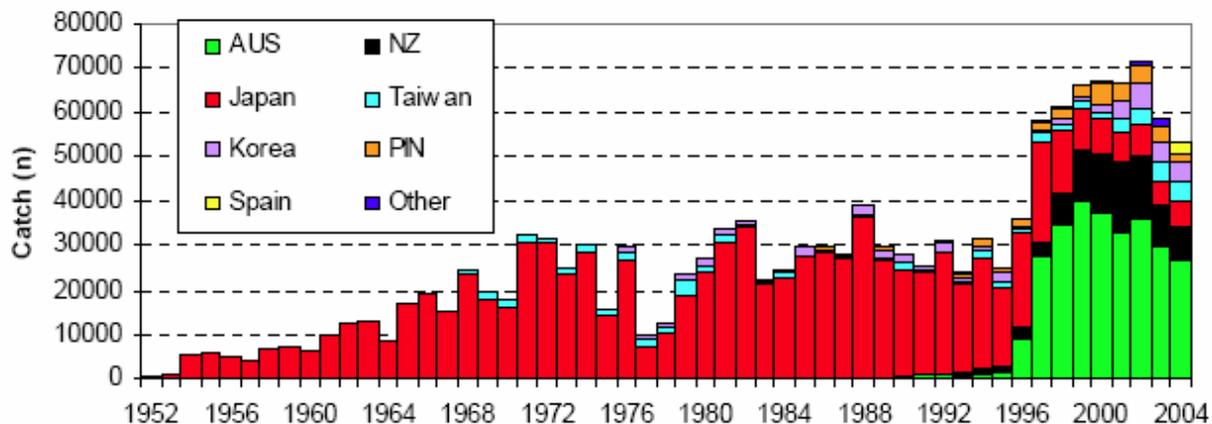


Figure 3. Swordfish catch in the SW Pacific Ocean, 1950 – 2004 (Figure from Kolody et al. 2006a).

Atlantic

Atlantic Ocean swordfish is separated into distinct stocks in the North Atlantic, South Atlantic, and Mediterranean (Alvarado-Bremer et al. 1996; Alvarado-Bremer et al. 1998; Chow and Takeyama 2000; Castro-Pampillon et al. 2002; Pujolar et al. 2002; Nohara et al. 2003). However, the exact location of the boundary between the Mediterranean and North Atlantic stocks remains unclear (ICCAT Mediterranean 2003).

North Atlantic swordfish was first caught in the 1800s in a summer harpoon fishery from Canada to Long Island (Berkeley et al. 1989; Tobias 1989). This fishery continued at a low level until the global expansion of longline fisheries in the 1950s and 1960s (Myers and Worm 2003). At this time incidental catches of swordfish in the Japanese tuna fleet and Norwegian shark fleet spurred the first targeted longlining for swordfish along the east coast of North America (Berkeley et al. 1989; Tobias 1989). Growth in the longline industry has continued until the present day, making pelagic longlines the most widespread fishing gear in the world (Myers and Worm 2003).

Most swordfish is captured with pelagic longline gear, which can be modified to target tunas, swordfish, or sharks depending on the season (Weidner 1999). Swordfish is also caught in mid-water gillnets in the Mediterranean and South Atlantic (Ashe 1996; Silvani et al. 1999). Pelagic trawl nets were used briefly in the Northwest Atlantic but the fishery was limited to tuna in 1992 (Gerrior et al. 1994). The United States swordfish catches by harpoons, handlines, and trawl remained less than 1% each of longline catches in the Northwest Atlantic from 1998 – 2002 (NOAA Fisheries 2003). Sport fishermen from the U.S. caught 48.3 mt of swordfish by rod and reel in the Northwest Atlantic in 2002, or 4.3% of longline landings and discards.

In the North Atlantic, swordfish is caught primarily by Spain (European Union) (45%), the United States (20%), Portugal (11%), and Canada (10%) (ICCAT 2005). Swordfish catches in the Atlantic have increased overall since 1950, but have been declining since about the mid-1990s (Figure 4).

In the South Atlantic, swordfish landings are distributed between a greater number of participating countries, with seven nations reporting catches between 100 and 1,000 mt each. South Atlantic

swordfish are primarily caught by Spain (European Union) (43%), Brazil (24%), and Uruguay (9%), with each country catching more than 1,000 mt in 2002 (data from ICCAT Atlantic 2003). Fisheries developed along the east coast of the U.S. and the Gulf of Mexico in 1980 and in the Caribbean in 1983, with eventual expansion to Venezuela after overfishing in the Straits of Florida depressed catches (Berkeley et al. 1989; Tobias 1989). South Atlantic swordfish were not targeted on a large scale until North Atlantic catches began to decline (NOAA Fisheries 1997). Brazilian landings remained below 500 mt until the 1980s; however, Brazil's government now encourages exploitation of pelagic fisheries to stimulate economic growth and divert pressure from coastal and freshwater resources (FIGIS 2001). The current South Atlantic swordfish fleet is a mix of nationally-owned vessels and vessels leased from international corporations originating in Japan, Taiwan, and Spain (Lessa et al. 1999; FIGIS 2001). Brazil's government has also promoted joint ventures with overseas companies in response to the expansion of foreign fleets in South Atlantic waters (FIGIS 2001). In summary, Atlantic-wide catches of swordfish are dominated by Spain, Brazil, and the United States, in that order (ICCAT Atlantic 2003). The Spanish longline fleet operates on a global scale in the Atlantic, Pacific, and Indian Oceans (Raymakers and Lynham 1999).

Canadian swordfish catch is from the Atlantic (1,584 mt in 2005), with no swordfish landed by Canadian vessels in the Pacific in 2005 (DFO 2006); 90% of the Canadian Atlantic catch is exported to the U.S. (DFO 2005). Swordfish is managed under the Canadian Atlantic Swordfish and Other Tunas 2004 – 2006 Integrated Fisheries Management Plan (IFMP) (DFO 2005). In the Gulf of Mexico, the Mexican longline fleet primarily targets yellowfin tuna, although swordfish may be caught incidentally.

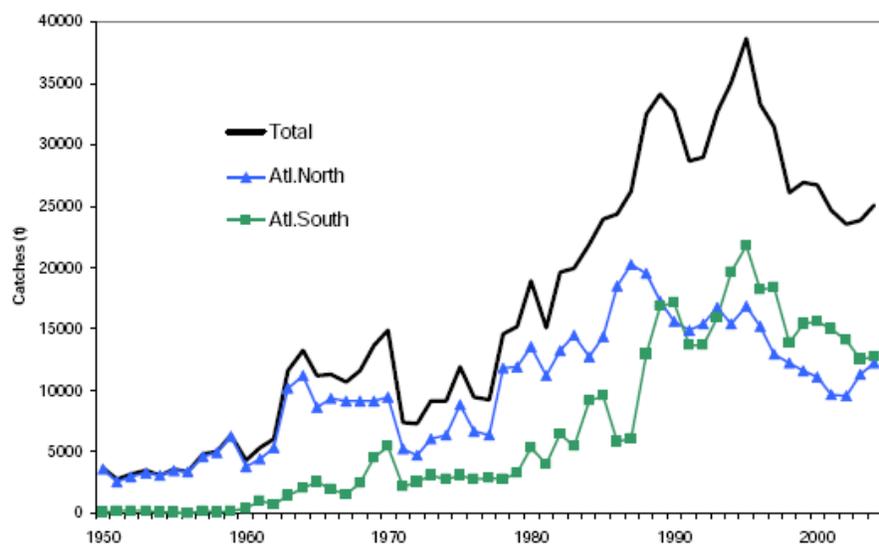


Figure 4. Total catches of swordfish in the Atlantic, including discards, 1950 – 2004 (Figure from ICCAT 2005).

Mediterranean

Mediterranean swordfish have been hunted with harpoons since ancient Greek and Roman times. The first longlines in the Mediterranean were set at the beginning of the twentieth century (Macías et al. 2004), though catch levels remained below 1,000 mt until 1970 (Figure 5) (NOAA Fisheries 1997; ICCAT Mediterranean 2003). Longlining expanded throughout the Mediterranean during the 1960s and 1970s, with stable landings through the 1980s (Macías et al. 2004). Total Mediterranean swordfish catches are comparable to totals from the North Atlantic despite being drawn from a much smaller geographic area (ICCAT Atlantic 2003). For Mediterranean longliners, swordfish is the target species for much of the year (Macías et al. 2004). From 1997 – 2001, Mediterranean swordfish were caught

primarily by Italy (46%), Morocco (22%), Greece (10%) (European Union), and Spain (9%) (European Union) (ICCAT 2007).

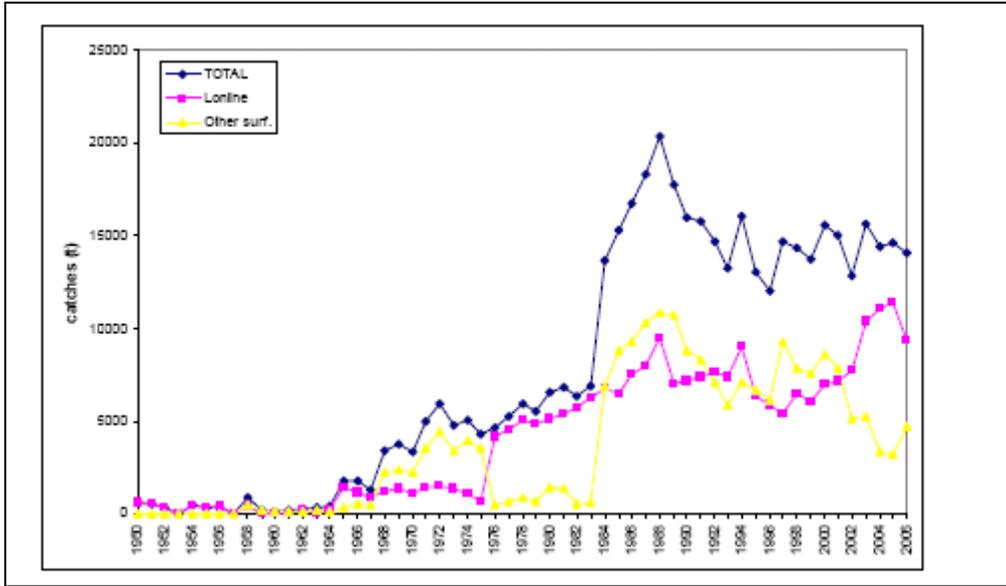


Figure 5. Catches of Mediterranean swordfish, 1950 – 2004 (Figure from ICCAT 2005).

Indian Ocean

Swordfish catch increased greatly around 1990, when fleets began targeting swordfish rather than retaining them as bycatch in the longline fleets targeting tuna (Figure 6) (IOTC 2006). According to the Indian Ocean Tuna Commission (IOTC 2006), the most common gear used to catch swordfish in the Indian Ocean are longlines (95%) and gillnets (5%). Catch data from 2004 suggest that 90% of catches is with longlines, while 10% is not listed (IOTC 2005). Fleets targeting swordfish in the Indian Ocean include those from Taiwan, Australia, Reunion Island, Seychelles, and Mauritius, as well as Atlantic countries such as Spain and Portugal (IOTC 2006).

Figure 6. Swordfish catches in the Indian Ocean, where most of the catch is dominated by longlines, with a smaller amount caught by gillnets (Figure from IOTC 2006).

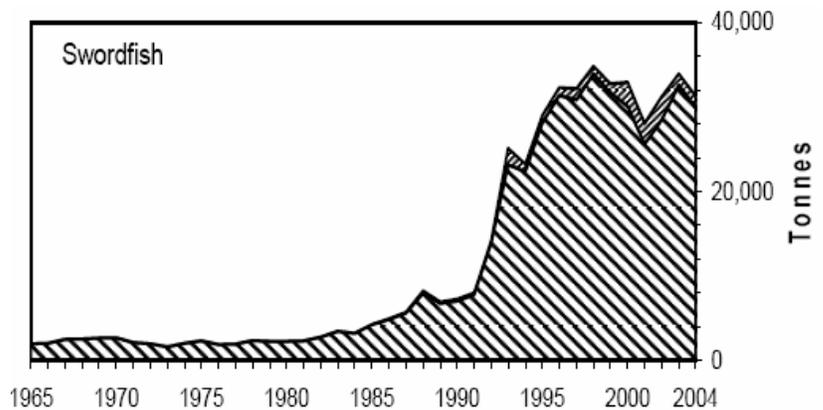


Table 1. Swordfish catch by region, country, and gear. Catch data are from 2004.

Region	Catch	Fishing Countries	Gears Used	Sources
EPO	18,893 mt (18.0% of total catch)	Spain (35%); Chile (22%); Japan (21%); USA (6%); China (5%); Korea (3%); Costa Rica (3%); Panama (3%); Ecuador, Mexico, French Polynesia, El Salvador, Peru, Nicaragua (< 1% each)	Longline (86%); other (14%)	IATTC 2005
NW Pacific	12,506 mt (12.0% of total catch)	Taiwan (47%); Japan (38%); California (10%); Hawaii (2%)	Longline (97%); gillnet (2%); harpoon (1%)	ISC 2004
SW Pacific	3,529 mt (3.4% of total catch)	Australia (51%); New Zealand (15%); Taiwan (12%); Japan (9%); Korea (6%); Spain (4%); Pacific Island Nations (3%); Others (<1%)	Data not available	Anonymous, pers. comm.
North Atlantic	11,867 mt (11.4% of total catch)	Spain (45%); USA (20%); Portugal (11%); Canada (10%); Japan (5%); Maroc (3%); UK (2%); France, Trinidad & Tobago, Grenada, China, Venezuela, Mexico, Taiwan, Philippines, Sta. Lucia, Ireland (< 1% each)	Longline (97%); other surface gear (3%)	ICCAT 2005
South Atlantic	12,778 mt (12.2% of total catch)	Spain (43%); Brazil (24%); Uruguay (9%); Taiwan (6%); Namibia (4%); Japan (4%); Portugal (3%); Ghana (3%); South Africa (2%); China (2%); Republic of Korea, Cote d'Ivoire, USA, Philippines (< 1% each)	Longline (96%); other surface gear (4%)	ICCAT 2005
Mediterranean	13,213 mt (12.7% of total catch)	Italy (53%); Maroc (25%); Greece (8%); Spain (7%); Algerie (4%); Malta (2%); Portugal, Cyprus, France (< 1% each)	Longline (75%); other surface gears (25%)	ICCAT 2005
Indian Ocean	31,600 mt (30.3% of total catch)	Taiwan (36%); Spain (15%); NEI-deep freezing (10%); Indonesia (8%); Japan (4%); Seychelles (3%); France (3%); Australia (2%); China (2%); NEI-fresh tuna (2%); Republic of Korea (1%)	Longline (90%); unaccounted for (10%)	IOTC 2005

Scope of the analysis and the ensuing recommendation:

This analysis encompasses the global swordfish fishery, and makes a recommendation on that which is prevalent in the U.S. market. The recommendation includes US (Hawaii and North and South Atlantic) and international longline and harpoon and handline fisheries, and the California and South American drift gillnet fisheries. Due to a lack of available information and because it represents a small proportion of the global fishery, the Mexican drift gillnet fishery is not included in this recommendation.

Availability of Science

Constraints on available abundance information for swordfish limit the assessment and management of this species as well as of other highly migratory large pelagic fishes (McAllister et al. 2003). Fishery-independent time series data are also lacking and fishery-dependent time series data are affected by possible biases caused by changes in targeting, gear, spatial distribution, and other factors (Ward et al. 2000; ICCAT Atlantic 2003). Some biological data, such as natural mortality rates, are also uncertain (Kolody et al. 2006a).

South Atlantic swordfish have been assessed in the past by the International Commission for Conservation of Atlantic Tunas (ICCAT). In 2002, ICCAT was unable to produce a new stock assessment, however, due to the paucity of data for several of the most important swordfish fishing fleets. Existing data show conflicting trends (ICCAT Atlantic 2003). At the 2006 assessment, this problem continued; data from the fisheries targeting swordfish gave a more optimistic trend than the data from the fisheries that catch swordfish incidentally.

The Mediterranean swordfish stock is better understood than the South Atlantic stock, but lack of historical data prevents a complete stock assessment from being carried out for this region as well (ICCAT Mediterranean 2003). Stock assessments for the Southeast Pacific are likewise unreliable because of uncertainty in artisanal catch estimates (Ward et al. 2000), and very little information was found for this report for the Northwest Pacific. Additionally, limited information was found on country-specific management of swordfish fisheries apart from that related to the United States.

Limited information was also found for this report on bycatch interaction rates for non-U.S. North Atlantic fleets, South Atlantic fleets, and Mediterranean fleets. Available bycatch data in general are limited for the South Atlantic. At-sea observers are thought to be the most reliable source of data on both catch and bycatch. North Pacific bycatch data for albatrosses and petrels are available only for the U.S. fishery in Alaska and Hawaii (Cooper 2000). In the western and central Pacific, bycatch estimates are uncertain because of conflicts between logbook and observer data (PFMC 2003). No information was found for this report on sea turtle, marine mammal, seabird, or billfish bycatch in the Chilean fishery. Little information was found on stock status, management, or bycatch levels in Panama or Mexico.

Market Availability

Common and market names:

Swordfish is also known as broadbill, broadbill swordfish, espada, and emperador.

Seasonal availability:

Swordfish is available year-round in the U.S. market, with peak landings in early fall. Freshly-landed swordfish are available in the Northeast United States from July to October, while swordfish may be caught in Hawaii throughout the year (Pacific Seafood Group 2001). Swordfish caught in California waters are generally destined for U.S. restaurants (PFMC 2005).

Product forms:

Swordfish is available as fresh or frozen steaks, fillets, and loins. Fresh, whole swordfish that have been headed and gutted are known as “bullets.” Frozen sashimi-quality fish are known as “clipper” swordfish (Pacific Seafood Group 2001).

Import and export sources and statistics:

Most of the swordfish available in the U.S. is imported (Figure 7) (NMFS 2006a). Domestically, swordfish is landed primarily in California (43%), followed by a number of other states (Figure 8) (NMFS 2006a); however, prior to the closure of the Hawaii-based swordfish fishery (in April 2001 and again in April 2006), due to high sea turtle interactions, Hawaii was the primary component of U.S. swordfish catch (Figure 9) (NMFS 2006a).

In 2005, swordfish was imported from 34 countries, including Singapore (27%), Canada (12%), Panama (12%), Chile (9%), Mexico (6%), and Brazil (5%), as well as Australia, Uruguay, South Africa, Costa Rica, Ecuador, Indonesia, and Vietnam ($\leq 5\%$ each). Other smaller importers included New Zealand, Trinidad and Tobago, Venezuela, Cook Islands, Taiwan, Malaysia, Japan, Pakistan, China, Thailand, Honduras, Columbia, El Salvador, Peru, the Philippines, Fiji, Tonga, Nicaragua, Sri Lanka, and Grenada ($\leq 2\%$ each) (NMFS 2006a). While Singapore supplies the highest volume of swordfish imports to the U.S., this product is simply processed in Singapore and originates from other fishing fleets such as Taiwan; Singapore is in fact that largest importer and re-exporter of swordfish worldwide (HQ 735084 August 17, 1993; NOAA 2004).

Approximately 70% of Atlantic swordfish on the U.S. market is imported (NMFS 2006b). Another estimate for Pacific and Atlantic swordfish combined, by LeBlanc (2003), suggests that imports (by weight) are twice the amount of U.S. domestic landings. Mediterranean swordfish are not often found in the U.S. market (NMFS 2006a).

In 2003, 53% of swordfish imports were from the Pacific, 27% from the Indian Ocean, 19% from the Atlantic, and 1% “not provided” (NMFS 2005a). Trade monitoring requirements under NMFS include a prohibition on the sale of undersized swordfish in the U.S.; all swordfish imports must be accompanied by a Certificate of Eligibility (COE) that includes information on the origin and size of the swordfish (NMFS 2005b).

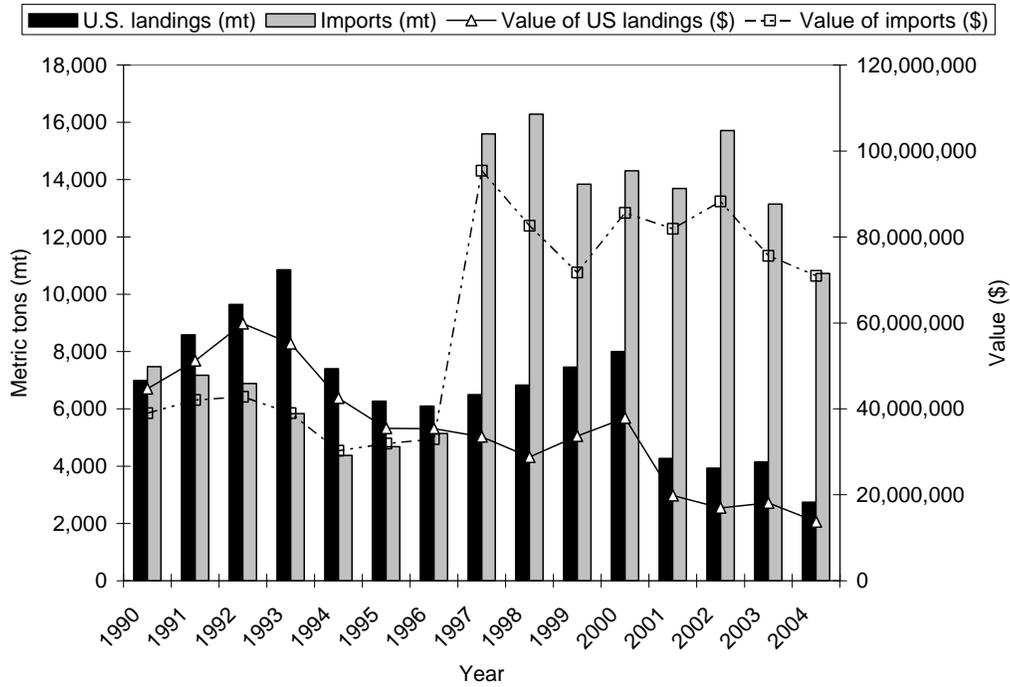


Figure 7. U.S. landings vs. imports of swordfish from 1990 – 2004 (Data from NMFS 2006a).

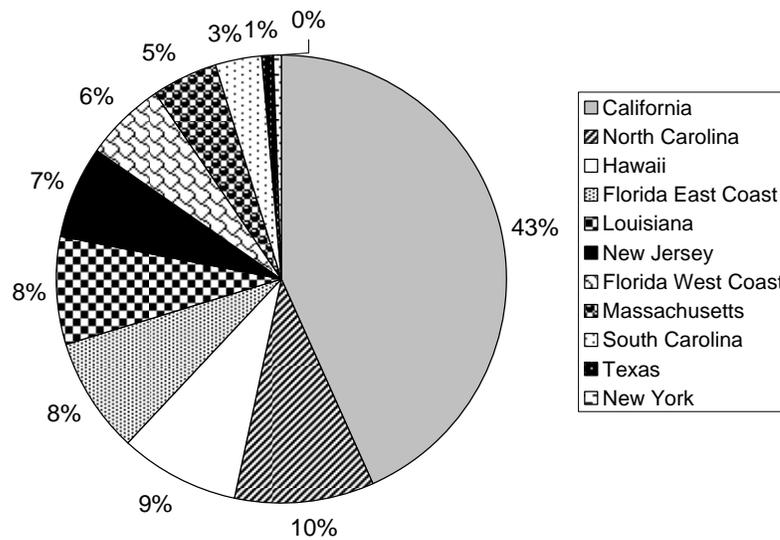


Figure 8. U.S. landings of swordfish in 2004 (Data from NMFS 2006a).

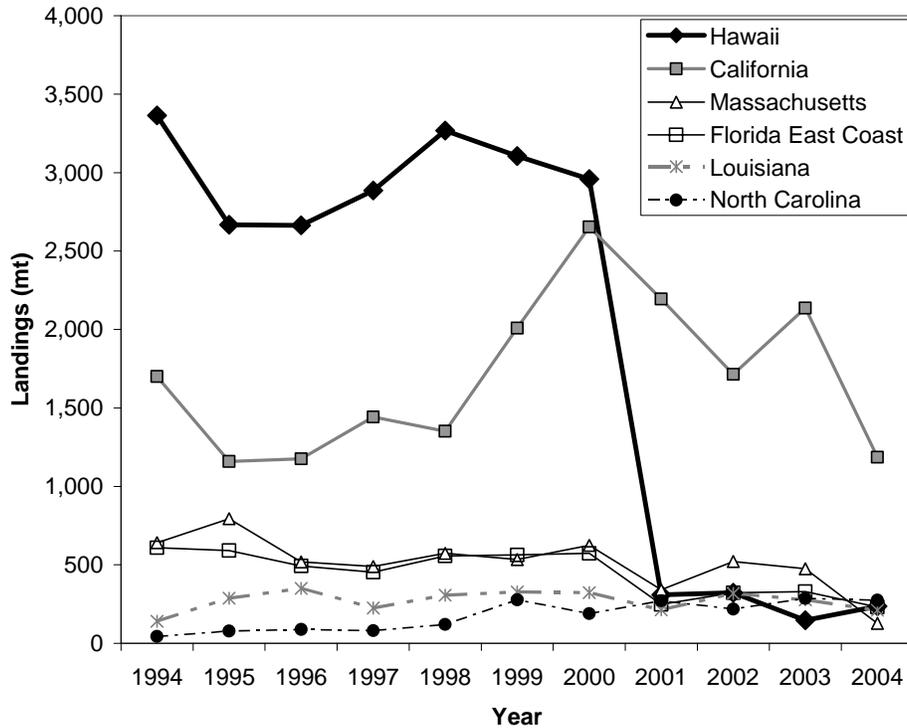


Figure 9. Trend in U.S. swordfish catches from 1994 – 2004. Hawaii and California are the primary states where swordfish is landed. Hawaii landings declined in 2001 when the fishery was closed due to sea turtle interactions (Data from NMFS 2006a).

III. Analysis of Seafood Watch® Sustainability Criteria for Wild-caught Species

Criterion 1: Inherent Vulnerability to Fishing Pressure

Swordfish exhibits moderate growth rates, longevity, and age at first maturity (Table 2). Fecundity for the species is high, with each female producing batches of between 1.5 and 8.7 million eggs, depending on age and size (Nakamura 1985 in Froese and Pauly 2006; Arocha 1997; Young et al. 2003). Off eastern Australia, female swordfish are mature at 150 cm fork length (FL) while males are mature at 90 cm FL (Young et al. 2003).

Females and males grow at different rates, but the species in general grows at a moderate to high rate compared to other fishes (Muus and Nielsen 1999 in Froese and Pauly 2006; Arocha 2003). The Von Bertalanffy growth coefficient (k) for swordfish has been estimated based on North Atlantic and Mediterranean males and females, and recent analysis comparing reports from different authors finds higher growth coefficients for males (range from 0.19 – 0.24) than for females (range from 0.094 – 0.21) (Arocha 2003). Swordfish populations likewise grow relatively rapidly; the intrinsic rate of increase (r) for North Atlantic swordfish is estimated to be between 0.41 and 0.56 by ICCAT researchers (McAllister et al. 1999; ICCAT 2003).

Age at first maturity also differs between sexes and is low to moderate compared with other fishes. Half the population of female swordfish is sexually mature at age 5 (range from 2 – 8 years) and half the population of male swordfish is sexually mature at age 3 (range from 2 – 6 years) (Arocha 1997 in NMFS Biological Opinion 2001). Although females grow faster, they mature later. Population models suggest that age at first capture must be high enough to protect the first two mature age classes for swordfish (age 5 and 6) to ensure a sustainable population (Au 1998).

The oldest swordfish found in a recent study were a 16-year-old female and a 12-year-old male (Arocha 2003). Another 10-year-old female was aged in a previous study (Alici and Oray 2001 in Froese and Pauly 2006). Swordfish ages are derived, with difficulty, from annual rings on fin rays rather than from otoliths (ear bones) (which are often used for age determination in other fishes) because the otoliths in swordfish are very small; also adult swordfish do not have scales (Muus and Nielsen 1999 in Froese and Pauly 2006).

Swordfish are highly migratory and globally distributed. Their range includes the Pacific, Atlantic, and Indian oceans, and multiple distinct stocks are found within each ocean basin (Froese and Pauly 2006). Limited satellite tracking of 29 individuals off the eastern United States recorded minimum travel distances of 2,500 kilometers (km) over the course of a month and a half (Sedberry and Loefer 2001). Swordfish travel between plateaus, seamounts, currents, and Gulf Stream fronts, and may migrate seasonally (Sedberry and Loefer 2001; Takahashi et al. 2003).

Spawning areas for the North Atlantic swordfish stock are widely distributed, with activity in the western and north-central Gulf of Mexico, Yucatan Channel, southern Florida and the southeastern United States, and northeastern Brazil (Govoni et al. 2003; F. Arocha, pers. comm.). However, the main spawning grounds for the North Atlantic swordfish stock are located southwest of the Sargasso Sea and northeast of the Lesser Antilles (F. Arocha, pers. comm.)

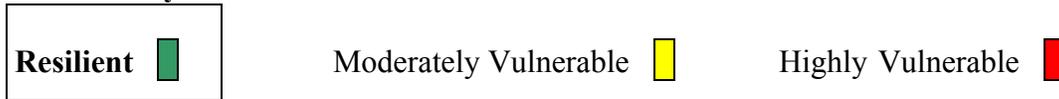
In contrast with other fish that form spawning aggregations, swordfish do not display any known behaviors that lead to increased vulnerability to fishing, though populations may be somewhat vulnerable because the largest individuals are female, and fisheries target larger individuals. In one study, all individuals greater than 210 cm were female and the proportion of females increased steadily in fish greater than 150 cm (Wang et al. 2003).

Table 2. Life history characteristics of swordfish.

Intrinsic Rate of Increase (r)	Age at Maturity	Growth Rate	Max Age	Max Size	Fecundity	Species Range	Special Behaviors	Sources
0.4	2 – 6 years for males; 2 – 8 years for females	k = 0.19 – 1.24 for males; k = 0.094 – 0.21 for females	16 years for females; 12 years for males	Max. published weight 650.0 kg	1.5 – 8.7 million eggs/batch	Pacific, Atlantic, and Indian Oceans	No special behaviors that increase ease of capture	Arocha 1997; McAllister et al. 1999; Arocha 2003; Froese & Pauly 2006

Synthesis

Swordfish are considered inherently resilient to fishing pressure because their populations grow relatively quickly. In addition, swordfish are characterized by an early to moderate age at first maturity, high growth rates, and moderate maximum age. Extremely high fecundity and a worldwide distribution also enable this species to support fishing pressure.

Inherent Vulnerability Rank:**Criterion 2: Status of Wild Stocks**

The stock status for swordfish varies by region (Table 3).

Eastern Pacific

The stock structure of swordfish in the Pacific Ocean is not well known, but there is evidence that there are two stocks in the Pacific, one in the EPO and one in the WCPO. It is also likely that there is a northern and southern stock of swordfish in the EPO (Hinton et al. 2004a); the stock status for each of these two stocks is described separately below. Swordfish in the EPO is officially considered not overfished by the IATTC because the CPUE on average is above that which corresponds to the abundance that would support MSY (Hinton et al. 2004a). According to the most recent SAFE (stock assessment and fishery evaluation) report, swordfish in the EPO is not overfished, overfishing is not occurring, and there is no evidence of declining abundance (Figure 10a, 10b) (PFMC 2005). In the EPO, standardized CPUE data are used to estimate abundance. Modeling and CPUE estimates suggest a stable biomass well above 50% of unexploited levels (Kleiber and Yokawa 2002; IATTC 2005). Based on length-frequency data, there were fewer large swordfish caught in the EPO longline fisheries in the 1990s and 2000s compared to the 1970s and 1980s (Hinton et al. 2004a).

Northeast Pacific

North Pacific swordfish catches were considered sustainable through the early 1980s (Ward et al. 2000), but MSY has not been estimated for Pacific swordfish (PFMC 2003). Landings for the Northeast Pacific increased from 1945 – 2002 with large fluctuations (IATTC 2004), while longline CPUEs have decreased over time in the North Pacific (Nakano 1998). However, a more recent analysis found relatively stable CPUEs for the Japanese longline fishery in this region (Hinton 2003). At the same time, drift gillnet CPUE from the Pacific swordfish fishery showed no trend for the Japanese fleet from 1977 – 1992 (Uosaki 1998). Catch and effort grew steadily to peak landings in 1984 and 1985, followed by a decline through 1993 (Holts and Sosa-Nishizaki 1998).

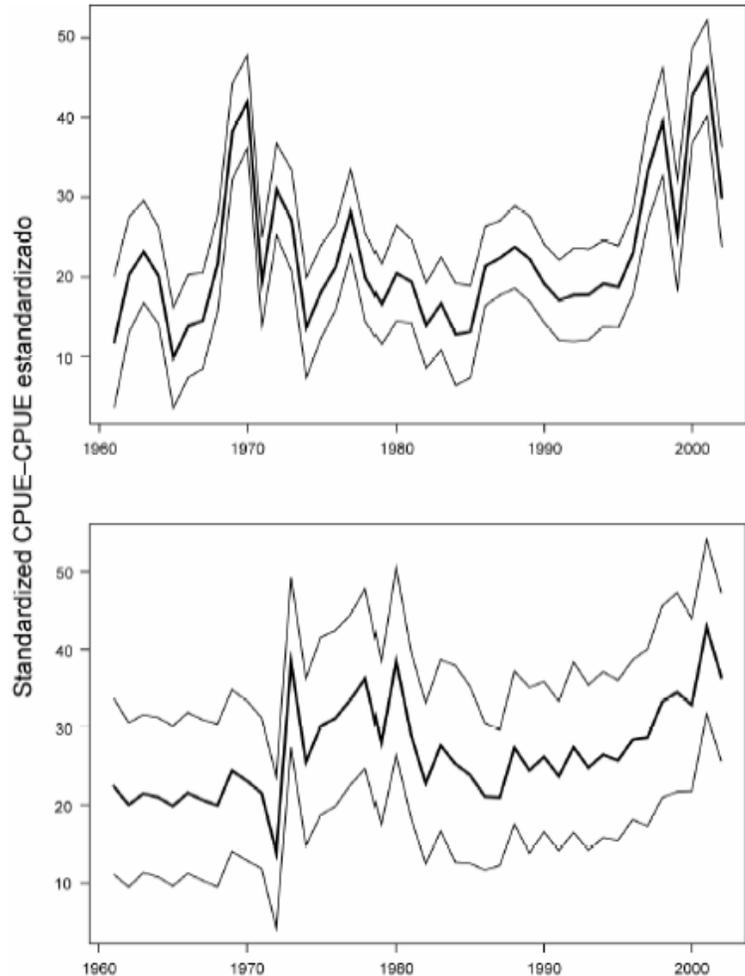
Southeast Pacific

Fishing pressure and catches in the Southeast Pacific increased sharply from 1998 – 2002, nearly doubling during that time period. Artisanal catches are not well known and add considerable uncertainty to the Southeast Pacific stock assessment (Ward et al. 2000). As the Southeast Pacific catch increased from 2,000 to 10,000 mt, fishermen saw a 30% decline in CPUE (Nakano 1998). During the same period, artisanal boats in Chile began to catch smaller fish, with a clear trend in decreasing fish weight (Barbieri et al. 1998). Chilean swordfish landings increased and then decreased between 1938 and approximately 1950. Catches remained flat until increasing briefly from 1985 – 1991 (Barbieri et al. 1998). As effort has increased in Chile, Peru, Ecuador, and Colombia, the fleet has been fishing farther offshore (Barbieri et al. 1998; Comision Permanente del Pacifico Sur 2004). CPUE declined from 1987 – 1994 with catches declining soon after (Barbieri et al. 1998). In the early 1990s, ICCAT limited

swordfish catches in the Atlantic in response to declining stocks. This led swordboats from Spain to shift their operations from the Atlantic to international waters off of Chile's EEZ, with subsidies from the European Union (ICTSD 2000).

Overall, although there is moderate uncertainty associated with the status of swordfish in the EPO, the stock is not overfished and overfishing is not occurring. Abundance trends are increasing in both the northern and southern EPO. The status of swordfish in the EPO is thus considered healthy, although there are concerns of increasing pressure in the southern EPO and this trend will need to be monitored closely.

Figures 10a, 10b. Relative swordfish abundance in the northern EPO (10a) and southern EPO (10b). 95% confidence intervals are included (Figure from Hinton et al. 2005).



Western and Central Pacific Ocean

Northwest Pacific

There is not a robust stock assessment for swordfish in the NW Pacific, and the most recent data for NW Pacific swordfish are from a number of different sources. Based on longline data from Japan, CPUE data are variable over time, and show declines in some areas but not others; some abundance estimates show a steady decline since the mid-1980s (ISC 2004). Based on the evidence of local depletions, there may be more than one swordfish stock in the NW Pacific (ISC 2004). It is recommended that the status of swordfish be closely monitored due to the observed declines (ISC 2004). A recent study using data

from the North Pacific suggested that any stock assessment for swordfish should address the sexual dimorphism of the species to reduce uncertainty (Wang et al. 2005).

Current stock assessments are highly uncertain, and stocks may have declined to below MSY (Ward et al. 2000). There are no robust estimates of B/B_{MSY} or F/F_{MSY} , and uncertainty remains high. Thus, the stock status of swordfish in the NW Pacific is deemed “Unknown” and of moderate conservation concern according to Seafood Watch® criteria.

Southwest Pacific

A stock assessment was completed for SW Pacific swordfish for the first time in 2005. Kolody et al. (2006a) ran several hundred models, and determined a 10 model “best plausible ensemble”—stock assessment information from these models is thus used to evaluate the stock status of SW Pacific swordfish. The 10 models that compose the “best plausible ensemble” give a range of estimates for B_{MSY} and F_{MSY} ratios, some more optimistic than others. The median value determined for SSB_{2004}/SSB_{MSY} was 3.4 (range of 0.75 – 6.4), and the median value for F_{2004}/F_{MSY} was 0.70 (range of 0.33 – 2.2). However, stock declines are projected for the short term for this stock based on 2004 effort data, and effort has declined since 2004. Evidence suggests that swordfish catch from the major fishing grounds, as well as the average size caught in the Australian longline fleet, is declining (Figure 11) (Kolody et al. 2006b). Estimates of the trend in biomass and F/F_{MSY} shown are from the preliminary assessment conducted in 2004 (Figures 12 and 13) (Kolody et al. 2006a).

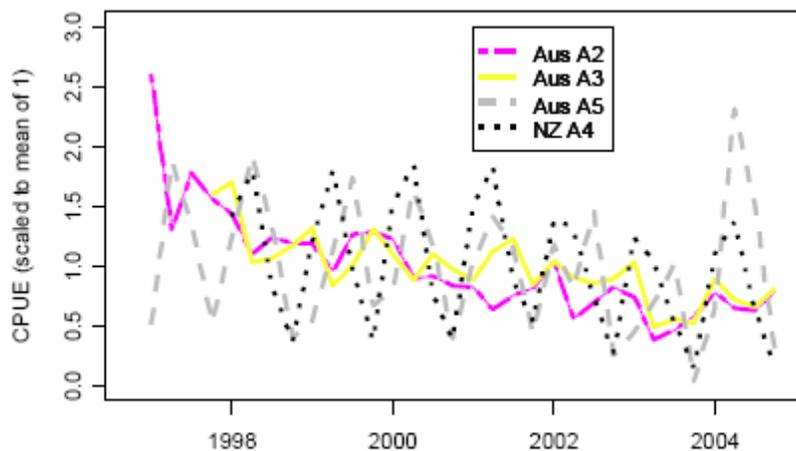
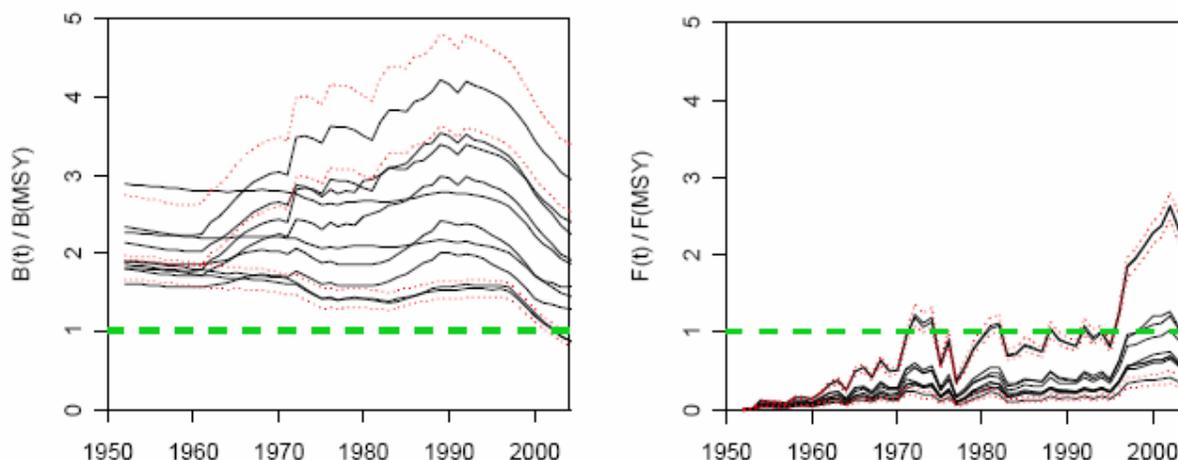


Figure 11. CPUE decline in the Australian and New Zealand fisheries (Figure from Kolody et al. 2006a).

The annual swordfish catch in the SW Pacific is thought to be on the order of 4,000 – 5,000 mt. Half of this catch may be attributable to distant-water tuna longliners (AFMA 2003). The status of SW Pacific swordfish stocks is thus uncertain, with “strong indications of localized depletion in inshore areas” (AFMA 2003). Pelagic longlining by Japan began in the 1950s, with catches of 1,000 mt per year. After Japanese fishing was phased out from 1979 – 1997, the Australian domestic fleet began to grow. New access to the United States market and a growing domestic Australian market provided ample opportunities for this fishery (Pogonoski et al. 2002). New Zealand also expanded its domestic fleet during the mid-1990s, and CPUE initially increased over time—however, these increases were a result in changes in targeting practices, rather than increased abundance (Nakano 1990). Swordfish effort in the SW Pacific notably expanded in 1996 with increasing catch rates in the first year (Pogonoski et al. 2002; AFMA 2003); however, swordfish catch rates dropped 25% and vessels began fishing farther offshore by 2000. Inshore CPUE continued to decline (AFMA 2003). In the Australian fishery in area 2

(the inshore fishery) in the SW Pacific, average swordfish size has generally been declining since 1998 (Kolody et al. 2006a). Uncertainty is considered high due to the range of estimates for B_{MSY} and F_{MSY} ratios (Kolody et al. 2006a).

Overall, the status of SW Pacific swordfish is considered moderate, as the median estimate of B/B_{MSY} is > 1 and the median estimate of F/F_{MSY} is < 1 . This ranking is also due in part to model uncertainty and increasing catches with declining CPUEs.



Figures 12 and 13. Estimates of the B_{MSY} and F_{MSY} ratios from the 10 model “best plausible ensemble” for SW Pacific swordfish. Dashed red lines are 95% confidence intervals (Figures from Kolody et al. 2006a).

Atlantic Ocean

North Atlantic

Historically, North Atlantic swordfish has been considered overfished, and the stock has experienced overfishing. Biomass declines were observed from the mid-1980s to about 2000 (NMFS 2005a). This decline in the North Atlantic swordfish stock was first officially recognized in the 1985 Atlantic Swordfish Fishery Management Plan (FMP), which called for measures to address the problem of overfishing (NOAA Fisheries 2003). ICCAT recommended reducing fishing effort for swordfish in 1990 and adopted the first country-specific fishing quotas for the species in 1994.

By 1997, ICCAT recommended that member countries reduce catches by 45% to prevent further degradation of the swordfish resource (NOAA Fisheries 2003). An international rebuilding program was launched in 1999 with further reductions in the fishing quotas for each country and requirements for accounting for dead discards in the total allowable catch (TAC) for swordfish (NOAA Fisheries 2003). The North Atlantic swordfish stock quickly showed signs of improvement, and current population estimates suggest recovery from the low 1997 biomass (ICCAT Atlantic 2003; Somma 2003).

The most recent stock assessment for North Atlantic swordfish was conducted in 2009 (ICCAT 2009a). According to the assessment, North Atlantic swordfish is not overfished, with $B_{2009}/B_{MSY}=1.05$ (80% confidence interval 0.94-1.24) (Figure 14) (ICCAT 2009b). While long-term trends in biomass are down, relative biomass has increased consistently since 2000, with improvements being attributed to increased recruitment, ICCAT regulatory recommendations, and reductions in fishing effort (ICCAT Atlantic 2003, ICCAT 2009b). The estimated fishing mortality also indicates that overfishing is not

occurring, as F_{2008}/F_{MSY} is 0.76 (80% confidence interval of 0.67 – 0.96) (Figure 15) (ICCAT 2009b). Relative fishing mortality has decreased in recent years and has been below F_{MSY} since 2005 (ICCAT 2009a). Results from sensitivity analyses and secondary model runs were consistent with the overall findings, suggesting that uncertainty in stock status is moderate to low (ICCAT 2009a). No fishery-independent data are available, but long time-series of catch and CPUE data are applied to regular stock assessments (ICCAT Atlantic 2003, ICCAT 2009a).

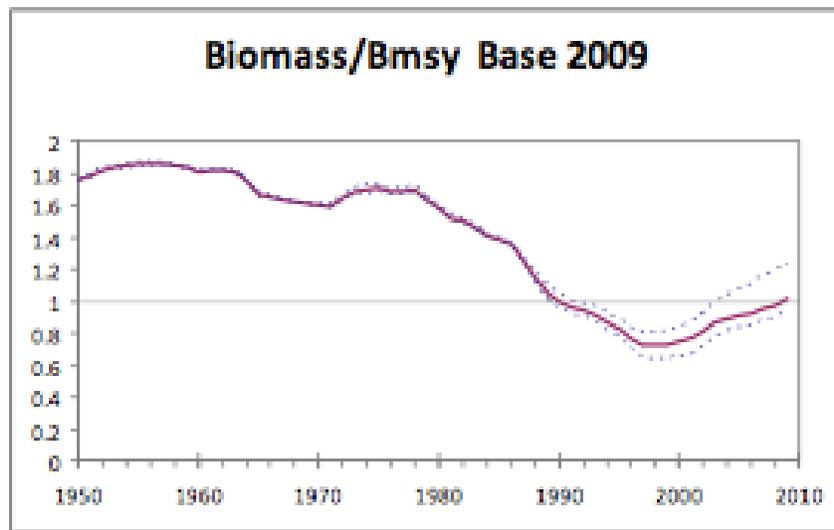


Figure 14. Estimates of B/B_{MSY} for North Atlantic swordfish from 1950-2009. The upper and lower lines are the 80% confidence ranges (Figure from ICCAT 2009b).

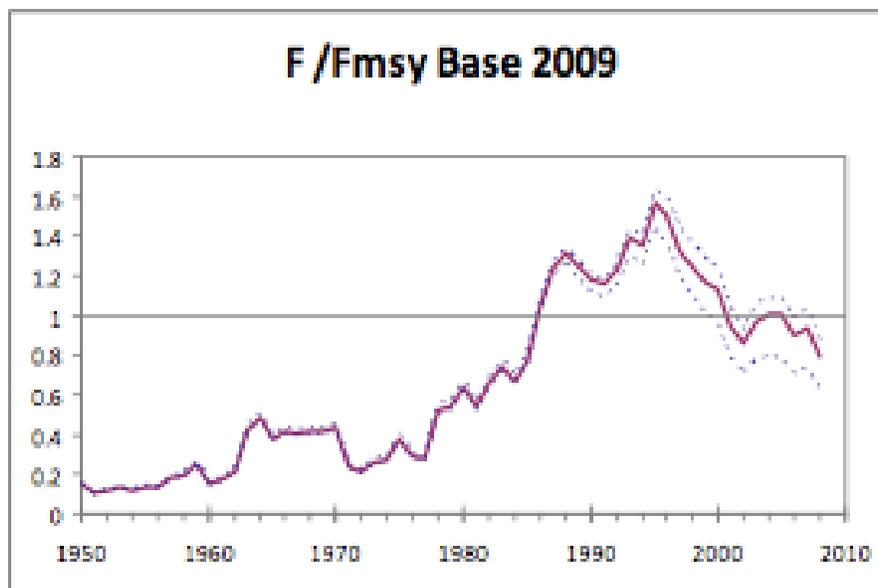


Figure 15. Estimates of F/F_{MSY} for North Atlantic swordfish, 1950 – 2009 (Figure from ICCAT 2009b).

The 2009 stock assessment findings indicate that the objectives of the rebuilding plan have been satisfied. Overfishing is no longer occurring, and there is a greater than 50% probability that biomass is above B_{MSY} . Therefore, ICCAT has declared the North Atlantic swordfish stock as “Rebuilt,” as defined by the criteria in the rebuilding plan (ICCAT 2009a). These conclusions should be met with caution however. In 2007 and 2008, catches were below the MSY level, allowing the stock to grow more rapidly than normal. If catch levels had reached the allowed quota, the biomass would have instead declined (ICCAT 2009a). Therefore, future management decisions regarding catch levels will certainly impact whether the stock remains above the B_{MSY} level.

The age distribution of North Atlantic swordfish catches has consistently included more juvenile fish than allowed by current ICCAT regulations. From 2006-2008, fish smaller than the size limit of 125 cm represented 28% of the catch, well over the 15% level recommended by ICCAT. Many fish smaller than 119 cm were also caught, in excess of the 0% limit. (ICCAT Atlantic 2003, ICCAT 2009a). Apart from this, little information exists regarding size, age, and sex distributions relative to normal conditions.

Due to the “rebuilt” status of North Atlantic swordfish, this stock is now considered healthy according to Seafood Watch® criteria; the stock is not overfished (above B_{MSY}), not experiencing overfishing, and uncertainty is low. However, Seafood Watch® recommends that this stock be monitored closely in the future, as future management decisions regarding catch levels may impact the overall stock status.

South Atlantic

Although there is a stock assessment for South Atlantic swordfish, the assessment results are highly uncertain. ICCAT researchers have attempted to estimate MSY for the South Atlantic swordfish stock but recent data are limited and show contradictory trends. While ICCAT (2009a) estimates that biomass of the stock relative to B_{MSY} is greater than 1, and fishing mortality relative to F_{MSY} is less than 1, uncertainty is high. Total allowable catch for the 2010-2012 South Atlantic swordfish fishery was reduced following ICCAT recommendations in 2009 (NOAA Fisheries 2009). Under the new TAC of 15,000 mt, it is estimated that biomass will remain above B_{MSY} 80% of the time.

Overall uncertainty in stock status for the South Atlantic swordfish stock is high (ICCAT Atlantic 2003; ICCAT 2009a). Despite expansion of swordfish fleets in this region, no CPUE data are available for several of the major fisheries (ICCAT Atlantic 2003). This lack of data prevents resolution of conflicting trends in bycatch and target CPUE for South Atlantic swordfish (ICCAT Atlantic 2003). The number of Atlantic swordfish caught by tuna vessels from Taiwan and Japan has shown a sharp decline since 1994 and 1985, respectively (ICCAT Atlantic 2003). The mean weight of swordfish caught in the South Atlantic by the Taiwanese fleet has been variable, but somewhat stable since 1980 (Chang and Hsu 2003). CPUE in the Taiwanese fleet has declined in some fishing areas of the South Atlantic (Chang and Hsu 2003). The Spanish (European Union) targeted swordfish fishery has shown a fairly flat trajectory of CPUE since 1990 with a slight increase for the most recent year (ICCAT Atlantic 2003).

Based on the high uncertainty in the stock assessment for South Atlantic swordfish, this stock is ranked as “Unknown,” and is considered of moderate conservation concern according to Seafood Watch® criteria.

Mediterranean

The most recent stock assessment for Mediterranean swordfish was conducted in 2007. While relative biomass range was estimated between 0.26 and 0.87 (with a point estimate of 0.87). Relative fishing mortality (F_{2005}/F_{MSY}) was estimated at 1.3, and MSY was determined to be between 14,250 and 15,500 mt (ICCAT 2007). The stock assessment indicates a declining stock abundance and a rise in fishing mortality (Figure 16). There has also been a 40% reduction in spawning stock biomass over the last 20 years. Presently, spawning stock biomass is below the level necessary to achieve MSY, and current fishing mortality is thought to be more than sufficient to drive spawning stock biomass per recruit to below 10% of the unfished condition (ICCAT 2007). Current landings also contain a high percentage of juvenile swordfish less than three years of age, composing 50-70% of the catch by numbers and 20-35% by weight (ICCAT 2005; 2007). This could potentially truncate the stock’s age distribution.

After the development of modern longlining and subsequent growth in fishing effort, Mediterranean swordfish catches peaked in 1988 and then declined abruptly before assuming a flat if fluctuating trend from 1990 – 2001 (ICCAT Mediterranean 2003). In Greek waters, reported catches increased from 1982 – 1989, and then declined from 1989 – 1997 (Stergiou et al. 2003). Uncertainty for the Mediterranean stock assessment is moderate, as the earliest available data on catch-at-size and catch-at-age for Mediterranean swordfish are from 1985, well after the first dramatic growth in landings from 1965 – 1972 and in the midst of the 1980s expansion of the fishery. Observed CPUE data became available only after 1987 (ICCAT Mediterranean 2003). Additional uncertainty is introduced by the operation of illegal driftnet fisheries (Silvani et al. 1999).

Stock status information for the Mediterranean stock indicate that the most recent estimates of fishing mortality are above F_{MSY} , indicating the occurrence of overfishing. Overall, the stock is considered poor according to Seafood Watch® criteria.

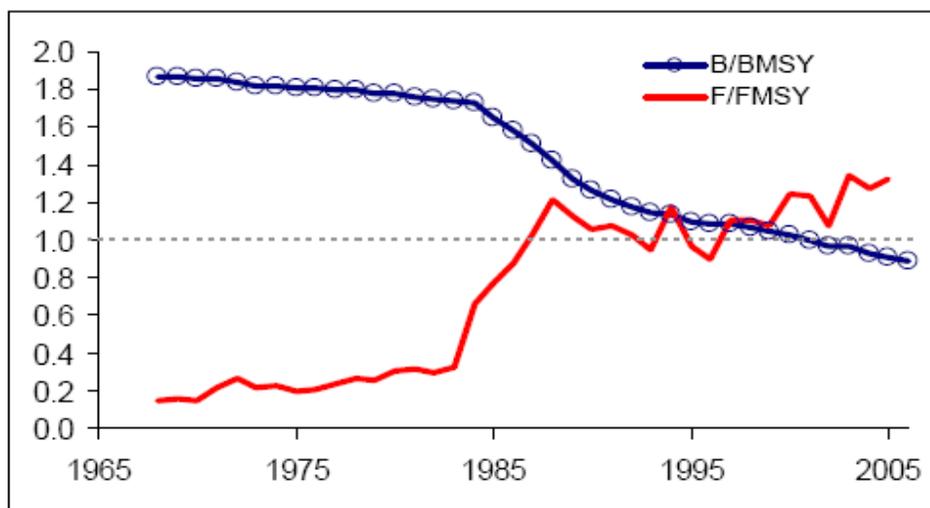


Figure 16. Estimated median relative biomass and fishing mortality over time (ASPIC production model) (Figure from ICCAT 2007).

Indian Ocean

Swordfish in the Indian Ocean was assessed in 2006 by the Working Party on Billfish (WPB). Several age aggregated surplus production models were used in this assessment; however, the results are considered preliminary and are associated with high uncertainty (IOTC 2006). These preliminary results suggest that swordfish in the Indian Ocean is not overfished (Figure 17), but that overfishing is probably occurring (Figure 18) (IOTC 2006). According to IOTC (2006), the current catch levels are likely not sustainable. CPUE trends vary, with decreasing CPUE in the Japanese fleet (Figure 19) and increasing CPUE in the Taiwanese fleet (IOTC 2006); the production models used for the stock assessment are based on the Japanese CPUE data. In the Taiwanese fleet, standardized catch rates have been variable since the late 1980s, but have declined overall since the late 1990s (Chang 2004). The current catch is above MSY. **Because overfishing is occurring, stock status for Indian Ocean swordfish is considered poor.**

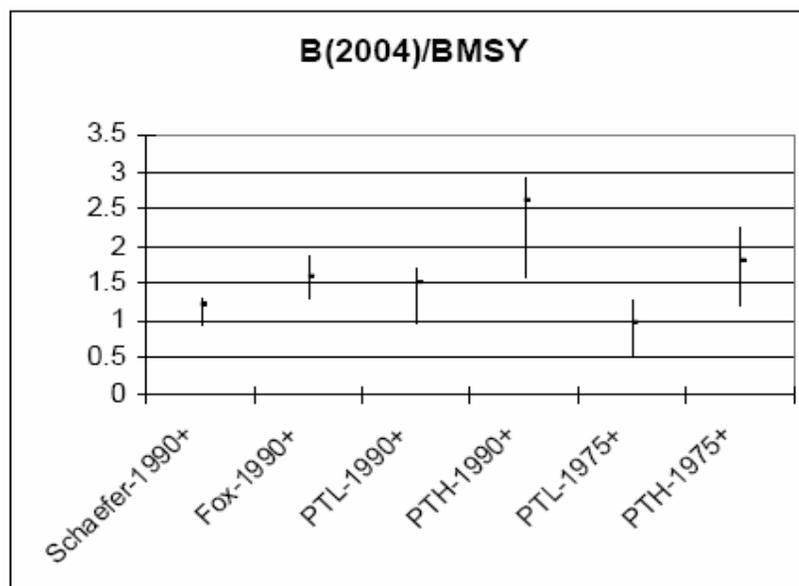


Figure 17. Model results for Indian Ocean swordfish; five of the six models support the conclusion that the stock is likely not overfished (Figure from IOTC 2006).

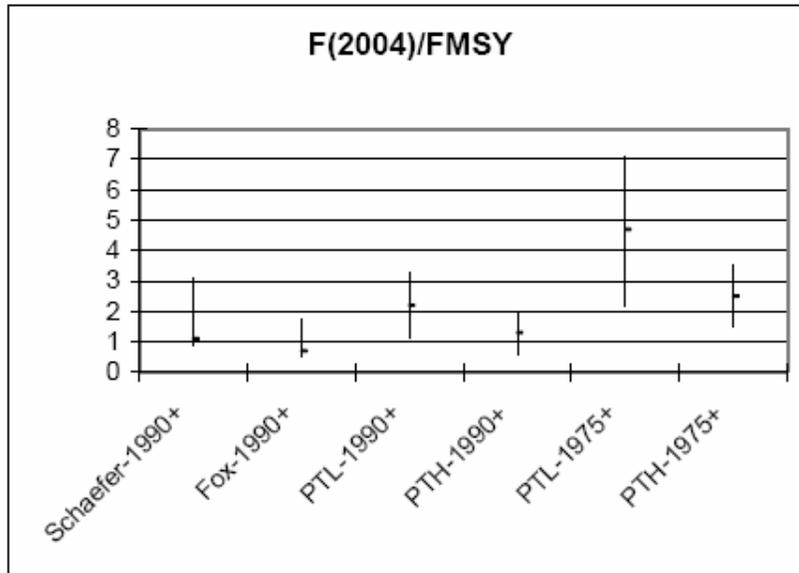


Figure 18. Relative fishing mortality for Indian Ocean swordfish; five of the six models support the conclusion that overfishing is likely occurring (Figure from IOTC 2006).

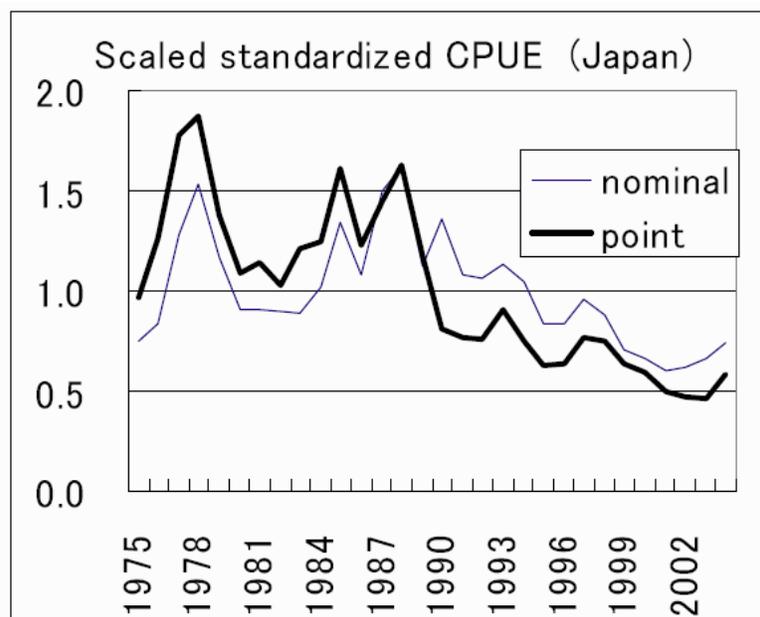


Figure 19. Standardized catch rate of swordfish in the Japanese fleet in the Indian Ocean (Figure from IOTC 2006).

Table 3. Stock status of swordfish.

Region	Classification Status	B/B _{MSY}	Occurrence of Overfishing	F/F _{MSY}	Abundance Trends/CPUE	Age/Size/Sex Distribution	Degree of Uncertainty in Stock Status	Sources	SFW Rank
NW Pacific (12% of total)	Unlikely overfished	Unknown	Unlikely	Unknown	Declining trends in some areas	Unknown	High	ISC 2004; PFMC 2005	Moderate
SW Pacific (4% of total)	Likely not overfished	> 1.0	Likely not occurring	< 1.0	Declining trends	Aus. fleet catching smaller swordfish	High	Kolody et al. 2006a; Kolody et al. 2006b	Moderate
Eastern Pacific (18% of total)	Not overfished	> 1.0	Not occurring	< 1.0	Variable trends; declining in the SE Pacific	SE Pacific fleet catching smaller fish	Moderate	Hinton et al. 2004; PFMC 2005	Healthy
North Atlantic (11% of total)	Not overfished	B ₂₀₀₉ /B _{MSY} = 1.05	Not occurring	F ₂₀₀₅ /F _{MSY} = 0.76	Declining long term, increasing short term	More juvenile swordfish are caught than permitted under ICCAT regs.	Low	ICCAT 2005; ICCAT 2009a; ICCAT 2009b	Healthy
South Atlantic (12% of total)	Unknown	Unknown, but likely > 1	Unknown	Unknown, but likely < 1	Variable trend depending on CPUE indices used	Unknown	High	ICCAT 2004; ICCAT 2005; ICCAT 2009	Moderate
Mediterranean (13% of total)	Possibly overfished	B ₂₀₀₅ /B _{MSY} = 0.87	Overfishing occurring	F ₂₀₀₅ /F _{MSY} = 1.3	Declining trend	High percentage of small swordfish caught	Moderate	ICCAT 2005; 2007	Poor
Indian Ocean (30% of total)	Likely not overfished	Range of 1 – 2.5	Overfishing likely occurring	Range of 1 – 4	Variable trend depending on CPUE indices used	Unknown	High	IOTC 2006	Poor

Synthesis

In the North Atlantic, swordfish is not overfished, and overfishing is not occurring. The stock was recently declared “rebuilt,” recent biomass trends are increasing, and overfishing is not occurring. Overall, the status of the North Atlantic swordfish stock is deemed healthy. There is little known about the status of swordfish in the South Atlantic, and uncertainty is high; thus the status of South Atlantic swordfish is a moderate conservation concern. Mediterranean swordfish are undergoing overfishing and stock abundance has declined over the last 20 years. Furthermore, Mediterranean catches comprise 50 –

70% juvenile fish, which may skew the stock’s age distribution. These factors combined result in a ranking of high conservation concern for the Mediterranean swordfish stock. Indian ocean stocks are also likely experiencing overfishing, resulting in a high conservation concern.

In the EPO, swordfish is not overfished, overfishing is not occurring, and standardized CPUE data indicate an increasing trend; thus, the stock is considered healthy. The swordfish stock in the SW Pacific is considered a moderate conservation concern due to $B/B_{MSY} > 1$ and $F/F_{MSY} < 1$, although CPUE has been declining with increasing catches and uncertainty is high. In the NW Pacific, the status of the swordfish stock is a moderate conservation concern due to the unknown nature of a majority of factors.

Status of Wild Stocks Rank:

Eastern Pacific (18% of total catch), **North Atlantic** (12% of total catch):



NW Pacific (12% of total catch), **SW Pacific** (4% of total catch), **South Atlantic** (12% of total catch):



Mediterranean (13% of total catch), **Indian** (30% of total catch):



Criterion 3: Nature and Extent of Bycatch

Seafood Watch® defines sustainable wild-caught seafood as marine life captured using fishing techniques that successfully minimize the catch of unwanted and/or unmarketable species (i.e., bycatch). Bycatch is defined as species that are caught but subsequently discarded (injured or dead) for any reason. Bycatch does not include incidental catch (non-targeted catch) if it is utilized, accounted for, and managed in some way.

Handline/Harpoon

Swordfish is caught with handlines and harpoons off both the Pacific and Atlantic coasts of the U.S. In the Atlantic, a handline fishery is developing off of the east coast of Florida (NMFS 2006b). Bycatch concerns are minimal with handlines and harpoons, as swordfish are caught one at a time with both of these gear types.

Drift gillnet¹

California

A gillnet is a large mesh net that hangs vertically in the water column; it is attached to a weighted leadline at the bottom and a buoyed floatline at the surface. The net is attached to a vessel at one end and a spar buoy affixed with a radar reflector and strobe light at the other. In the California drift gillnet fishery, the nets are 4,800 – 6,000 ft long (the latter being the legal maximum) and set at depths of 90 – 170 ft. The nets hang at a minimum depth of 36 ft, under regulations enacted to decrease incidental capture of marine mammals. The mesh webbing of a gillnet is hung loosely, like drapes, which gives the net its entangling properties. Drift gillnet trips range from one night to one month, but typically last 5 – 15 days. Nets are deployed at sunset and hauled in at sunrise (Hanan et al. 1993; PFMC 2003).

The California drift gillnet fishery primarily targets swordfish and common thresher sharks (PFMC 2003). The fishery now operates primarily outside of state waters to about 150 miles offshore (PFMC 2003). Drift gillnetting is prohibited off of Washington.

An observer program for the California drift gillnet fishery has been in effect since 1990. While in place primarily to monitor interactions with marine mammals and sea turtles, the program also provides data on the life history and distribution of pelagic sharks, billfish, and swordfish. The primary target species in the fishery is swordfish, though fishing effort within 15 km of the coast and around the Channel Islands usually targets pelagic sharks (Rasmussen and Holts 2002). Observer coverage has increased from about 5% in 1990 to 20% in 1999, with an average coverage of about 16% (NMFS 2000).

The composition of finfish catch in the California drift gillnet fishery varies annually and geographically. Rasmussen and Holts (2002) provide a summary of data gathered during the observer program from 1990 – 1998. Catches during this time period were dominated by ocean sunfish (*Mola mola*), blue sharks, swordfish, and albacore tuna; combined, these species accounted for about 62% of catches. Neither of the top two species caught were landed, and about 80% of ocean sunfish were released alive. Rays (*Raja* spp.) were also released alive more often than not (about 70%). Blue sharks, in contrast, were dead 75% of the time and of the other unwanted (or prohibited) species, all tunas were dead, as were the majority of mackerels (95%), invertebrates (80%), and other fishes (70%). Overall, bycatch in the drift gillnet fishery accounted for 59% of total catch, and therefore 144% of targeted catch. About 50% of the bycatch was released dead, and if sunfish are excluded, 81% of the bycatch was released dead (Rasmussen and Holts 2002). Catch composition for the 2001/2002 fishing season was similar to the summary for years 1990 – 1998, although the percentage of total catch retained was probably even lower (Figure 20) (NMFS/SRO 2005). For the 2003/04 and 2004/05 fishing seasons, bycatch was 57% and 72% of total catch, respectively (PFMC 2005).

¹ Portions of the drift gillnet bycatch section are taken directly from the Sharks Seafood Watch® report written by Santi Roberts and is available at:

http://www.mbayaq.org/cr/cr_seafoodwatch/content/media/MBA_SeafoodWatch_SharksReport.pdf.

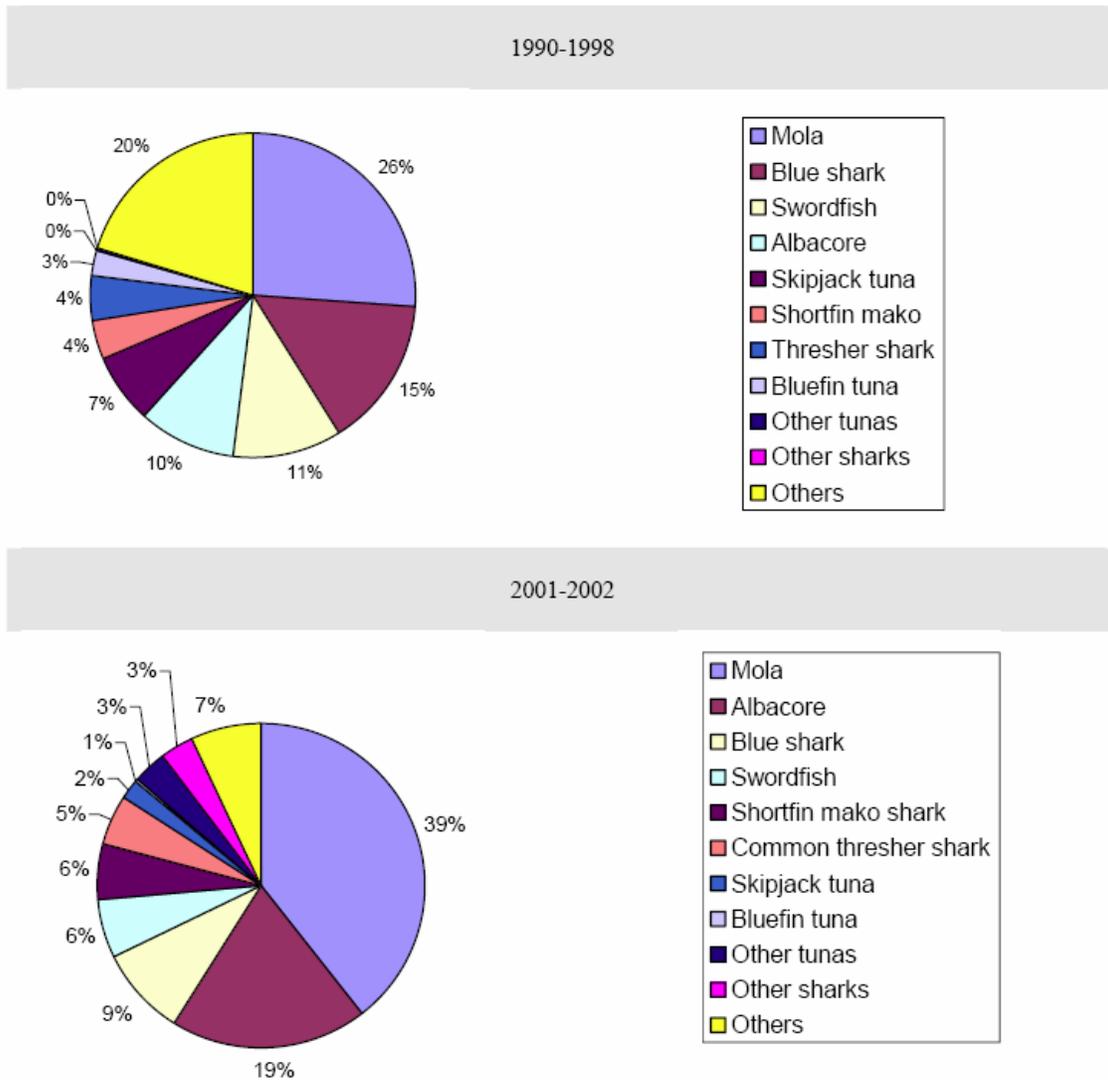


Figure 20. Composition of California drift gillnet catch, 1990 – 1998 (Data from Rasmussen and Holts 2002) and 2001 – 2002 (Data from NMFS/SRO 2005).

Endangered species: marine mammals, sea turtles, and seabirds

Midwater gillnets are generally considered to have among the highest bycatch rates of marine mammals, seabirds, sea turtles, sharks, and finfish, of all commercial fishing gears (Chuenpagdee et al. 2003). In the early 1990s, concerns were raised that several marine mammal species were being taken in the California drift gillnet fishery in numbers exceeding their Potential Biological Removal (PBR) (therefore inhibiting their recovery); this led to NMFS convening a Pacific Offshore Cetacean Take Reduction Team on February 12, 1996 (Federal Register, 61 FR 5385). In 1997, NMFS issued a Biological Opinion (BiOp) concluding that continued fishing under the recommendations outlined in the resulting Take Reduction Plan (TRP) (minimum net depth of 36 feet, pingers attached to nets, and skipper workshops) was not likely to jeopardize the continued existence of the humpback whale (*Megaptera novaeangliae*), sperm whale (*Physeter macrocephalus*), leatherback turtle, or loggerhead turtle (NMFS 2000). However, higher than estimated takes of leatherback and loggerhead sea turtles over the next several years obligated NMFS to carry out another evaluation. The resultant BiOp was

issued in 2000, and concluded that the fishery as regulated under the TRP would likely jeopardize the continued existence of Pacific leatherback and loggerhead sea turtles (NMFS 2000). Area closures were recommended for both species, as well as continued international conservation programs for leatherbacks. The BiOp concluded that if these measures were implemented, leatherbacks and loggerheads would no longer be in jeopardy (NMFS 2000). Since the implementation of these closed areas, no leatherback takes have been observed in the fishery, and only a single loggerhead was caught, and released alive (2000/2001 and 2001/2002 fishing seasons) (NMFS/SRO 2005). However, considerable non-turtle bycatch continues in the California drift gillnet fishery.

Several other marine mammals are still caught in the California drift gillnet fishery, although takes of these species have declined (Figure 21). Takes of short beaked common dolphins (*Delphinus delphis*) and several other dolphin species have declined or are caught too rarely to analyze the trend. One each of a fin (*Balaenoptera physalis*), humpback, and minke (*Balaenoptera acuterostrata*) whale were caught in 1999/2000, the latter two of which were released alive. These species were not caught at any other point between 1997 and 2002. California sea lions (*Zalophus californianus*) and elephant seals (*Mirounga angustirostris*) are also caught most years (NMFS/SRO 2005), but takes have generally declined considerably. These declines led to NMFS moving the fishery from Category I to Category II in the List of Fisheries for 2003, reflecting the decreased (but not eliminated) threat to the continued survival of protected marine mammals. However, the fishery was moved back to Category I² recently (January 4, 2006) due to the incidental catch of a single short-finned pilot whale in 2003. This species is rare in waters off the U.S. West Coast, with the total number of estimated individuals in the region at about 80 in 2003. The species thus has a very low PBR rate of 1.19 per year. Seabirds, such as fulmars (*Fulmaris glacialis*), are very rarely caught in this fishery.

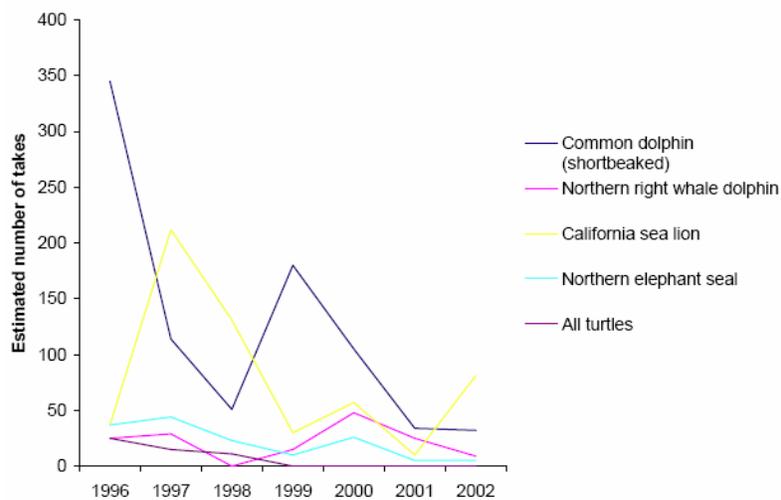


Figure 21. Trend in bycatch of selected marine mammals and all sea turtles in the California drift gillnet fishery for sharks and swordfish, 1996 – 2002 (Data from Caretta et al. 2005). Other marine mammal species were caught in very low numbers or intermittently over this period.

² To be considered a Category I fishery, the annual mortality and serious injury of a marine mammal stock in the fishery is greater than or equal to 50% of the PBR level. The PBR level is “the maximum number of animals, not including natural mortalities, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimal sustainable population” (69 CR 153, August 10 2004). For a Category II fishery, “annual mortality and serious injury of a stock in a given fishery is greater than 1% and less than 50% of the PBR level” (50 CFR 229, August 22, 2006).

In summary, management measures such as pingers, minimum depth, and closed areas appear to have had the desired effect of substantially reducing takes of endangered species of marine mammals and sea turtles. However, these species are still caught in lower numbers, and concerns remain due to the bycatch of short-finned pilot whales. In addition, bycatch still accounts for 144% of the targeted catch in this fishery (in 2004). For this reason, bycatch in the California drift gillnet fishery is deemed a high conservation concern according to Seafood Watch® criteria.

International drift gillnet

There are little data on drift gillnet fisheries in other regions, although large-scale pelagic drift gillnetting was prohibited by a United Nations (UN) Resolution in 1992 (Tudela et al. 2005). Despite the resolution, illegal drift gillnetting continues to occur in some regions, with marine mammals and pelagic sharks being common bycatch species in some fisheries. In other regions, sea turtle bycatch is also a concern (Tudela et al. 2005).

Several South American countries have gillnet fisheries, including Chile and Peru. It has been estimated that at least 2,000 leatherbacks are killed each year in the Chilean and Peruvian gillnet fisheries for swordfish, and effort in the Chilean gillnet fishery has increased dramatically in recent years (Figure 22) (Eckert and Eckert 1997). It is estimated that 80% of the turtles caught in these gillnets die; the extraordinary bycatch of this critically endangered species coupled with the high estimates of mortality result in a critical conservation concern for swordfish caught in the South American gillnet fishery.

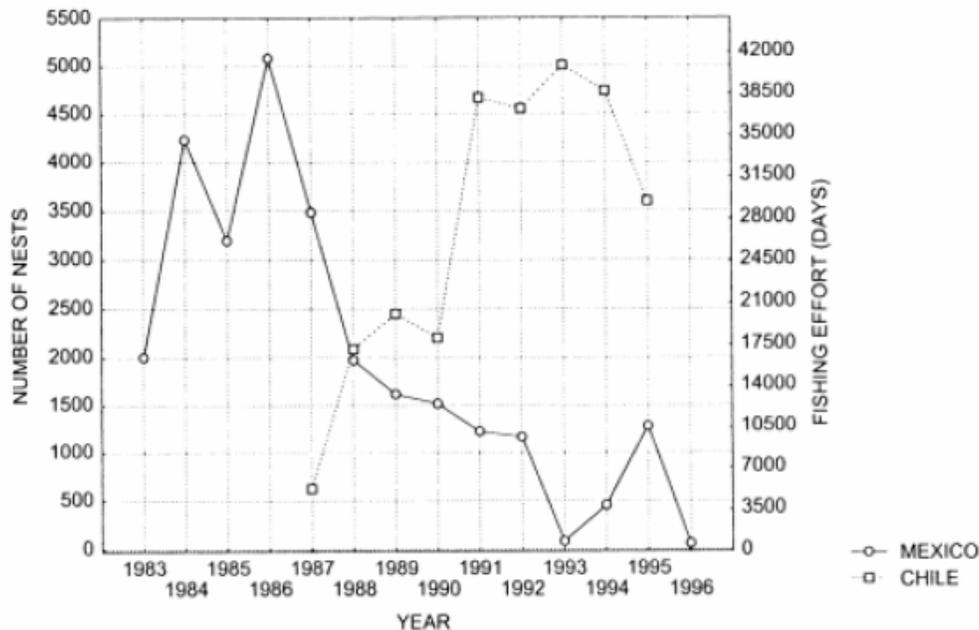


Figure 22. Increase in fishing effort for the Chilean gillnet fishery targeting swordfish (open squares), in relation to the decline in leatherback nests on Mexican beaches (open circles) (Figure from Eckert and Eckert 1997).

Longline—Overview

Overall, bycatch in the pelagic longline fisheries targeting tunas and swordfish remains an ongoing problem. Sea turtles, fishes, sharks, marine mammals, and seabirds are caught in the various pelagic longline fisheries throughout the world's oceans. All seven species of sea turtles are endangered or

threatened, and a recent study estimated that over 200,000 loggerheads and 50,000 leatherback sea turtles were taken as bycatch (i.e., interacted with the fisheries) in pelagic longline fisheries in the year 2000. This amounted to 20,000 to 40,000 leatherback and 30,000 to 75,000 loggerhead sea turtles caught as bycatch in the Pacific Ocean alone (Lewison et al. 2004a).

In the Pacific Ocean, nesting populations of both loggerhead and leatherback sea turtles have exhibited severe declines, with loggerheads exhibiting an 80 – 86% decline over the last 20 years (Kamezaki et al. 2003; Limpus and Limpus 2003) and leatherbacks exhibiting a greater than 95% decline over the same time period (Crowder 2000; Spotila et al. 2000). The bycatch of seabirds in longline fisheries worldwide is one of the principal drivers threatening these seabird populations (Gilman 2001). Some seabird species are at risk of becoming extinct, and their survival is threatened by the global presence of longline fisheries (Gilman 2001). Lewison and Crowder (2003) conclude that U.S., Japanese, and Taiwanese longline vessels are the largest source of mortality to the black-footed albatross. The combined mortality of this species due to U.S. and international longline vessels is likely to be above an estimated PBR threshold of 10,000 birds per year (Lewison and Crowder 2003).

In addition to sea turtles and seabirds, studies such as that conducted by Stevens (1996) suggest that high seas Pacific longline fisheries take millions of blue sharks each year, with unknown consequences to the population structure of this species. Estimates of annual fishing mortality for blue sharks ranges from 10 – 20 million blue sharks worldwide (IUCN 2004). A recent study found that the biomass of sharks in the fin trade is much higher than the numbers reported to the FAO, with an estimated 26 – 73 million sharks traded each year (Clarke et al. 2006). Thus, based on the continued take of these vulnerable species, Seafood Watch® concludes that bycatch in these longline fisheries is a critical conservation concern.

Longline—Swordfish

Specific bycatch data for the swordfish longline fishery are not available in all the regions where swordfish is caught; therefore, extrapolations from longline fisheries in general have been applied to the swordfish fishery in this analysis. For many of the longline fisheries, there are no consistent data (IATTC 2004b). In some cases, there are detailed observer data for some fishing nations while none exist for many others. When examining the effects of bycatch, both the level of bycatch and the population effects of bycatch are considered, as recommended by Lewison et al. (2004b). Many of the species caught as bycatch in the longline fishery for swordfish are long-lived, late-maturing, and slow-growing. These species are particularly vulnerable to excessive mortality (Musick 1999). Moreover, in general, catch data may underestimate the total mortality of certain bycatch species, as hooked animals may fall off hooks prior to the lines being retrieved (Ward et al. 2004).

The existence of illegal, unreported, and unregulated (IUU) fishing vessels adds further uncertainty to the issue of bycatch in the pelagic longline fishery. The incidental mortality of certain bycatch species, such as seabirds, may be substantial on these vessels, but the magnitude of this bycatch is unknown (Tuck et al. 2003). It is believed that IUU fishing is more prevalent in the Atlantic and Indian Oceans than in the Pacific (Tuck et al. 2003).

While pelagic longlines are set at different depths and configured to target specific species, non-target species are known to interact with this gear. In longline fisheries, interactions occur with a range of species, including endangered and protected sea turtles, seabirds, marine mammals, sharks and other fishes. These non-target animals approach or are attracted to baited longline hooks and may become

hooked or entangled in the gear, causing them to be injured or drown (NMFS 2001). Tunas are caught using deep-set longline gear, which generally results in one tenth the bycatch rates in the shallow-set fishery targeting swordfish (Lewison et al. 2004a; Kaplan 2005). However, mortality rates for some species, including sea turtles, are higher for deep-set longlines as the animals cannot surface to breathe.

Although comprehensive global bycatch data for longlines are non-existent, there are some data for specific longline fisheries. Longline gear varies according to the size and intensity of the fishery, the configuration of the gear, the region in which the gear is used, and the country fishing with the gear. Although these differences may result in differing levels of bycatch, Seafood Watch® adopts a precautionary approach in assuming that problematic bycatch levels in one swordfish fishery are similar to those in other swordfish fisheries, unless there are data to show otherwise. The average discard rate, or the proportion of total catch that is discarded, is 22% for HMS longline fisheries (Kelleher 2005). In the U.S., the discard to landings ratio for finfish in the HMS fishery (pelagic longline, bottom longline, and drift/set gillnets) is estimated to be 0.52. The discard to landings ratio for the pelagic longline fishery alone is 0.67, with swordfish and sharks comprising the major species groups that are discarded (Harrington et al. 2005). For the Mexican longline fleet in the Pacific, blue sharks comprise the majority of the catch, followed by swordfish and other pelagic species (INP undated). As evidenced by observer data in the WCPO, mortality rates differ for the various types of longlines (Figure 23). Overall, seabird bycatch in longline fisheries is lower in the Atlantic than in other ocean basins.

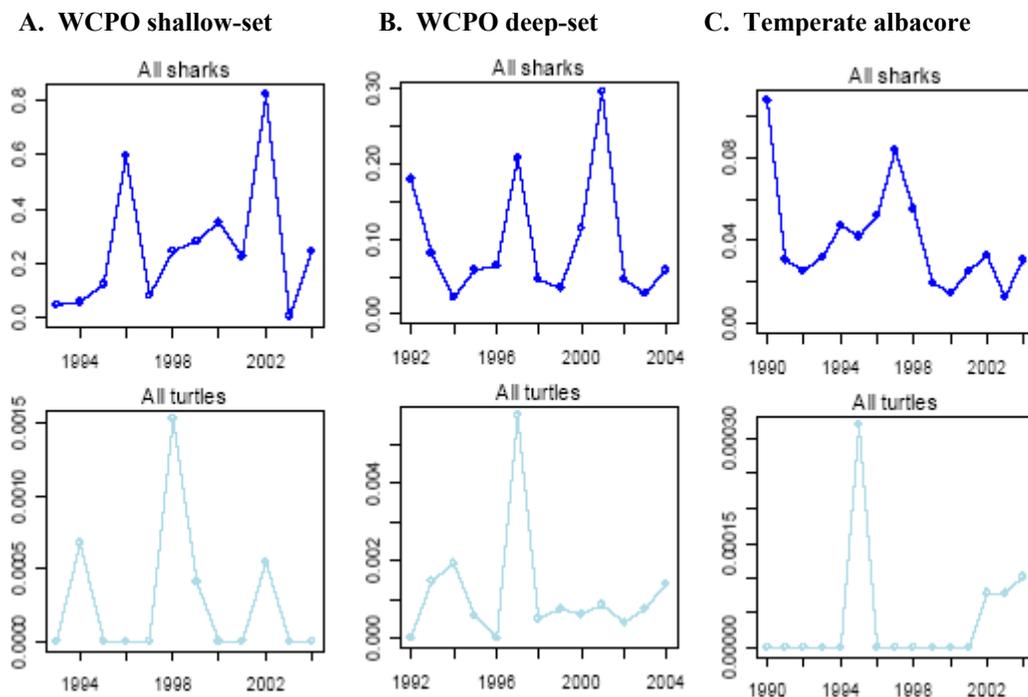


Figure 23. Mortality rates in the A. WCPO shallow set longline fishery, B. WCPO deep set longline fishery, and C. temperate albacore fishery. The x-axis is mortalities per 100 hooks and the y-axis is year. Noting the change in scale for each panel, sea turtle mortalities were highest in the deep set fishery and shark mortalities were highest in the shallow set fishery (Figure from Molony 2005).

Fishes: bycatch rates

Discards of swordfish and tuna in the U.S. Atlantic pelagic longline fishery generally exhibited a gradual decline from 1995 – 2004 (Figure 24) (NMFS 2006b). Discards of these target species may be economic or regulatory discards. The only fish species for which discards were higher than landings was bluefin tuna. In 2004, the most recent year for which data are available, slightly two times more bluefin tuna were discarded than were kept (NMFS 2006b). For highly migratory species, both the number of individuals kept and the number of individuals discarded have declined over this time period, as has fishing effort (NMFS 2004c).

Longline fisheries targeting tunas and swordfish are also responsible for the majority of the fishing mortality of blue and white marlin (Goodyear 1999; Peel et al. 2003). In the Atlantic, the commercial sale of billfish was prohibited in 1991, and although the reported catch of billfish dropped greatly after this (Goodyear 1999), it is likely that reported bycatch rates in the logbooks are underestimates of the actual bycatch rates, based on observer coverage (Cramer 1996). For fisheries where logbook data are available, the catch ratio of billfish to the targeted species is low. Billfish catch is approximately 5% of the total combined catch of albacore, yellowfin, bigeye, bluefin, and southern bluefin (Uozumi 2003).

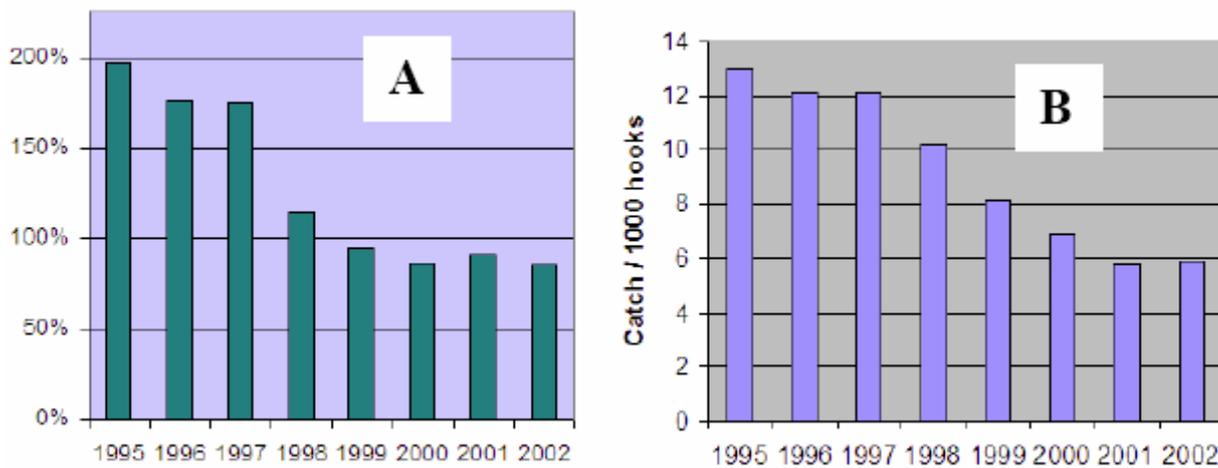


Figure 24a. Discards as % targeted catch for U.S. pelagic longlines, 1995 – 2002. **Figure 24b.** Bycatch interaction rates for U.S. pelagic longlines, 1995 – 2002. No adjustments were made for changes in abundance of bycatch species over time.

Bycatch is defined as species that are caught but subsequently discarded. Interaction rates and percentages were calculated using data from mandatory logbooks in the U.S. fleet of Atlantic pelagic longliners, as reported in the NOAA Fisheries 2004 Biological Opinion.

Non-tuna species caught in the WCPO longline fisheries include black marlin, blue marlin, Indo-Pacific sailfish, shortbill spearfish, striped marlin, swordfish, blue shark, mako sharks, oceanic whitetip shark, silky shark, other shark and ray species, barracudas, common dolphinfish, escolar, lancetfishes, oilfish, ocean sunfish, opah, pomfrets, wahoo, and other fishes (Lawson 2004). While some of these species are kept in some fisheries and are thus not deemed bycatch, others such as moonfish and pomfret are largely discarded. Industrialized fisheries in the WCPO often retain billfish and shark catch (Molony 2005). It is important to note that recreational catch-and-release fisheries for these billfish species also contribute to total mortality rates in some regions, although the magnitude of these mortalities is far less than for the pelagic longline fishery. For instance, over 99% of all white marlin are released in recreational

fisheries (Goodyear and Prince 2003); however, the survival of these released marlin may be affected by the type of hook used. In the western North Atlantic recreational fishery, white marlin survival is higher when caught on circle hooks (100%) than when caught on J-hooks (65%) (Horodysky and Graves 2005). In addition, there are little data examining survival rates following stomach eversion (Horodysky and Graves 2005). Although this mortality affects the stock status of billfish, Seafood Watch® does not incorporate recreational fisheries effects when evaluating commercial fisheries.

The mortality of billfish in longline fisheries targeting swordfish and tunas varies according to fishery and species. When data sets from the U.S., Japanese, and Venezuelan fisheries were combined, the proportion of billfish that were dead when the gear was retrieved ranged from 0.472 for blue marlin in the Gulf of Mexico to 0.673 for white marlin in the Northwest Atlantic (Farber and Lee 1991). Observer data from Japanese fisheries in Australia suggest that 74% of black marlin, 71% of blue marlin, and 60% of striped marlin were dead or moribund when the gear was retrieved (Findlay et al. 2003). There are, however, differences in billfish mortality rates in different fisheries operating in the same waters; Japanese and Australian fisheries operating in the same waters, for example, have been shown to have different billfish mortality rates due to differences in gear configuration (Findlay et al. 2003). According to the most recently available logbook data for the Atlantic pelagic longline fishery, discards of blue marlin declined from 1995 – 2002, but have been somewhat stable since 1998, averaging 1,160 individuals discarded annually from 1998 – 2002 (NMFS 2004c). White marlin discards exhibited a similar pattern, with an average of 1,404 individuals discarded annually from 1998 – 2002 (NMFS 2004c).

The Hawaii-based pelagic longline fishery targeting tuna and swordfish also catches, and often lands, several billfish species including blue and striped marlin. There are no specific management measures for either of these marlin species (Dalzell and Boggs 2003). Catch per unit effort data for striped marlin in Hawaiian fisheries from 1990 – 1999 indicate a declining trend in the recreational, commercial longline, and commercial troll fisheries (Dalzell and Boggs 2003). However, CPUE data may not be an accurate indicator of abundance due to increases in the proportion of the fleet setting deep-set longlines. The most recent stock assessment shows that stocks are at about the MSY level, and given the uncertainty with the assessment the results could be more optimistic (Kleiber et al. 2003). While the population could have been subject to $F > F_{MSY}$ over the past several decades, high recruitment maintained the population near B_{MSY} . Deep-set longlines are likely to have lower marlin bycatch rates than shallow-set longlines targeting swordfish (Dalzell and Boggs 2003).

In the Indian Ocean, 2005 observer data from Western Australia longline vessels suggest that more than half of the species caught were bycatch (or greater than 100% of landings), the most common of which were sharks. While some of these bycatch species are kept and sold, such as dolphinfish, there is no market for other species that are commonly caught, such as stingrays (IOTC 2005a).

Fishes: population impacts

The stock status of billfish species varies by ocean basin and species (Table 4). The pelagic longline fisheries targeting yellowfin and bigeye tuna and swordfish cause the highest Atlantic marlin mortality (Peel et al. 2003). In the Atlantic, biomass estimates for blue marlin, white marlin, and sailfish are all below B_{MSY} while fishing mortality on these stocks is above F_{MSY} (Peel et al. 2003; Uozumi 2003). Although the 2006 assessments for blue and white marlin showed limited improvement, there is still a concern associated with the catch of blue marlin in the small scale fisheries that are not included in the

rebuilding plans. The Atlantic blue marlin stock is at 40% of B_{MSY} , current fishing mortality is four times F_{MSY} , and overfishing has been occurring for the last 10 – 15 years (ICCAT 2001a). The only management measure in place for Atlantic blue marlin is an attempt to reduce pelagic longline and purse seine landings to 50% of 1996 or 1999 levels, whichever is greater (ICCAT 2001a). White marlin occurs only in the Atlantic; the most recent assessment for this species was in 2000, and indicated that biomass throughout the late 1990s was about 15% of B_{MSY} while fishing mortality was more than five times F_{MSY} (ICCAT 2001a). As with blue marlin, the only management measure in place is a limit on longline and purse seine landings to 33% of the 1996 or 1999 level (ICCAT 2001a). For Atlantic sailfish, MSY is not estimated and there are no management measures in place (ICCAT 2001b).

Observer data from the U.S. pelagic longline fishery in the Atlantic show that the number of bluefin tuna discarded was higher than the number kept every year from 1995 – 2002. Both East and West Atlantic bluefin stocks are overfished and experiencing overfishing, and considered overexploited and depleted, respectively (NMFS 2004c; Majkowski 2004). Any dead discarding of bluefin tuna in Atlantic pelagic longline fisheries removes individuals from stocks that are already a critical conservation concern.

Although no stock assessments were conducted for marlin, sailfish, and spearfish in the Indian Ocean in the 1990s, previous assessments indicate that biomass of blue marlin, striped marlin, and black marlin are either at or above MSY (Uozumi 2003). The status of sailfish and spearfish in the Indian Ocean is unknown. Therefore, high uncertainty exists concerning the status of these stocks, as well as the level of discarding. Catch of non-tuna species has not been well documented in the Indian Ocean, and the level of discarding in the industrial fisheries may be high based on data from other oceans (IOTC 2005b). The level of bycatch in the artisanal fisheries in the Indian Ocean is likely very low (IOTC 2005b).

In contrast to the Atlantic, blue and striped marlin biomass is either at or above the MSY level in the Pacific. In addition, current fishing mortality is below F_{AMS} (fishing mortality at which the average maximum sustainable yield is produced) for striped marlin in the North Pacific (Hinton and Maunder 2004) and SW Pacific (Langley et al. 2006). The status of black marlin, sailfish, and spearfish is unknown in the Pacific (Uozumi 2003). Blue marlin in the Pacific is close to being fully exploited, although due to model uncertainty the situation may be more optimistic (Kleiber et al. 2003). There is, however, uncertainty associated with stock assessment results derived from production models, due to uncertainty in catch and abundance indices, particularly as these data are from fisheries that do not target billfish (Uozumi 2003). In addition, changes in both spatial coverage and vertical coverage over time may result in a misinterpretation of CPUE data for billfish if changes in the fisheries do not adequately cover billfish habitat (Uozumi 2003). At this time, there does not appear to be a critical conservation concern associated with billfish bycatch in the Pacific, although caution is warranted, as the stock status of many of these species is unknown. Billfish bycatch in the Atlantic, however, is considered a critical conservation concern due to the poor stock status of these species, as well as the bycatch of bluefin tuna.

Table 4. Stock status of billfish in the Atlantic, Pacific, and Indian Oceans (Table from Uozumi 2003).

Species	Stock	Stock status
Atlantic blue marlin	Atlantic	Lower than MSY
White marlin	Atlantic	Lower than MSY
Atlantic sailfish	East Atlantic	Lower than MSY
Longbill spearfish	Atlantic	Unknown
Indo-Pacific blue marlin	Indian ³	At MSY level
Striped marlin	Indian ³	Higher than MSY
Black marlin	Indian ³	At MSY level
Indo-Pacific sailfish	Indian ³	Unknown
Shortbill spearfish	Indian ³	Unknown
Indo-Pacific blue marlin	Pacific	Higher than MSY
Striped marlin	North Pacific	At or higher than MSY
Striped marlin ⁴	SW Pacific	Almost at MSY ($B_{CURRENT}/B_{MSY} = 0.90$)
Black marlin	Pacific	Unknown
Indo-Pacific sailfish	Pacific	Unknown
Shortbill spearfish	Pacific	Unknown

Sea turtles: bycatch rates

All seven species of sea turtle are listed as threatened or endangered under the U.S. Endangered Species Act (ESA) of 1978, and six of these species are also listed on the IUCN Red List of Threatened Species (Table 5). Some of these sea turtle species are caught as bycatch in the pelagic longline fisheries targeting tuna and swordfish, particularly green, hawksbill, Kemp's ridley, leatherback, loggerhead, and olive ridley. Sea turtles are more commonly caught as bycatch in tropical waters, and in shallow-set fisheries targeting swordfish more than in deep-set fisheries targeting tunas (Beverly et al. 2004). As evidenced by the closure of the U.S. longline fishery in the Northeast Distant Waters (NED), sea turtles are also caught as bycatch in other regions.

Leatherback sea turtles are attracted to squid bait used on longlines (Skillman and Balazs 1992), and commonly get entangled in the lead lines even if they don't bite the hooks (NMFS and USFWS 1998). Loggerhead sea turtles have been shown to spend the majority of their time at depths shallower than 100 m, and the elimination of shallow-set longlines is predicted to result in reduced bycatch of loggerheads (Polovina et al. 2003). Even in deep-set longlines, however, there is the potential for hooks to be present at shallow depths when the gear is being set and retrieved, or if the lines do not sink to the appropriate depth (Polovina et al. 2003).

Turtles can be hooked in the esophagus or in the jaw (as well as in the flipper), though some studies have found that there does not appear to be a difference in survivability between lightly and deeply-hooked turtles (Polovina et al. 2000; Parker et al. in press). However, the findings of other studies suggest that deeply hooked turtles are less likely to survive (Chaloupka et al. 2004a). Estimates of sea turtle post-release mortality using satellite tracking has been both controversial and problematic (Hays et al. 2003; Chaloupka et al. 2004a; Chaloupka et al. 2004b; Hays et al. 2004a) with estimates ranging from 0.08 for lightly-hooked turtles to 0.38 for deeply-hooked turtles (Chaloupka et al. 2004a). In

³ Note that assessments for billfish species in the Indian Ocean were completed prior to the 1990s.

⁴ SW Pacific striped marlin data are from Langley et al. 2006.

general, sea turtle takes greatly exceed documented mortalities in longline fisheries, although there are little data on delayed mortality.

Table 5. Global conservation status of sea turtles that interact with pelagic longline fisheries.

Species	Status under the U.S. ESA	Status on the IUCN Red List
Green	Threatened, Endangered	Endangered
Hawksbill	Endangered	Critically endangered
Kemp's ridley	Endangered	Critically endangered
Leatherback	Endangered	Critically endangered
Loggerhead	Threatened	Endangered
Olive ridley	Threatened, Endangered	Endangered

Although more countries are beginning to collect bycatch data, they are generally not available to the public and therefore a thorough analysis of sea turtle bycatch interactions with international vessels is difficult. However, Lewison et al. (2004a) attempted to quantify the incidental take of loggerhead and leatherback sea turtles on a global scale. By integrating catch data from more than 40 nations and bycatch data from 13 international observer programs, the authors estimated that over 200,000 loggerheads and 50,000 leatherback sea turtles were taken as bycatch in pelagic longline fisheries in the year 2000. This amounted to 20,000 to 40,000 leatherback and 30,000 to 75,000 loggerhead sea turtles caught as bycatch in the Pacific Ocean alone (Lewison et al. 2004a). These authors suggest that a large number of interactions with protected species occur regularly with the international longline fleet, and jeopardize the continued survival of these endangered and threatened sea turtle species.

Other studies estimate that sea turtle takes are much lower in the Pacific; Hatase et al. (2002) estimate that in 2000 international pelagic longline fisheries resulted in 800 to 1,266 loggerhead takes and 139 to 222 loggerhead mortalities. Certain areas in the Pacific may also have less sea turtle bycatch than other areas; for instance, leatherbacks have rarely or never been seen in the waters of American Samoa, Guam, the Republic of Palau, the Commonwealth of the Northern Marianas, Republic of the Marshall Islands, and the Federated States of Micronesia (NMFS and USFWS 1998), thereby reducing the potential for fishery interactions in these areas. It is estimated that Australian longline vessels incidentally take about 400 turtles per year, which is lower than estimates from other longline fisheries (Robins et al. 2002). The average catch rate of sea turtles in the Australian longline fishery is estimated at 0.024 turtles/1,000 hooks (Robins et al. 2002). Observer data (with 5.1% targeted observer coverage level) in the Australian ETBF reports that five green turtles, 15 leatherbacks, and five unspecified turtles were released alive in 2004/05 (Lynch 2005). Bycatch rates in the temperate western Pacific have been estimated at 0.007 turtles/1,000 hooks for both the deep-set fresh and freezer vessels, with annual estimates of 129 turtle takes and 564 turtle takes, respectively (Robins et al. 2002). Observer data from <1% of the longline fleet in the WCPO suggest that 2,182 turtles are taken in this fishery annually, with a 23 – 27% mortality rate (OFP 2001 in NMFS 2005c). The highest CPUEs are in the tropical shallow-set longline fishery, although the highest mortalities are in the tropical deep-set fishery. Turtle bycatch is lower in the temperate albacore fishery (Molony 2005). The Japanese tuna longline fleet is estimated to take 6,000 turtles annually in the eastern tropical Pacific (ETP), with a 50% mortality rate (Meeting Minutes, 4th Meeting of the Working Group on Bycatch, IATTC, January 14-16, 2004, in NMFS 2005c). Sea turtle bycatch rates in the Costa Rican longline fleet have been estimated ranging from 19.43 turtles/1,000 hooks with an 8.8% mortality rate to 14.4 turtles/1,000 hooks with a 0% mortality rate (Arauz 2001).

Sea turtle mortalities in the Hawaii-based longline fishery have dropped considerably since the 2001 closure of the shallow-set swordfish fishery (Figure 25). From 2002 – 2004, interactions with green turtles remained relatively stable, leatherback and olive ridley interactions increased, and loggerhead interactions declined to zero in both 2003 and 2004 (NMFS 2005c; PIRO 2005a). In 2004, it was estimated that 0 loggerheads, 15 leatherbacks, 46 olive ridleys, and 5 green turtles were taken as bycatch in the Hawaiian deep-set longline fishery (PIRO 2005a). The maximum number of leatherback interactions allowed in the shallow-set fishery is 16; if this number is reached in the shallow-set fishery the fishery is closed. This regulation does not apply to the deep-set fishery, however. In 2004, the first year that the shallow-set fishery targeting swordfish re-opened, two sea turtles, one leatherback and one loggerhead, were observed as takes; both were released injured (PIRO 2005a). However, 2004 data from the shallow-set fishery should not be considered a source of new information due to low fishing effort (NMFS 2005c). With 26.1% observer coverage in 2005, four olive ridleys were observed as “released dead” and one leatherback was “released injured” in the deep-set fishery; with 100% observer coverage in the shallow-set fishery, 10 loggerheads and eight leatherbacks were “released injured” (PIRO 2005a). The shallow-set swordfish fishery was closed in April 2006, as the loggerhead cap was reached. Mortality rates based on observer rates were 0.86 for green turtles, 0.34 for leatherbacks, 0.44 for loggerheads, and 0.96 for olive ridleys (Boggs 2005 in NMFS 2005c).

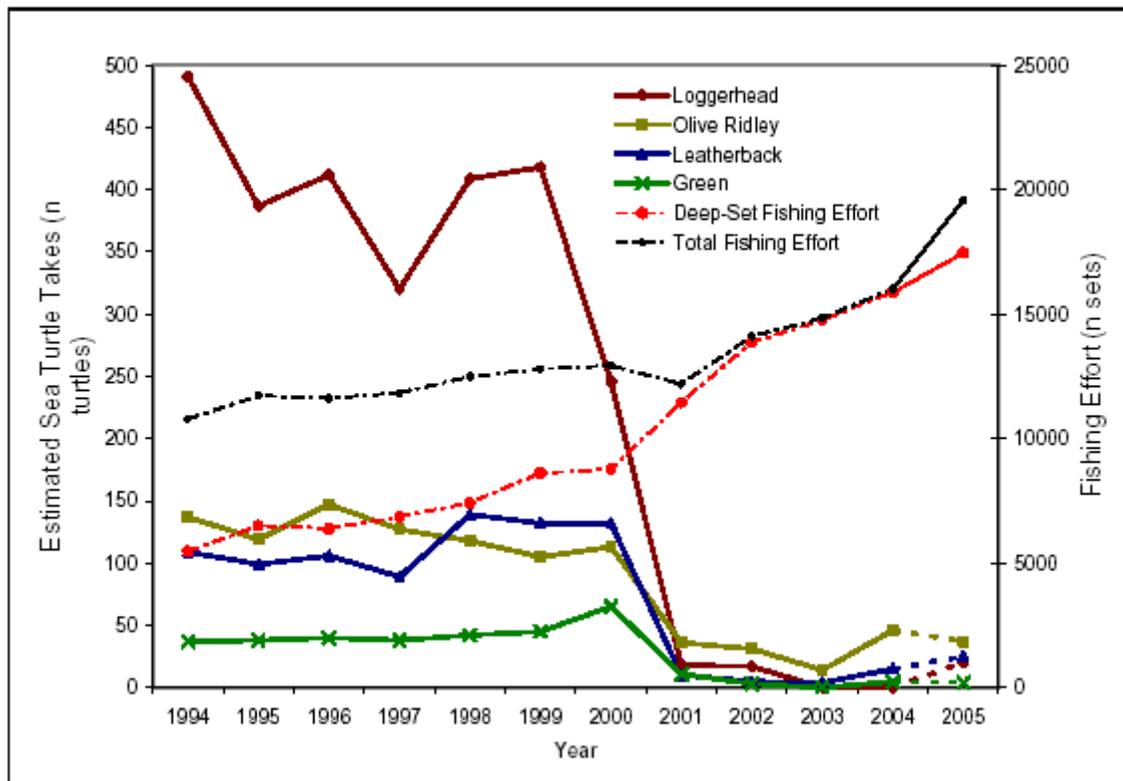


Figure 25. Sea turtle mortalities in 1994 – 2004 and projected for 2005 in the Hawaii-based longline fleet (Figure from NMFS 2005c).

Off the southern coast of Brazil, loggerheads and leatherbacks have been documented as takes in the longline fishery targeting swordfish, sharks, and tunas (Kotas et al. 2004). Over the course of three trips and 34 sets, 145 loggerheads (4.31/1,000 hooks) and 20 leatherbacks (0.59/1,000 hooks) were taken (Kotas et al. 2004). Of these turtles, 19 loggerheads and 1 leatherback were released dead (Kotas et al.

2004). These mortality levels may be underestimated, however, due to post-release mortality related to hooking wounds and stress from capture (Kotas et al. 2004). In another study, the catch rate for sea turtles was estimated at 1.5 turtles/1,000 hooks during research cruises off the coast of Brazil in the South Atlantic (Pinedo and Polacheck 2004). Although all turtles were released alive, there are no estimates of post-release mortality; given the increased longlining effort in the South Atlantic, turtle bycatch in this fishery is cause for concern (Pinedo and Polacheck 2004). It has been estimated that in 2000, Japanese longline vessels targeting tuna in the eastern Pacific resulted in 25 leatherback mortalities (166 total leatherback takes) and approximately 3,000 mortalities of all other sea turtle species, most of which were olive ridleys (IATTC 2004b). In Uruguay, loggerhead and leatherback bycatch has been estimated at 1.8 individuals/1,000 hooks, with incidental mortality at 1.9% (Achaval et al. 1998).

Although the pelagic longline fishery in the Atlantic interacts with other sea turtle species, loggerheads and leatherbacks are the primary concern due to their high interaction rates. Sea turtle bycatch estimates for the U.S. pelagic longline fishery in the Atlantic in 2002 were 575 loggerhead takes⁵ (2 mortalities), 962 leatherback takes (33 mortalities), and 50 unidentified turtle takes (NMFS 2004c). The number of loggerhead and leatherback turtle takes was generally stable from 1992 – 2002, although there was a peak in loggerhead takes in 1995.

Though total loggerhead takes appear high in the Atlantic longline fisheries, the estimated mortalities are low; the average annual loggerhead mortality from 1992 – 2002 was 7 individuals, with an estimated 2 loggerheads killed in 2002 (NMFS 2004d). The mortality data for leatherbacks are far more variable, with an estimated 88 leatherbacks killed in 1992, and then zero mortalities until 2002, when 33 leatherbacks were estimated killed in this fishery (NMFS 2004c). The estimated zero mortality may be a reflection of the low level of observer coverage in this fishery, rather than low sea turtle bycatch, however. From 1995 – 2000, observer coverage ranged from 2.5 – 5.2% (NMFS 2004c); it has been estimated that 20% observer coverage is a minimal level for common bycatch species, and the minimal observer coverage for rare species is 50% (Babcock et al. 2003). Factors such as the size of a fishery and the distribution of catch may warrant increased levels of observer coverage (Babcock et al. 2003). In some instances low mortality levels can jeopardize the recovery of a protected species, and 100% observer coverage is necessary (Babcock et al. 2003). The 2004 BiOp found that the expected number of takes and mortalities in the Atlantic HMS fishery is likely to reduce the survival or recovery of leatherbacks.

For the pelagic longline fishery, the most effective management measures are likely to be gear modifications, rather than area closures (which potentially result in the displacement of effort to other areas where bycatch may be higher) (James et al. 2005). Hook and gear modifications were required in the U.S. Atlantic pelagic longline fishery in mid-2004, and in 2005 the take of leatherbacks was greatly reduced (Figure 26) (NMFS 2006b). If this declining trend continues, the conservation concern for this fishery will continue to be ranked differently than the international longline fleets. Mexican longline vessels targeting tunas in the Gulf of Mexico have been shown to catch 5 turtles/100 trips with incidental mortality at 1.6 turtles/100 trips (Ulloa Ramírez and González Ania 2000).

⁵ These take estimates do not include any estimates of post-release mortality.

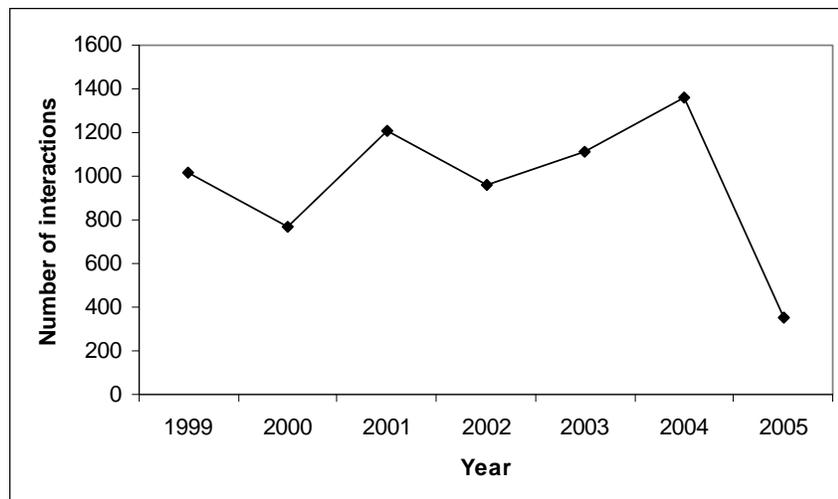


Figure 26. Hook and bait requirements in 2004 may have resulted in fewer leatherback interactions in 2005. Seafood Watch® will continue to monitor this trend (NMFS 2006b Consolidated HMS FMP).

Additional bycatch estimates from longline fisheries in the South Atlantic have indicated that the CPUE for loggerheads and leatherbacks combined was 0.37/1,000 hooks from 86 sets (Achaval et al. 2000). With over 13 million hooks set in 1999 by Brazilian boats alone in the Southwest Atlantic (ICCAT 2001c), the potential for large amounts of sea turtle bycatch is high. In addition, fishery closures in the North Atlantic due to overfished species such as swordfish and tunas may result in effort being displaced to the South Atlantic, possibly increasing sea turtle bycatch there (Kotas et al. 2004). Lewison et al. (2004a) estimate that 1.4 billion hooks were set on pelagic longline gear in the year 2000 alone, with 1.2 billion of those hooks targeting tunas. In the Indian Ocean, South African observer data suggest a catch rate of 0.05 turtles/1,000 hooks; turtles were alive in 85% of these interactions (IOTC 2005b). In the eastern Atlantic, olive ridleys and leatherbacks have been observed interacting with longlines targeting swordfish and tunas, with a CPUE of 0.09 for olive ridleys and 0.39 for leatherbacks (Carranza et al. 2006). In the Gulf of Guinea, the CPUE for olive ridleys was 0.38 and the CPUE for leatherbacks was 0.64 (Carranza et al. 2006). Of the 40 leatherbacks caught, 5% were observed mortalities (Carranza et al. 2006). There were no estimates for post-release mortality for either of these species in the Carranza et al. (2006) study.

All these studies demonstrate that sea turtle bycatch occurs in many fisheries across most ocean basins. Although there is not observer coverage or logbook data for every fishery targeting tuna, the available data suggest that sea turtle bycatch is an ongoing and important issue in many, if not all, of these fisheries.

Sea turtles: population impacts

Sea turtle populations face several threats, including incidental take in fisheries, the killing of nesting females, egg collection at nesting beaches, habitat loss, and pollution and debris. The population impacts of sea turtle bycatch vary according to the sea turtle species and the region. In the Pacific Ocean, nesting populations of both loggerhead and leatherback sea turtles have exhibited severe declines, with loggerheads exhibiting an 80 – 86% decline over the last 20 years (Kamezaki et al. 2003; Limpus and Limpus 2003) and leatherbacks exhibiting a decline of greater than 95% over the same time period (Crowder 2000; Spotila et al. 2000). The number of nesting females at several nesting beaches in Japan have been declining since 1990 (Sato et al. 1997), and population declines of loggerheads nesting in Japan have been attributed to the bycatch of small females in pelagic longline fisheries in the Pacific

(Hatase et al. 2002). More recent data suggest that loggerhead nesting is increasing on some Japanese beaches (I. Kinan, pers. comm.; Sea Turtle Association of Japan unpubl. data).

Some sea turtle species, such as green turtles in the Hawaiian Islands, are recovering (Balazs and Chaloupka 2004); however, there is an overall declining trend for green turtle abundance worldwide (Seminoff 2004). While research has shown that leatherbacks have migratory pathways in the Pacific, the same is not true in the Atlantic, where leatherbacks are likely to disperse widely from the main nesting beaches in French Guiana and Suriname (Ferraroli et al. 2004; Hays et al. 2004). The distribution of leatherbacks in the Atlantic also shows that these animals spend time and forage in the same areas and depths where pelagic longline fisheries operate (Ferraroli et al. 2004; Hays et al. 2004b). Spotila et al. (2000) estimate that if leatherbacks in the eastern Pacific can only sustain 1% annual anthropogenic mortality, this is equal to the loss of 17 adult females and 13 subadult females per year. The 2005 BiOp on the Hawaii-based, pelagic longline fishery concluded that the continued authorization of this fishery is not likely to jeopardize the continued existence of green, leatherback, loggerhead, and olive ridley sea turtles (NMFS 2005c).

Population data for leatherbacks in the Atlantic are uncertain and conflicting; however, the main nesting beaches in French Guiana and Suriname have exhibited a declining trend, with nesting declining at about 15% annually (NMFS 2004c). Leatherback bycatch in the Atlantic pelagic longline fishery has more severe population consequences than loggerhead bycatch primarily because approximately half of the leatherbacks taken in the pelagic longline fishery are mature breeders while the other half are subadults; leatherbacks are sexually mature in 5 – 15 years, while loggerheads mature later (NMFS 2004c). Using the estimates of turtle bycatch from Lewison et al. (2004a), as well as post interaction mortality estimates, sex ratio data, and adult to juvenile ratio data, total leatherback mortality for adult females was estimated at 4,100 leatherbacks per year in the international fisheries in the Atlantic and Mediterranean (NMFS 2004c). While the U.S. longline fleet in the Atlantic accounts for only 1.2 – 1.4% of this mortality per year, the annual mortality of adult and sub-adult females in the U.S. fishery is “not discountable” (NMFS 2004c p. 6-8). In addition, there is considerable uncertainty associated with the status and trends of leatherbacks in the Atlantic. It has been shown that a combination of 18/0 circle hooks and mackerel bait reduces loggerhead interaction rates by 90% and leatherback interactions by 65% (Watson et al. 2005). The 2004 BiOp concludes that the proposed management measures in the U.S. Atlantic pelagic longline fishery are likely to jeopardize the continued existence of leatherbacks, but not the existence of the other turtle species that are taken as bycatch in this fishery. The NMFS jeopardy finding was based on estimated annual mortalities in the U.S. fishery of approximately 200 leatherbacks, continuing indefinitely (NMFS 2004c).

Seabirds: bycatch rates

There are an estimated 61 seabird species that are affected by longline fisheries, 25 of which are threatened with extinction as a result of being caught as bycatch in longlines (Brothers et al. 1999). Estimates for seabird bycatch in longline fisheries in the North Pacific alone are approximately 35,000 albatross takes per year (Cousins et al. 2001). In addition, observed mortalities of seabirds may be underestimated, as seabirds may fall from hooks before being hauled on deck (Cousins and Cooper 2000; Ward et al. 2004); mortality estimates for some seabirds may be underestimated by as much as 45% (Ward et al. 2004). Lewison and Crowder (2003) estimate that approximately 10,000 black-footed albatrosses are killed each year in all of the fleets in the North Pacific, and this level of mortality is likely contributing to population declines. The U.S. rate was estimated at 2,000 individuals per year

while the international rates were estimated, as a moderate-case scenario, at 8,000 individuals per year (Lewison and Crowder 2003). In the Northeast Pacific, black-footed albatrosses have been shown to overlap with the distribution of longline fisheries both spatially and temporally (Hyrenbach and Dotson 2003). Recent data from the Hawaii-based deep-set longline fishery indicate that takes of black-footed and Laysan albatrosses have declined, with only 16 black-footed and 10 Laysan albatrosses estimated as takes in 2004 (Figure 27); around 1,000 of each species were taken each year in 1999 – 2000 (PIRO 2005b). As of the writing of this report in 2005, 11 black-footed albatrosses, 6 Laysan albatrosses, and 1 brown booby had been released dead in the deep-set Hawaii fishery; observer coverage was 16.3% in the first quarter, 22.7% in the second quarter, and 37.9% in the third quarter (PIRO 2005b). One cause of these dramatic declines in seabird bycatch is a side-setting technique that has been developed that greatly reduces seabird takes in longlines, which has been used by the Hawaii-based fleet since 2001.

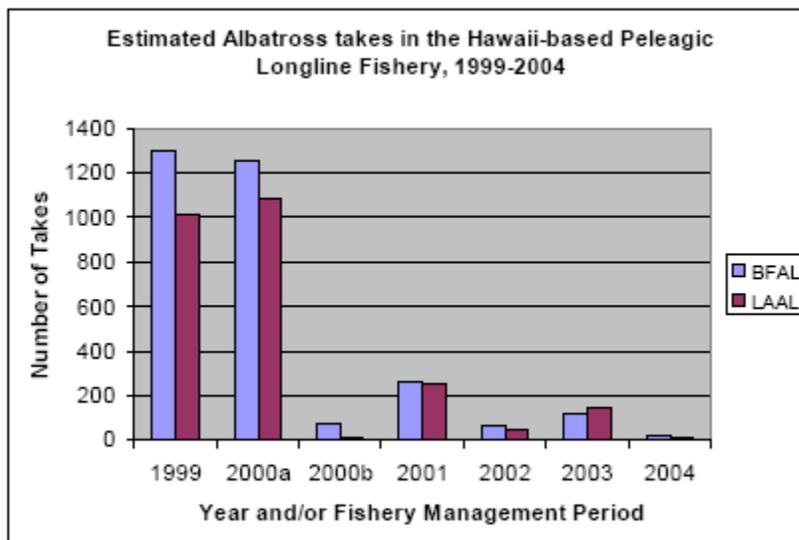


Figure 27. Total estimated takes of black-footed (BFAL) and Laysan albatross (LAAL) in the Hawaii-based longline fishery, 1999 – 2004 (Figure from PIR 2005b).

High seabird bycatch rates are also found in the Japanese longline fishery, where the mean catch rate is 0.92 birds/1,000 hooks (Brothers and Foster 1997). Catch rates have been shown to be higher in the Australian fishery, possibly due to a lack of bird-scaring devices such as tori lines (Brothers and Foster 1997). There has been a recent decrease in seabird bycatch in Australian and New Zealand fisheries, however, which has been attributed to both an increase in the use of mitigation measures and a decrease in effort (Tuck et al. 2003).

In addition to the bycatch of endangered albatrosses, there is also bycatch of seabird species that are not listed on either the U.S. ESA or the IUCN Red List. Cory's shearwaters, for instance, are caught in large numbers in the Mediterranean. Spanish longlining vessels alone have been estimated to catch as much as 4 – 6% of the local breeding population each year, which is considered unsustainable for the long-term existence of this colony (Cooper et al. 2003). In the western Mediterranean, however, Spanish longline vessels targeting albacore have been shown to have a seabird bycatch rate of only 0.0234 birds/1,000 hooks, which is lower than the bycatch rates shown for South African and Japanese fleets in Australian waters (Valeiras and Camiñas 2003). In general, there are little data concerning seabird bycatch in the Mediterranean (Cooper et al. 2003).

Though seabird bycatch mitigation measures are likely necessary in the WCPO, none are required (Small 2005). Observer data suggest that annual seabird takes in WCPO longline fisheries are from 0 –

9,800 birds, with annual mortality rates from 24 – 100% (Molony 2005). Seabird takes in the Atlantic, on the other hand, are low, which is likely due to the night-setting of pelagic longlines (NMFS 2004c), as well as the absence of albatross species in the region.

In the Indian Ocean, an estimated 300,000 seabirds, including 100,000 albatrosses, are killed annually (IOTC 2005b). Of the albatross species that interact with longline fisheries in the Indian Ocean, 19 out of 21 are threatened with extinction (IOTC 2005b). Observer data from South African vessels indicate that the most common seabird species caught are white-chinned petrel, black-browed albatross, shy albatross, and yellow-nosed albatross (IOTC 2005b). The catch rate for South African fisheries averaged 0.2 birds/1,000 hooks in the domestic fleet and 0.8 birds/1,000 hooks in the foreign fleet (IOTC 2005b).

It is important to note that it cannot be assumed that fisheries with higher fishing effort have higher levels of seabird bycatch or that the population impacts of fisheries with higher effort are more substantial (Tuck et al. 2003).

Seabird bycatch: population impacts

Seabirds are particularly vulnerable to population decreases, as they are long-lived, have low reproductive rates, and mature late (Tuck et al. 2003). The bycatch of seabirds in longline fisheries worldwide is one of the principal threats to their populations (Gilman 2001). Some seabird species are at risk of becoming extinct, and their survival is threatened by the global presence of longline fisheries (Gilman 2001). For example, Lewison and Crowder (2003) conclude that U.S., Japanese, and Taiwanese longline vessels are the largest source of mortality to the black-footed albatross; the combined mortality due to U.S. and international longline vessels is likely above an estimated PBR threshold of 10,000 birds per year (Lewison and Crowder 2003). Pelagic longlines also result in seabird bycatch in the Southern Ocean and the Mediterranean (Prince et al. 1998; Belda and Sanchez 2001). Fishing effort in the Southern Ocean, particularly by Taiwanese vessels, has been expanding since the 1970s, and seabirds in the region have shown dramatic declines attributed to incidental take in longline fisheries (Brothers 1991; Cooper 2000; Nel et al. 2002). The continuation of current fishing levels in the Southern Ocean, without the presence of mitigation measures and combined with the effects of IUU fishing, may be jeopardizing the sustainability of these seabird populations (Tuck et al. 2003).

Marine mammals: bycatch rates

In the Pacific, the Hawaii-based longline fishery for swordfish, tuna, and billfish is listed as a Category I fishery in the NOAA Fisheries List of Fisheries for 2004, due to interactions with humpback whales, false killer whales, Risso's dolphins, bottlenose dolphins, spinner dolphins, short-finned pilot whales, and sperm whales. While there has been one observed interaction of an endangered sperm whale with the longline fishery in the Hawaiian EEZ, the effects of interactions with the Hawaii-based longline fishery in U.S. and international waters is unknown (Caretta et al. 2005). However, one cetacean species, the false killer whale (*Pseudorca crassidens*), is presently categorized as a "strategic" stock under the 1994 Marine Mammal Protection Act (MMPA) (Caretta et al. 2002).

All marine mammals, regardless of whether or not they are listed under the ESA, are protected under the MMPA. In 2004, 28 false killer whales were estimated taken (but not necessarily killed) in the Hawaii-based deep-set longline fishery. Uncertainty in population size and stock structure of false killer whales make it difficult to evaluate population-level impacts of the fishery on this species (K. Forney, SWFSC,

pers. comm.). Efforts are presently underway by NMFS to address these important research needs (Caretta et al. 2002).

The longline fishery for large pelagics in the Atlantic Ocean, Gulf of Mexico, and Caribbean is also a Category I fishery due to interactions with humpback whales, minke whales, Risso's dolphins, long-finned pilot whales, short-finned whales, common dolphins, Atlantic spotted dolphins, pantropical spotted dolphins, striped dolphins, bottlenose dolphins, harbor porpoises, and pygmy sperm whales (69 FR 153, August 10, 2004). The only two species in this fishery that are listed as endangered under the ESA, and therefore strategic under the MMPA, are humpback whales and pygmy sperm whales in the western North Atlantic.

Note that these bycatch rates are only for the U.S. components of the pelagic longline fishery, and the international bycatch levels of marine mammals may be greater than domestic levels. Additionally, of all the protected species interactions, pelagic longlines do not generally result in as much marine mammal bycatch as other gear types such as gillnets (Lewison et al. 2004b; Reeves et al. 2005).

Marine mammals: population impacts

The annual PBR for the Hawaiian stock of false killer whales is 1.0, while the estimate of mortality and serious injury of this species in the Hawaii-based longline fishery is 4.4 individuals (Caretta et al. 2005). The contribution of pelagic longline gear to humpback whale mortalities is not included in the most recent humpback whale stock assessment; however, the average annual fishery-related mortality for humpbacks exceeds the PBR for this species (NMFS 2005e). There has been one report of serious injury to a pygmy sperm whale in the pelagic longline fishery off of Florida, and the average annual estimated mortality is 6 for this stock of marine mammals. Because the PBR for pygmy sperm whales is 3, this stock is considered strategic (NMFS 2005e).

Sharks and rays: bycatch rates

Despite their known vulnerability to overfishing, sharks have been increasingly exploited in recent decades, both as bycatch, from the 1960s onward, and as targets in directed fisheries, which expanded rapidly beginning in the 1980s (Baum et al. 2003). The most common shark and ray species caught in longline fisheries are blue sharks, silky sharks, pelagic stingrays, and oceanic whitetip sharks (Williams 1997). As with the other species caught as bycatch in pelagic longline fisheries, the type and quantity of shark bycatch may vary with fishing location, gear configuration, etc. In New Zealand waters in general, blue shark bycatch has declined by about 40% from 1988/89 to 1990/91 while porbeagle and mako shark bycatch was variable over the same time period (Francis et al. 2001). In the Japanese longline fishery operating in the EPO, the most common shark species caught are blue, silky, oceanic whitetip, crocodile, shortfin mako, longfin mako, salmon, bigeye thresher, and pelagic thresher sharks. From 1971 – 1997, the total shark catch in this fishery generally increased, although catch declined in 1996 and 1997 due to decreases in fishing effort (Okamoto and Bayliff 2003).

Based on observer data (42 sets observed in 2001 – 2002) in the U.S. West Coast pelagic longline fishery, the discard rate varies greatly by species. During 2001 – 2002, economically valuable species such as swordfish had a discard rate of approximately 14% while 100% of the blue sharks caught were discarded (PFMC and NMFS 2003). Blue sharks are the most commonly discarded species in the pelagic longline fishery, as well as *Carcharinus* spp. (Kelleher 2005). Data from the observer program in the U.S. Atlantic longline fishery targeting swordfish and tunas suggest that 69% of the blue sharks

caught are released alive (Diaz and Serafy 2005). Discard mortality is also higher in younger blue sharks (Diaz and Serafy 2005). Other than the recent work on the decline of Atlantic shark species by Baum et al. (2003), few data are available detailing the international exploitation of sharks, particularly in the Pacific. Earlier studies, such as that conducted by Stevens (1996) suggest that high seas Pacific fisheries take millions of blue sharks each year, with unknown consequences to the population structure of the species. Estimates of annual fishing mortality range from 10 – 20 million blue sharks worldwide (IUCN 2004). A recent study found that the biomass of sharks in the fin trade is much higher than the numbers reported to the FAO, with an estimated 26 – 73 million sharks traded each year (Clarke et al. 2006). In particular, Clarke et al. (2006) conclude that blue shark catches in the Pacific are likely near or exceeding MSY.

In the Spanish longline fleets targeting swordfish in the North Atlantic, sharks comprise the majority of the catch; blue sharks accounted for 67% of the total landings while swordfish accounted for 17% of total landings (Buencuerpo et al. 1998). Although blue sharks were the most common species caught, the population impacts may be more severe for shortfin mako sharks due to the number of immature sharks caught (Buencuerpo et al. 1998). In the U.S. pelagic longline fleet in the Atlantic, pelagic shark discards are greater than pelagic shark landings; in 2003 the discard/catch ratio for pelagic sharks was 0.88 (NMFS 2005d).

Limited observer data (an average of 6% observer coverage) from 1999 – 2003 in the WCPO show that after tunas (bigeye, yellowfin, and albacore), blue sharks were the most common species caught in the western tropical Pacific shallow-set fishery, the western tropical Pacific deep-set fishery, and the western South Pacific albacore fishery during that time period (Langley et al. 2005). The number of blue sharks discarded relative to the number caught is not available in Langley et al. (2005). In general, sharks and billfish were the most commonly non-tuna species caught during 1999 – 2003. Molony (2005) found that shark CPUE was highest in the tropical shallow-set longline fishery, although levels were similar in the tropical deep-set longline fishery and the temperate albacore longline fishery. It is likely that shark catch is equivalent to shark mortality, as anecdotal evidence suggests that possibly all of the sharks brought on board are killed before being discarded (Molony 2005). In the central WCPO, total shark mortalities have been estimated at 500,000 – 1.4 million sharks annually based on observer data from the longline fisheries (Molony 2005).

In the Indian Ocean, South African observer data (from 9% of the hooks set) suggest a catch rate of 7 sharks/1,000 hooks, with blue and mako sharks the most commonly caught shark species (IOTC 2005b).

Sharks and rays: population impacts

Blue sharks have been shown to be sensitive to low exploitation rates (Schindler et al. 2002), but in the Atlantic, blue shark biomass appears to be above B_{MSY} (ICCAT 2005b). Similarly, a 2001 assessment of MSY for blue sharks in the North Pacific concluded that for the population of blue sharks in this region, there is no danger of the stock collapsing (Kleiber et al. 2001). The status of the Atlantic shortfin mako stock, however, is highly uncertain, and it is possible that current biomass levels are below B_{MSY} , particularly in light of the 50% depletion seen in the CPUE data for this species (ICCAT 2005b). Although blue sharks are not protected under the U.S. ESA, the IUCN Red List of Threatened Species categorizes the blue shark as “Lower Risk,” and it is close to qualifying for the “Vulnerable” category (IUCN 2004). The IUCN defines “Vulnerable” as facing a high risk of extinction in the wild (IUCN 2004).

Most other sharks caught in the Pacific are considered incidental catch and are not retained (except the fins); the exceptions are thresher and mako sharks, whose meat has market value with no special processing required (NMFS 2003). Post-release mortality of discarded sharks is unknown. Given the observed declines in CPUE of heavily fished sharks in the Atlantic Ocean (Crowder and Myers 2001), and the fact that fishing pressure in the Pacific is greater than the Atlantic (52% of global fishing effort in 2000 was in the Pacific, 37% in the Atlantic, 11% in the Indian Ocean) (Lewison et al. 2004a), it seems reasonable to assume the incidental catch of many shark species in the Pacific may be having a negative impact on population levels.

As with seabirds and sea turtles, the impacts of longline fisheries on shark populations are not fully understood. The population consequences of bycatch of shark species in the Pacific is not well known, but the findings of Baum et al. (2003) in the Atlantic Ocean indicate caution is warranted for these highly vulnerable species. For more information on sharks, please see the Seafood Watch® Sharks Report at: http://www.mbayaq.org/cr/cr_seafoodwatch/content/media/MBA_SeafoodWatch_SharksReport.pdf.

Synthesis

Handline and harpoon fishing methods have minimal bycatch, and are thus considered to be of low conservation concern. For longlines, although there are limited data regarding international bycatch levels and trends, the continued bycatch of sea turtles, seabirds, marine mammals, sharks, billfish, and other pelagic fishes remains a critical conservation concern for the majority of swordfish fleets. In the absence of data demonstrating that bycatch rates are declining, Seafood Watch® must adopt the precautionary approach in considering the severity of the bycatch problem in global longline fisheries. Even for those fisheries which can demonstrate low or declining bycatch as a result of sufficient observer coverage and management measures, the bycatch of species with vulnerable life histories (e.g., sea turtles and sharks) or species with a critical stock status (e.g., some species of billfish) remains a high conservation concern.

The jeopardy finding for leatherbacks in the Atlantic similarly results in a critical conservation concern for the international longline fishery, while declines in leatherback interaction rates in the U.S. Atlantic longline fishery in 2005 result in a ranking of high conservation concern for that fishery. Seafood Watch® will continue to monitor this trend, and it will become a critical issue if sea turtle takes rise again in the U.S. Atlantic longline fishery. In addition, the continued bycatch of marlin species with critical stock status remains a concern in the Atlantic.

In the Pacific, seabird bycatch remains a concern, in addition to sea turtle bycatch. Observer data from the Hawaii-based longline fishery indicates that bycatch in this fishery is a high conservation concern, whereas critical bycatch concerns remain associated with global longline fisheries in the Pacific. Although there are no available data from the Indian Ocean, Seafood Watch® must adopt the precautionary approach and conclude that bycatch levels for protected and highly vulnerable bycatch species remains a critical conservation concern in this region. Based on the estimates of leatherback bycatch in the South American gillnet fisheries, bycatch in these fisheries also ranks as a critical conservation concern.

For the purposes of this report, generalizations are made to make recommendations to the general public, although Seafood Watch® recognizes that there are differences between the various swordfish longline fisheries. Country or fishery-specific data could be used to refute these generalizations.

Nature of Bycatch Rank:

Harpoon, Handline:



Hawaii-based longline, California drift gillnet, U.S. Atlantic longline:



International longline, South American gillnet:



Criterion 4: Effect of Fishing Practices on Habitats and Ecosystems

Habitat Effects

The gears used to catch swordfish (i.e., pelagic longlines, drift gillnets, handlines, harpoons) have minimal habitat effects, as they are either pelagic or surface gears and do not come into contact with the seafloor (Chuenpagdee et al. 2003). However, there is a risk of “ghost fishing” with gear such as drift gillnets. This occurs when the net, or pieces of it, are lost and then remain in the ocean, and essentially continue catching fish, protected species, etc. without being retrieved.

Ecosystem Effects

It has been suggested that the global oceans have lost 90% of the large predators, such as tunas and swordfish, due to the expanding and pervasive pelagic longline fishery (Myers and Worm 2003). Based on CPUE data, Myers and Worm (2003) found that while catches in a previously unfished area remained high at first, catch declined after several years of fishing pressure. However, this argument has proved to be controversial, with questions raised concerning the methodology used (Walters 2003) and the magnitude of the declines (Hampton et al. 2005). Both climate change and fishing pressure have been linked to ocean-wide declines in large predator diversity, with fishing being the primary driver behind long-term variation (Ward and Myers 2005; Worm et al. 2005). According to an analysis of Japanese longline data by Worm et al. (2005), diversity in the world’s oceans has declined by 10 – 50% over the last 50 years.

In the tropical Pacific, large-scale commercial fishing has been linked to ocean ecosystem changes, such as declines in large predator abundance and increases in small species abundance (Ward and Myers 2005). Ward and Myers (2005) looked at scientific survey data conducted in the 1950s and observer data from the 1990s and found that the number of fish caught declined from 58 fish/1,000 hooks to 25

fish/1,000 hooks over this time period. However, other studies have found dissimilar results (Cox et al. 2002). Using an ecosystem model, Cox et al. (2002) found fewer declines of large predators such as tunas and billfishes in a larger area of the Pacific.

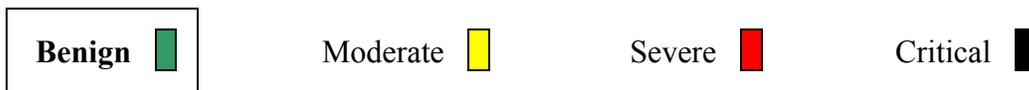
Kitchell et al. (2002) found that central North Pacific tuna and swordfish are likely more important predators than blue sharks. Pauly and Palomares (2005) found that the total length of tuna and billfish caught worldwide exhibited a continual decline from 1950 – 2000, and that “fishing down the foodweb” is more prevalent than previously thought. The removal of apex predators by commercial fisheries may have a large impact on trophic dynamics and thus pelagic ecosystems, even with sustainable fishing mortality rates (Essington et al. 2002). The removal of large predators, such as tunas, sharks, and billfishes, from the ecosystem may affect the interactions between these species, as well as result in considerable top-down effects (effects on prey species populations and the food chain below these large predators) (Fonteneau 2003).

Synthesis

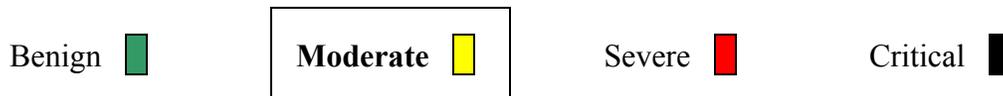
Pelagic longline, drift gillnet, handline, and harpoon gear have negligible habitat effects. The ecosystem effects of removing large predators, such as tuna, billfishes, and sharks, however, remain controversial. Due to the nature of the ecosystem effects caused by the removal of large predators from the ecosystem, combined with the benign habitat effects of the gear used, the conservation concern for harpoon, handline, and drift gillnet gear is low, while the conservation concern for pelagic longlines is moderate.

Effect of Fishing Practices Rank:

Handline, Harpoon, Drift gillnet:



Pelagic longline:



Criterion 5: Effectiveness of the Management Regime

North Pacific

Management of Pacific swordfish is divided between a large number of countries and international authorities that primarily focus on tuna-related data exchange and assessment (Table 6). No swordfish quotas are currently in place in the Pacific (PFMC 2003). Bycatch reduction efforts and management are described under “Criterion 3: Nature and extent of discarded bycatch,” earlier in this report. Ecosystem-based management should be an important component of the management efforts for swordfish, including the use of Marine Protected Areas (MPAs) and size limits.

Research on North Pacific swordfish is conducted by the Interim Scientific Committee (ISC), which began in 1995 as a joint agreement between Japan and the United States regarding tuna and tuna-like species. Current member countries include Canada, Taiwan, Japan, the Republic of Korea, Mexico,

People's Republic of China, and the United States. The ISC was intended to provide an information base for any future multilateral management regime, but no such regime currently exists (ISC website 2005).

Eastern Pacific

The Inter-American Tropical Tuna Commission (IATTC) provides management recommendations to member countries in the EPO, including Northeast and Southeast Pacific stocks (IATTC 2004). IATTC also reviews stock status in the EPO (Pacific Fishery Management Council 2003).

Northeast Pacific

United States swordboats along the west coast of North America are regulated by a new fishery management plan for highly migratory species (McInnis 2004). The plan was prepared by the Pacific Fishery Management Council (PFMC) and given federal approval by NOAA Fisheries in 2004 (McInnis 2004). High-seas pelagic longliners based on the U.S. West Coast are required to keep a logbook and turn in landings receipts. The current fishery is a deep-set longline fishery targeting tuna and also landing swordfish; there is 100% observer coverage for this fishery (PFMC 2005). Shallow-set longlining is prohibited within the U.S. EEZ, and U.S. vessels are prohibited from shallow-set longlining east of 150° W longitude. Vessel monitoring systems (VMS) and logbooks are required for both the California and Hawaii-based fleets (Cousins et al. 2000). The U.S. drift gillnet fishery for swordfish and sharks has been active since 1997 and is closely regulated at the state level and federal level (PFMC 2003). Regular data collection includes market sampling and observers; the average rate of observer coverage is 20% (PFMC 2005).

The California Department of Fish and Game (CDF&G) began sampling fish markets in 1981, and continued to do so through at least 1993 (Holts and Sosa-Nishizaki 1998). At-sea observers for either the CDF&G or the NMFS (NOAA Fisheries) have been at work since 1980 with some breaks in coverage (Pacific Fishery Management Council 2003). From 1990 – 1993, observer coverage averaged between 5% and 28% of driftnet vessel trips (Holts and Sosa-Nishizaki 1998). Harpoon boats on the U.S. West Coast report basic logbook information on effort and number of swordfish landed (PFMC 2003).

Southeast Pacific

Chile and the European Commission agreed in 2001 to form a multilateral organization to manage swordfish in the Southeast Pacific (Murphy 2001). This agreement ended a decade-long dispute over conservation of swordfish stocks and access to Chilean ports. The jurisdiction of the new organization will be in the high seas beyond territorial waters of Chile, Perú, Colombia, and Ecuador (Comisión Permanente del Pacífico Sur 2004). Two international meetings followed the 2001 agreement, in 2002 and 2004, which included additional countries operating domestic or high-seas fleets in the Southeast Pacific (Comisión Permanente del Pacífico Sur 2004). Chile, Colombia, Ecuador, Perú, the European Community (EC), Japan, and Taiwan attended the 2004 meeting. China and Korea were invited but did not attend. These meetings have focused on the exchange of scientific information related to swordfish, and on the beginnings of how joint management might operate (Comisión Permanente del Pacífico Sur 2004).

Western and Central Pacific

The Western and Central Pacific Fisheries Management Commission (WCPFC) manages swordfish in the WCPO. The commission's mandate comes from a series of Multilateral High-level Conferences (MHLC) on South Pacific tuna fisheries, convened from 1994 – 2000 by the South Pacific Forum Fisheries Agency (FFA) (Nandan and Lodge 2000). These conferences represent growing recognition of the unique management challenges of highly migratory species, codified in the United Nations conference on straddling stocks and highly migratory fish stocks.

Taiwan

Taiwanese tuna vessels land swordfish incidentally, and fish primarily in the western Pacific and Indian Oceans. The majority (93%) of swordfish landed by Taiwan is caught in the far sea fishery (beyond Taiwan's EEZ), with the remaining 3% of swordfish landed in the offshore fishery (within Taiwan's EEZ, which is 12 – 200 miles from the coast) (Fisheries Agency 2005). To address overfishing of bigeye tuna worldwide, Taiwan has agreed to remove 160 large-scale longline vessels from their fishing fleet, which currently comprises 614 large scale longline vessels (Fisheries Agency undated). Since 1991 Taiwan's fisheries have been limited entry, and management has implemented a number of buyback programs to reduce fishing capacity (Fisheries Agency undated). Additional management measures include increasing the frequency of catch reporting via VMS, allocating quotas to individual vessels, increasing observer coverage and port sampling, implementing additional management measures for small and medium-scale longline vessels, and increasing the severity of the punishments for not abiding by the aforementioned regulations (Fisheries Agency undated). To address bycatch in its longline fisheries, Taiwan has a National Plan of Action for Reducing Incidental Catch of Seabirds in Longline Fisheries, which includes a regulation for tori line use on longline vessels fishing south of 28°S, and encourages vessels to follow any additional regulations as implemented by the various regional fishery management organizations (RFMOs). After four years of data collection, increased mitigation measures will be implemented where necessary (Fisheries Agency 2007a). Based on observer coverage since 2001, estimated seabird bycatch rates are 0.0313 to 0.0619 seabirds per 1,000 hooks (Fisheries Agency 2007). Sharks are caught incidentally in the tuna longline fishery, primarily blue sharks (70 – 80%) as well as mako, thresher, hammerhead, and oceanic whitetip sharks—most of these sharks are landed and sold at foreign ports and catch statistics are poor as they are incidental species (Fisheries Agency 2007b). Quantitative data on other species caught incidentally in the tuna longline fishery are unknown. There do not appear to be any additional management measures for swordfish in the Taiwanese fleet, and the degree of enforcement and monitoring are unknown.

Australia

Australia's swordfish fishery is regulated by the national Australian Fishery Management Authority (AFMA) under its management plans for the Eastern Tuna and Billfish Fishery (ETBF) and the Western Tuna and Billfish Fishery (WTBF). The ETBF Management Plan was accepted in 2005, and stipulates that both longline and minor line (handline, troll, rod and reel) may be used to target the species that are managed under the management plan (COMLAW 2005). Within the ETBF management plan, measures include transferable statutory fishing rights (SFR) and a total allowable effort level (effort is managed through controlling the number of hooks that can be set); additional objectives include determining reference points for the fishery, data collection, monitoring, and compliance. The management plan addresses bycatch by requiring that AFMA implement a bycatch action plan (BAP), which is reviewed every two years (COMLAW 2005). There is observer coverage, and vessel monitoring systems (VMS) are required (AFMA 2005). The annual TAC for swordfish in the ETBF is 1,400 mt, and there are

monthly “trigger limits” used to determine whether fishermen are subject to 10 fish bycatch limit (AFMA 2007). Gear restrictions include a prohibition on the use of wire leaders, which increase shark catches (Gilman et al. 2007).

Historically, observers have been placed on Japanese longliners fishing in Australian waters, and voluntary logbooks have been collected since the 1960s. However, mandatory logbooks began only in 1995 and there is no independent verification of logbook data. Observer coverage of the domestic fleet began in 2003, with a target of 5.1% coverage (AFMA 2003; Lynch 2005). The discarding of “no-take” species, which are not allowed by law to be kept, declined from the 2003/04 to 2004/05 fishing season; these species include black and blue marlin, grey nurse sharks, and great white sharks (Lynch 2005). The AFMA has established bycatch limits for seabirds (0.05/1,000 hooks), and the day-set ETBF was recently closed when seabird catches increased (AFMA 2006a). Currently, seabird bycatch mitigation measures (e.g., tori poles, regulations regarding offal discharge), are required in the ETBF but not the WTBF, and there has been no observer coverage in the WTBF despite high bycatch rates in the Japanese fleet that operated in this region (DAFF 2003; AFMA 2004). Although the BAP requires monitoring and data collection, mitigation measures for other protected species have not been implemented (AFMA 2004), but research is being conducted to address sea turtle interactions (AFMA 2006c). The U.S. is one of the main markets for the ETBF in Australia (AFMA 2006b).

New Zealand

In New Zealand, swordfish is generally caught incidentally in the tuna longline fishery. Swordfish is managed under the New Zealand Ministry of Fisheries, and was included in the Ministry of Fisheries’ quota management system in 2004 (Ministry of Fisheries undated). The total allowable commercial catch for swordfish in New Zealand waters is 885 mt (Ministry of Fisheries undated). The management authorities in New Zealand are responsible for ensuring that any management measures implemented by the WCPFC are enforced in New Zealand waters. In 2004, New Zealand implemented a National Plan of Action to Reduce the Incidental Catch of Seabirds in New Zealand Fisheries; the Plan contains both mandatory and voluntary measures, some of which have shown to be effective in the longline fisheries (Ministry of Fisheries 2006). Specific data on the number of seabirds taken as bycatch in the tuna longline fishery are not available, thus it is unknown whether mitigation measures have been successful. Other than a total allowable catch, there do not appear to be any additional management measures in this fishery, and there is no management plan currently in place.

North Atlantic

Atlantic swordfish stocks are assessed periodically by the International Commission for Conservation of Atlantic Tunas (ICCAT). The most recent stock assessment for the North Atlantic stock was carried out in 2009. Reviews of mathematical models used for ICCAT swordfish assessments suggest that ICCAT’s methods are generally robust (Prager 1996; Prager 2002; Prager 2003, ICCAT 2009a), although alternatives have been proposed (Maunder 2003). ICCAT was established in 1971 and regular Commission meetings are held annually. Recommendations adopted by ICCAT, including country-specific quotas (which include dead discards) and a minimum size for swordfish caught in the North and South Atlantic, are legally binding on ICCAT’s 27 member countries (Raymakers and Lynham 1999). The North Atlantic swordfish quota is allocated to the EC (52%), the U.S. (30%), Canada (11%), Japan (7%), and other countries (DFO 2005). However, each member nation develops its own legislation to implement ICCAT recommendations. Beginning in 1991, ICCAT member countries were asked to decrease their swordfish catch by 15% (based on 1998 catch levels for each country) (DFO 2005).

Few nations apply precautionary management to developing swordfish fisheries, and most have a track record of fishing swordfish beyond optimum levels (Ward 2000). Recent improvements in North Atlantic stock status notwithstanding, ICCAT recommendations and resultant management measures were only put in place after declines in the North Atlantic swordfish stock (NOAA Fisheries 2003).

The European Community joined ICCAT in 1997, superseding previous memberships by individual countries from the European Union (EU). The EU sets total allowable catches (TACs) that must be recorded in logbooks on each vessel in the North Atlantic swordfish fishery, and required a minimum size for swordfish until that requirement was revoked in 2000 (Raymakers and Lynham 1999). Within the European Community, the Common Fisheries Policy and fisheries-related Council Regulations are binding on all EU members. However, enforcement and monitoring are the responsibility of each individual country, and the EU has limited recourse if a particular country does not follow through (Raymakers and Lynham 1999). Regulations from ICCAT and the EU primarily address catch quotas and minimum size limits. Apart from EU and ICCAT requirements, fisheries legislation in Spain is comprised of many separate and relatively weak regulations from the central government (Raymakers and Lynham 1999).

The Department of Fisheries and Oceans Canada (DFO) manages the Canadian swordfish fleet. Canadian management measures for swordfish occur under the Canadian Atlantic Swordfish and Other Tunas 2004 – 2006 Integrated Fisheries Management Plan (IFMP) (DFO 2005). Under the IFMP, the swordfish fleet is involved in monitoring and data collecting. Management measures include limited entry, time/area closures (specifically, longlines are prohibited in the Gully Marine Protected Area, and swordfish fishing is prohibited in certain areas to reduce catch of small swordfish and bluefin tuna), observer coverage (minimum 5% at-sea observer coverage), regulations regarding hailing in and hailing out (i.e., entering or exiting the fishing zone), logbook requirements, at-sea inspections, and dockside monitoring (DFO 2005). In 2000, Canada's quota was allocated among the fleet, with 90% of the quota allocated to the longline fleet and 10% allocated to the harpoon fleet; in addition, the longline fleet utilizes an individual transferable quota (ITQ) system (DFO 2005). The Canadian fishery has a limited entry program due to limited licenses for the fishery. Although there are approximately 1,200 licenses for the harpoon fishery, only 188 of these licenses are actively used; there are 77 longline licenses, 40 of which are actively used (DFO 2005). The proportion of longline and harpoon catch varies annually, with harpoons accounting for as much as 22% of total Canadian catch in some years (DFO 2005).

It is unclear as to whether or not there are specific bycatch mitigation measures required on a fleet-wide basis, but all longline vessels are required to have an Incidental Harm Permit for the incidental take of leatherback sea turtles, and new management measures were enacted under the recent Species at Risk Act (SARA) in 2003, which affected the longline fleet (DFO 2005). All sea turtles and marlins caught incidentally in this fishery must be released (DFO 2005). All members (currently 30 active vessels) of the Nova Scotia Swordfishermen's Association have turtle de-hooking kits on board (DFO 2005). In addition, the DFO is in the process of developing a National Plan of Action for sharks (DFO 2005). In 1996, the Canadian longline fleet switched from using the traditional J hooks to circle hooks, which is thought to reduce the catch of protected species such as sea turtles; approximately 75% of the fleet now uses 16/0 circles hooks (DFO 2005). An additional concern in the longline fishery is the dead discarding of bluefin tuna, which is mandated by law; Canadian dead discards of bluefin tuna often exceed their allocated 5.6 mt quota (DFO 2005). The DFO is currently working on trial measures to

reduce the dead discarding of bluefin (DFO 2005). However, as observer data from the Canadian longline fleet operating in the Atlantic could not be obtained for this report, bycatch in this fishery is deemed critical according to Seafood Watch® criteria.

Import of undersized swordfish to the U.S. market from any Atlantic region is prohibited. All Atlantic swordfish are required to have a Certificate of Eligibility and dealer permits to facilitate tracking and enforcement of the minimum size (NOAA Fisheries 1999). The United States fishery is managed under the Magnuson-Stevens Conservation and Management Act and the Atlantic Tunas Convention Act, which requires implementation of all ICCAT recommendations (NOAA Fisheries 2003). For the U.S. pelagic longline fleet, 5% observer coverage using stratified random sampling is required annually to comply with the Endangered Species Act (NMFS Biological Opinion 2001). Bycatch reduction is managed directly in the United States fishery as described earlier under “Criterion 3: Nature and Extent of Bycatch.”

Mediterranean

Most Mediterranean countries participate in the non-binding General Fisheries Commission for the Mediterranean (GFCM), formed in 1949 through the Food and Agriculture Organization of the United Nations (FAO). The GFCM encompasses the Mediterranean and the Black Sea and includes many non-EU and non-ICCAT countries in Eastern Europe, northern Africa, and the Middle East (FAO Fisheries website; Raymakers and Lynham 1999). ICCAT receives fisheries data from GFCM members through a Joint Working Group on stocks of large pelagic species in the Mediterranean Sea (Raymakers and Lynham 1999). These data, most recently updated in 2007, indicate that management has failed to adequately maintain stock productivity or prevent overfishing. ICCAT has responded by issuing a series of recommendations including large scale areas closures during spawning periods and technical modifications of longline gears in order to reduce juvenile catch. ICCAT also recommends that national scientific delegations conduct further research into technology and time-area closures to further protect juvenile swordfish.

Mediterranean swordfish formerly had a minimum size requirement under EU regulations but not under ICCAT (Raymakers and Lynham 1999). This requirement may have resulted in under-reporting of juvenile catches (ICCAT Mediterranean 2003). The EU minimum size requirement was abandoned in 2000. The Mediterranean is beyond the reach of the U.S. swordfish fleet and jurisdiction, but import of undersized swordfish to the U.S. market is prohibited as described above for the North Atlantic. In Italy, a previous, more stringent size requirement came back into effect after cessation of the EU minimum size requirement for Atlantic swordfish (ICCAT Mediterranean).

South Atlantic

All available information was considered in developing current ICCAT management measures for the South Atlantic; however, effective management is constrained by the lack of data for the South Atlantic swordfish fisheries (McAllister et al. 2003). While there is a stock assessment for South Atlantic swordfish, it is considered highly uncertain, and due to conflicting information and poorly estimated production model benchmarks, the Standing Committee on Research and Statistics (SCRS) uses a catch-only modeling analysis to set recommendations. According to the 2009 stock assessment, a TAC of 15,000 would result in the biomass remaining above B_{MSY} 80% of the time. The SCRS recommended that TACs be reduced from 17,000 to 15,000 to maintain stock productivity (ICCAT 2009a), and ICCAT adopted the recommended TAC of 15,000 for 2010-2012 (NOAA Fisheries 2009).

In 1997 ICCAT established an allocation scheme to account for current South Atlantic swordfish fisheries by member countries, and has recommended in recent years that current catch levels be maintained (Neto and Lima 1998; NOAA Fisheries 2003). ICCAT management measures in place include an overall TAC for the South Atlantic, but no country-specific quotas. ICCAT has also set a minimum size limit for both South and North Atlantic swordfish of 125 cm with 15% tolerance, or 119 cm lower jaw fork length (LJFL) with zero tolerance and evaluation of discards (ICCAT Atlantic 2003). Swordfish vessels in the South Atlantic are beyond the jurisdiction of the U.S. EEZ (NOAA Fisheries 2004 SAFE report); however, imports of undersized swordfish are prohibited in the U.S. market as described above for the North Atlantic.

Indian Ocean

In the Indian Ocean, swordfish falls under the jurisdiction of the Indian Ocean Tuna Commission (IOTC). There do not appear to be any commission-wide regulations regarding swordfish in the Indian Ocean, although individual countries may have measures for their fleets in domestic and international waters. For instance, Australia recently approved the 2005 Western Tuna and Billfish Fishery Management Plan, which includes an ITQ program. In 2003, there were 348 large-scale, licensed vessels fishing for tuna and tuna-like species in the Indian Ocean (IOTC 2004). There is no quota for swordfish in the Indian Ocean, and no comprehensive bycatch reduction plan. It is unknown whether enforcement of regulations in the Indian Ocean is adequate, and it is unknown if scientific advice is followed or not. The primary fleets targeting swordfish in the Indian Ocean are Taiwan, Australia, Reunion Island, Seychelles, Mauritius, Spain, and Portugal (IOTC 2006). The IOTC recently adopted several conservation measures, which address, among other things, IUU fishing, seabird bycatch in longline fisheries, and fishing capacity (IOTC 2006). IOTC member countries include Australia, China, Comoros, Eritrea, European Community, France, Guinea, India, Iran, Japan, Kenya, Republic of Korea, Madagascar, Malaysia, Mauritius, Oman, Pakistan, Philippines, Seychelles, Sri Lanka, Sudan, Thailand, United Kingdom, and Vanuatu. Cooperating non-contracting parties include Belize, Indonesia, Senegal, and South Africa.

Table 6. Commercial catch management measures for the swordfish fishery⁶.

Region	Management Jurisdictions & Agencies	Total Allowable Landings	Size Limit	Gear Restrictions	Trip Limit	Area Closures	Sources
Atlantic Ocean	ICCAT, NMFS (U.S.)	Country-specific TACs in the N Atl; TAC target in the S Atl	125 cm with 15% tolerance or 119 cm LJFL with 0 tolerance	Several gear restrictions and area closures designed to reduce non-target species bycatch in addition to protected species and sea turtles	None	Closed areas to reduce protected species bycatch (Canada, U.S. fisheries)	NMFS 2004c; DFO 2005; ICCAT 2005
Pacific Ocean	IATTC, NMFS (U.S.), PFMC (U.S.), WPFMC (U.S.), WCPFC	None	None	Longlining prohibited in U.S. EEZ off the coast of CA, OR, WA	None	Closed areas to reduce protected species bycatch (U.S. fishery)	IATTC; WPFMC
Indian Ocean	IOTC	None	None	Capacity limit for 24 m or larger vessels	None	None	IOTC 2004
Mediterranean Sea ⁷	ICCAT, GFCM	None	Minimum size & effort controls for some fleets	Ban on driftnet use as introduced by the EC	None	National closed areas	ICCAT 2005

Synthesis

Management of North Atlantic swordfish is divided between Spain, the United States, Canada, and other countries under ICCAT. The North Atlantic swordfish stock assessment is based on regular collection of fishery-dependent data. U.S. regulations include a bycatch plan and are enforced through observer coverage, mandatory logbooks, and other measures. However, these measures were put in place only after significant decline in North Atlantic swordfish populations. International management of swordfish in the North Atlantic is moderately effective, while U.S. management is deemed highly effective in part due to bycatch mitigation measures, including a closed area in the U.S. EEZ to protect undersize swordfish, and adequate enforcement.

South Atlantic management is limited by lack of data for several swordfish fisheries and an incomplete stock assessment for the South Atlantic swordfish stock. There is no large-scale plan to reduce bycatch in South Atlantic swordfish fisheries and regulations are not enforced. Though the South Atlantic swordfish stock status is uncertain, currently stocks are believed to not be overfished with no overfishing occurring, and management has complied with scientific recommendations to maintain stock

⁶ Although there may be no commission regulations listed, individual countries may have management measures in place.

⁷ There are no ICCAT regulations in the Mediterranean.

productivity in the long-term. International management of swordfish in the South Atlantic is thus deemed moderately effective.

Management of Mediterranean swordfish benefits from regular collection of fishery-dependent data but is limited by an incomplete stock assessment. Management measures are partially enforced in EU member countries, however a substantial proportion of fishing nations targeting the Mediterranean swordfish stock are not from the EU. Evidence of a large-scale bycatch reduction plan for the Mediterranean swordfish fishery was not found for this report, and management has failed to maintain stock productivity and prevent overfishing. Therefore, the management of swordfish in the Mediterranean is deemed critical for the longline fishery, which has serious bycatch concerns that are not addressed adequately, and ineffective for the harpoon and handline fisheries.

In the EPO, there is a robust stock assessment and adequate scientific monitoring, and stock abundance has been maintained. Bycatch has been addressed in the California drift gillnet fishery, but not in the international longline fishery. Bycatch and enforcement concerns in the international longline fishery result in a rank of moderately effective management for the international fleet, while U.S. management of swordfish in the EPO is deemed highly effective.

In the NW and SW Pacific, management has not been in place long enough to evaluate whether management measures have affected stock abundance. While there is a recent stock assessment for the SW Pacific, there is not one for the NW Pacific. Due to enforcement and bycatch concerns in the international longline fishery, management for the international fleet is ranked moderately effective. The Hawaii-based fleet on the other hand has implemented bycatch mitigation measures and is characterized by adequate enforcement; management of this fishery is thus considered highly effective.

In the Indian Ocean, there is no bycatch mitigation plan for the longline fleet, and there remains inadequate enforcement. Overall, the biomass level is likely at or above B_{MSY} . Thus, management of swordfish in the Indian Ocean is deemed moderately effective.

Effectiveness of Management Rank:

U.S. (including Hawaii), Canada:

Highly Effective 

Moderately Effective 

Ineffective 

Critical 

International (EPO, NW Pacific, North Atlantic, South Atlantic), Indian Ocean, SW Pacific:

Highly Effective 

Moderately Effective 

Ineffective 

Critical 

Mediterranean (harpoon, handline):Highly Effective Moderately Effective **Ineffective** Critical **Mediterranean (longline):**Highly Effective Moderately Effective Ineffective **Critical** **IV. Overall Evaluation and Seafood Recommendation**

Swordfish (*Xiphias gladius*) is a highly migratory species distributed throughout the world's oceans. As a species with an early age at maturity and moderate longevity, swordfish is inherently resilient to fishing pressure. For stock assessment purposes, there are eight swordfish stocks: the Northeast Pacific, Southeast Pacific, Southwest Pacific, Northwest Pacific, North Atlantic, South Atlantic, Indian Ocean, and Mediterranean Sea. Stocks are healthy in the eastern Pacific (EPO), where stocks are not overfished and overfishing is not occurring. Abundance trends are also increasing in these regions. There are no robust stock assessments for swordfish in the Northwest Pacific or South Atlantic, and there is a paucity of data concerning stock status in these regions. Stocks in the NW Pacific and South Atlantic are considered unknown and a moderate conservation concern. In the SW Pacific, model uncertainty and declining CPUEs with increasing catches results in a moderate conservation concern. In the North Atlantic, the stock is now considered rebuilt, and overfishing is not occurring. Overfishing is occurring in the Mediterranean and likely occurring in the Indian Ocean, thus these stocks are considered poor.

Swordfish is most commonly caught with longlines, although there is some catch with drift gillnets, handlines, and harpoons. The level of bycatch varies according to gear type. Pelagic longlines catch a number of incidental species, including endangered and threatened sea turtles, seabirds, marine mammals, sharks, and billfish. The Hawaii and U.S. Atlantic longline fisheries, which have observer data demonstrating that their fishery has declining bycatch trends, or evidence that bycatch levels are not contributing to the decline of the species, are considered to be of high conservation concern (rather than critical) for the bycatch criterion; all other pelagic longline fisheries are considered to have critical bycatch levels. Bycatch in the California drift gillnet fishery is also a high conservation concern due to the take of protected species such as marine mammals; however, bycatch rates have declined in this relatively well-managed fishery. Bycatch in drift gillnet fisheries is also a critical conservation concern in South America. There are negligible bycatch concerns associated in the handline and harpoon fisheries. All gears used to catch swordfish have minimal habitat effects; however, the ecosystem effects of removing large predators such as swordfish are not well understood. Concerns surrounding the removal of large predators, combined with the benign habitat effects of the above gears, result in a moderate conservation concern for pelagic longlines and a low concern for handlines, harpoons, and drift gillnets for habitat and ecosystem impacts of the fishery.

Management of swordfish is complicated by the fact that individual countries may have more or less stringent regulations than those of the international management bodies. U.S. management of the swordfish fisheries is deemed effective due to adequate enforcement, reporting, and bycatch mitigation efforts. In the international swordfish fisheries on the other hand, there is no comprehensive enforcement plan and no comprehensive bycatch mitigation plan. Management of the international

fleets is thus deemed only moderately effective, with the exception of the Mediterranean which is deemed ineffective for the handline/harpoon fisheries and critical for the longline fishery.

Overall, all harpoon and handline-caught swordfish from the U.S. Atlantic, Hawaii, Canada, North Atlantic and Eastern Pacific are recommended as **Best Choices**. Harpoon or handline-caught swordfish from the international fleets of the Indian Ocean, Southwest Pacific, Western and Central Pacific, Northwest Pacific, and South Atlantic are all recommended as **Good Alternatives**. All U.S. longline-caught swordfish and California drift gillnet-caught swordfish are also recommended as **Good Alternatives**. Swordfish from the Mediterranean (all gear types) is recommended as **Avoid** due to poor stock status and ineffective management. Swordfish from international longline fleets and the South American drift gillnet fleet is also recommended as **Avoid** because of concerns related to bycatch

Table of Sustainability Ranks

Sustainability Criteria	Conservation Concern			
	Low	Moderate	High	Critical
Inherent Vulnerability	✓			
Status of Stocks	✓ • Eastern Pacific • North Atlantic	✓ • NW Pacific • South Atlantic • SW Pacific	✓ • Mediterranean • Indian Ocean	
Nature of Bycatch	✓ • Harpoon • Handline		✓ • Hawaii longline • U.S. Atlantic longline • California drift gillnet	✓ • International longline • South Am. gillnet
Habitat & Ecosystem Effects	✓ • Harpoon • Handline • Drift gillnet	✓ • Longline		
Management Effectiveness	✓ • U.S. • Canada	✓ • International (EPO, NW Pacific, North Atlantic, South Atlantic) • Indian Ocean • SW Pacific	✓ • Mediterranean (harpoon & handline)	✓ Mediterranean (longline)

Overall Seafood Recommendation

Seafood Watch® Recommendation	Where Caught and Gear Used
Best Choices 	Harpoon or handline (North Atlantic, eastern Pacific, U.S. Atlantic, Hawaii, Canada)
Good Alternatives 	California drift gillnet
	Harpoon or handline (Southwest Pacific, Indian Ocean, international western and central Pacific, international northwest Pacific, international South Atlantic)
	U.S. Atlantic and Hawaii longline
Avoid 	International longline
	South American drift gillnet
	Mediterranean (all gears)

Supplemental Information

Health consumption information on the Seafood Watch® pocket guides is provided by Environmental Defense Fund. Environmental Defense Fund applies the same risk-based methodology as the U.S. Environmental Protection Agency (EPA) to data from government studies and papers published in scientific journals. The Environmental Defense Fund consumption advisory for swordfish is based on mercury contamination. The number of meals of swordfish that can safely be eaten each month is 0 for females, 1 for males, 0 for older children, and 0 for younger children. More detailed information about the Environmental Defense Fund advisory can be found at <http://www.edf.org/page.cfm?tagID=16309>.

The U.S. FDA/EPA joint consumption advisory recommends that women of child-bearing age and children not consume swordfish (<http://www.cfsan.fda.gov/~dms/admehg3.html>). The FDA limit for human consumption is 1.0 ppm (FDA 1994).

Acknowledgements

Seafood Watch® would like to thank Dr. Freddy Arocha, Dr. Murdoch McAllister, and Dr. Elizabeth Babcock for reviewing the sections on Atlantic swordfish for scientific accuracy and completeness. We also received constructive comments on specific sections of the report from Dr. Jaime Mejuto, an anonymous reviewer from NOAA Fisheries, and an anonymous reviewer from the Commonwealth Scientific and Industrial Research Organization (CSIRO).

Scientific review does not constitute an endorsement of the Seafood Watch® program, or its seafood recommendations, on the part of the reviewing scientists. Seafood Watch® is solely responsible for the conclusions reached in this report.

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VI. Appendices

Appendix I: Stock Status Update

January 7, 2011: Kristen Bor

Prior to 2007, biological reference points for Mediterranean swordfish were unknown. According to the 2007 stock assessment, the Mediterranean swordfish stock has a B/B_{MSY} of between 0.26 and 0.87 and F/F_{MSY} of 1.3. Therefore the stock is undergoing overfishing. Stock abundance and spawning stock biomass have also decreased substantially over the last 20 years. This results in no change in stock status ranking. Management rank of Mediterranean swordfish has been changed from moderately effective to ineffective because there is now evidence to suggest that management in the Mediterranean has not maintained stock productivity. Therefore, the overall Seafood Watch® recommendation for all swordfish caught in the Mediterranean is “Avoid.”

In the 2007 Seafood Watch® report, North Atlantic swordfish was approaching rebuilt status, but biomass was slightly below B_{MSY} . In the most recent stock assessment, conducted by ICCAT in 2009, the North Atlantic swordfish is declared to be “rebuilt.” According to the assessment, North Atlantic swordfish is not overfished ($B_{2009}/B_{MSY}=1.05$) and overfishing is not occurring ($F_{2008}/F_{MSY}=0.76$). This results in a change in the stock status from moderate to healthy, and the overall Seafood Watch® recommendation has changed. The recommendation for harpoon and handline-caught swordfish from the North Atlantic is “Best Choice.” However, for North Atlantic stocks caught by international long-line or international drift gillnet fleets, the recommendation remains “Avoid.”

Appendix 2**Capture Fisheries Evaluation****Species:** *Swordfish***Region:** *All***Analyst:** *Jesse Marsh***Date:** *1/7/2011*

Seafood Watch™ defines sustainable seafood as originating from sources, whether fished⁸ or farmed, that can maintain or increase production in the long-term without jeopardizing the structure or function of affected ecosystems.

The following **guiding principles** illustrate the qualities that capture fisheries must possess to be considered sustainable by the Seafood Watch program. Species from sustainable capture fisheries:

- have a low vulnerability to fishing pressure, and hence a low probability of being overfished, because of their inherent life history characteristics;
- have stock structure and abundance sufficient to maintain or enhance long-term fishery productivity;
- are captured using techniques that minimize the catch of unwanted and/or unmarketable species;
- are captured in ways that maintain natural functional relationships among species in the ecosystem, conserves the diversity and productivity of the surrounding ecosystem, and do not result in irreversible ecosystem state changes; and
- have a management regime that implements and enforces all local, national and international laws and utilizes a precautionary approach to ensure the long-term productivity of the resource and integrity of the ecosystem.

Seafood Watch has developed a set of five sustainability **criteria**, corresponding to these guiding principles, to evaluate capture fisheries for the purpose of developing a seafood recommendation for consumers and businesses. These criteria are:

1. Inherent vulnerability to fishing pressure
2. Status of wild stocks
3. Nature and extent of discarded bycatch
4. Effect of fishing practices on habitats and ecosystems
5. Effectiveness of the management regime

Each criterion includes:

- Primary factors to evaluate and rank
- Secondary factors to evaluate and rank
- Evaluation guidelines⁹ to synthesize these factors
- A resulting **rank** for that criterion

Once a rank has been assigned to each criterion, an **overall seafood recommendation** for the species in question is developed based on additional evaluation guidelines. The ranks for each criterion, and the resulting overall

⁸ “Fish” is used throughout this document to refer to finfish, shellfish and other wild-caught invertebrates.

⁹ Evaluation Guidelines throughout this document reflect common combinations of primary and secondary factors that result in a given level of conservation concern. Not all possible combinations are shown – other combinations should be matched as closely as possible to the existing guidelines.

seafood recommendation, are summarized in a table. Criterion ranks and the overall seafood recommendation are color-coded to correspond to the categories of the Seafood Watch pocket guide:

Best Choices/Green: Consumers are strongly encouraged to purchase seafood in this category. The wild-caught species is sustainable as defined by Seafood Watch.

Good Alternatives/Yellow: Consumers are encouraged to purchase seafood in this category, as they are better choices than seafood in the Avoid category. However there are some concerns with how this species is fished and thus it does not demonstrate all of the qualities of a sustainable fishery as defined by Seafood Watch.

Avoid/Red: Consumers are encouraged to avoid seafood in this category, at least for now. Species in this category do not demonstrate enough qualities to be defined as sustainable by Seafood Watch.

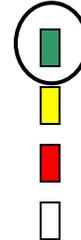
CRITERION 1: INHERENT VULNERABILITY TO FISHING PRESSURE

Guiding Principle: Sustainable wild-caught species have a low vulnerability to fishing pressure, and hence a low probability of being overfished, because of their inherent life history characteristics.

Primary Factors¹⁰ to evaluate

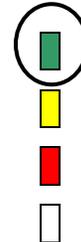
Intrinsic rate of increase ('r')

- High (> 0.16) **0.4**
- Medium (0.05 - 0.16)
- Low (< 0.05)
- Unavailable/Unknown



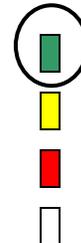
Age at 1st maturity

- Low (< 5 years) **2-6 for males, 2-8 females**
- Medium (5 - 10 years)
- High (> 10 years)
- Unavailable/Unknown



Von Bertalanffy growth coefficient ('k')

- High (> 0.16) **0.19-1.24 males, 0.09-0.21 females**
- Medium (0.05 - 0.15)
- Low (< 0.05)
- Unavailable/Unknown



Maximum age

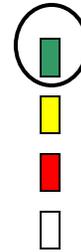
- Low (< 11 years)
- Medium (11 - 30 years) **16 yrs (males), 12 yrs (females)**
- High (> 30 years)
- Unavailable/Unknown



¹⁰ These primary factors and evaluation guidelines follow the recommendations of Musick et al. (2000). Marine, estuarine, and diadromous fish stocks at risk of extinction in North America (exclusive of Pacific salmonids). Fisheries 25:6-30.

Reproductive potential (fecundity)

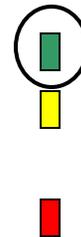
- High (> 100 inds./year)
- Moderate (10 – 100 inds./year)
- Low (< 10 inds./year)
- Unavailable/Unknown



Secondary Factors to evaluate

Species range

- Broad (e.g. species exists in multiple ocean basins, has multiple intermixing stocks or is highly migratory)
- Limited (e.g. species exists in one ocean basin)
- Narrow (e.g. endemism or numerous evolutionary significant units or restricted to one coastline)



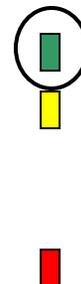
Special Behaviors or Requirements: Existence of special behaviors that increase ease or population consequences of capture (e.g. migratory bottlenecks, spawning aggregations, site fidelity, unusual attraction to gear, sequential hermaphrodites, segregation by sex, etc., OR specific and limited habitat requirements within the species' range).

- No known behaviors or requirements OR behaviors that decrease vulnerability (e.g. widely dispersed during spawning)
- Some (i.e. 1 - 2) behaviors or requirements
- Many (i.e. > 2) behaviors or requirements



Quality of Habitat: Degradation from non-fishery impacts

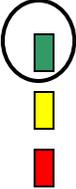
- Habitat is robust
- Habitat has been moderately altered by non-fishery impacts
- Habitat has been substantially compromised from non-fishery impacts and thus has reduced capacity to support this species (e.g. from dams, pollution, or coastal development)



Evaluation Guidelines

- 1) Primary Factors
 - a) If 'r' is known, use it as the basis for the rank of the Primary Factors.
 - b) If 'r' is unknown, then the rank from the remaining Primary Factors (in order of importance, as listed) is the basis for the rank.

- 2) Secondary Factors
 - a) If a majority (2 out of 3) of the Secondary Factors rank as Red, reclassify the species into the next lower rank (i.e. Green becomes Yellow, Yellow becomes Red). No other combination of Secondary Factors can modify the rank from the Primary Factors.
 - b) No combination of primary and secondary factors can result in a Critical Conservation Concern for this criterion.

Conservation Concern: Inherent Vulnerability	
➤ Low (Inherently Resilient)	
➤ Moderate (Inherently Neutral)	
➤ High (Inherently Vulnerable)	

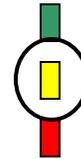
CRITERION 2: STATUS OF WILD STOCKS

Guiding Principle: Sustainable wild-caught species have stock structure and abundance sufficient to maintain or enhance long-term fishery productivity.

Primary Factors to evaluate

Management classification status

- Underutilized OR close to virgin biomass
- Fully fished OR recovering from overfished OR unknown **all**
- Recruitment or growth overfished, overexploited, depleted or “threatened”



Current population abundance relative to B_{MSY}

- At or above B_{MSY} (> 100%) **SW Pac, EPO, IO, Natl**
- Moderately Below B_{MSY} (50 – 100%) OR unknown **NW Pac, SAtl, Med**
- Substantially below B_{MSY} (< 50%)



Occurrence of overfishing (current level of fishing mortality relative to overfishing threshold)

- Overfishing not occurring ($F_{curr}/F_{msy} < 1.0$)
NWPac (unlikely), SWPac (unlikely), EPO, Natl
- Overfishing is likely/probable OR fishing effort is increasing with poor understanding of stock status OR Unknown **SAtl**
- Overfishing occurring ($F_{curr}/F_{msy} > 1.0$) **IO, Med (F2005/F_{MSY} = 1.3)**



Overall degree of uncertainty in status of stock

- Low (i.e. current stock assessment and other fishery-independent data are robust OR reliable long-term fishery-dependent data available)
EPO, Natl, Med
- Medium (i.e. only limited, fishery-dependent data on stock status are available)
SW Pac
- High (i.e. little or no current fishery-dependent or independent information on stock status OR models/estimates broadly disputed or otherwise out-of-date)
IO, NWPac, SAtl



Long-term trend (relative to species' generation time) in population abundance as measured by either fishery-independent (stock assessment) or fishery-dependent (standardized CPUE) measures

- Trend is up **EPO**
- Trend is flat or variable (among areas, over time or among methods) OR Unknown **SAtl, IO**
- Trend is down **NWPac, SWPac, NAtl, Med**



Short-term trend in population abundance as measured by either fishery-independent (stock assessment) or fishery-dependent (standardized CPUE) measures

- Trend is up **EPO, NAtl**
- Trend is flat or variable (among areas, over time or among methods) OR Unknown **SAtl, IO,**
- Trend is down **NWPac, SWPac, Med**



Current age, size or sex distribution of the stock relative to natural condition

- Distribution(s) is(are) functionally normal
- Distribution(s) unknown **all**
- Distribution(s) is(are) skewed



Evaluation Guidelines

A “**Healthy**” Stock:

- 1) Is underutilized (near virgin biomass)
- 2) Has a biomass at or above BMSY AND overfishing is not occurring AND distribution parameters are functionally normal AND stock uncertainty is not high

A “**Moderate**” Stock:

- 1) Has a biomass at 50-100% of BMSY AND overfishing is not occurring
- 2) Is recovering from overfishing AND short-term trend in abundance is up AND overfishing not occurring AND stock uncertainty is low
- 3) Has an Unknown status because the majority of primary factors are unknown.

A “**Poor**” Stock:

- 1) Is fully fished AND trend in abundance is down AND distribution parameters are skewed
- 2) Is overfished, overexploited or depleted AND trends in abundance and CPUE are up.
- 3) Overfishing is occurring AND stock is not currently overfished.

A stock is considered a **Critical Conservation Concern** and the species is ranked “Avoid”, regardless of other criteria, if it is:

- 1) Overfished, overexploited or depleted AND trend in abundance is flat or down
- 2) Overfished AND overfishing is occurring
- 3) Listed as a “threatened species” or similar proxy by national or international bodies

Conservation Concern: Status of Stocks

- Low (Stock Healthy) **EPO, NATl**
- Moderate (Stock Moderate or Unknown) **NW Pac, SATl, SW Pac**
- High (Stock Poor) **IO, Med**
- Stock Critical



CRITERION 3: NATURE AND EXTENT OF DISCARDED BYCATCH¹¹

Guiding Principle: A sustainable wild-caught species is captured using techniques that minimize the catch of unwanted and/or unmarketable species.

Primary Factors to evaluate

Quantity of bycatch, including any species of “special concern” (i.e. those identified as “endangered”, “threatened” or “protected” under state, federal or international law)

- Quantity of bycatch is low (< 10% of targeted landings on a per number basis) AND does not regularly include species of special concern **harpoon, handline** 
- Quantity of bycatch is moderate (10 – 100% of targeted landings on a per number basis) AND does not regularly include species of special concern OR Unknown 
- Quantity of bycatch is high (> 100% of targeted landings on a per number basis) OR bycatch regularly includes threatened, endangered or protected species **LL (longline), All DGN (drift gillnet)** 

Population consequences of bycatch

- Low: Evidence indicates quantity of bycatch has little or no impact on population levels **Harpoon, handline** 
- Moderate: Conflicting evidence of population consequences of bycatch OR Unknown 
- Severe: Evidence indicates quantity of bycatch is a contributing factor in driving one or more bycatch species toward extinction OR is a contributing factor in limiting the recovery of a species of “special concern” **LL, All DGN** 

Trend in bycatch interaction rates (adjusting for changes in abundance of bycatch species) as a result of management measures (including fishing seasons, protected areas and gear innovations):

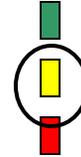
- Trend in bycatch interaction rates is down **US LL, CA DGN** 
- Trend in bycatch interaction rates is flat OR **Unknown international LL** 
- Trend in bycatch interaction rates is up **South American DGN** 
- Not applicable because quantity of bycatch is low **harpoon, handline** 

¹¹ Bycatch is defined as species that are caught but subsequently discarded because they are of undesirable size, sex or species composition. Unobserved fishing mortality associated with fishing gear (e.g. animals passing through nets, breaking free of hooks or lines, ghost fishing, illegal harvest and under or misreporting) is also considered bycatch. Bycatch does not include incidental catch (non-targeted catch) if it is utilized, is accounted for, and is managed in some way.

Secondary Factor to evaluate

Evidence that the ecosystem has been or likely will be substantially altered (relative to natural variability) in response to the continued discard of the bycatch species

- Studies show no evidence of ecosystem impacts
- Conflicting evidence of ecosystem impacts OR **Unknown**
- Studies show evidence of substantial ecosystem impacts



Evaluation Guidelines

Bycatch is “**Minimal**” if:

- 1) Quantity of bycatch is <10% of targeted landings AND bycatch has little or no impact on population levels.

Bycatch is “**Moderate**” if:

- 1) Quantity of bycatch is 10 - 100% of targeted landings
- 2) Bycatch regularly includes species of “special concern” AND bycatch has little or no impact on the bycatch population levels AND the trend in bycatch interaction rates is not up.

Bycatch is “**Severe**” if:

- 1) Quantity of bycatch is > 100% of targeted landings
- 2) Bycatch regularly includes species of “special concern” AND evidence indicates bycatch rate is a contributing factor toward extinction or limiting recovery AND trend in bycatch is down.

Bycatch is considered a **Critical Conservation Concern** and the species is ranked “Avoid”, regardless of other criteria, if:

- 1) Bycatch regularly includes species of special concern AND evidence indicates bycatch rate is a factor contributing to extinction or limiting recovery AND trend in bycatch interaction rates is not down.
- 2) Quantity of bycatch is high AND studies show evidence of substantial ecosystem impacts.

Conservation Concern: Nature and Extent of Discarded Bycatch	
<ul style="list-style-type: none"> ➤ Low (Bycatch Minimal) harpoon, handline 	
<ul style="list-style-type: none"> ➤ Moderate (Bycatch Moderate) 	
<ul style="list-style-type: none"> ➤ High (Bycatch Severe) CA DGN, US LL 	
<ul style="list-style-type: none"> ➤ Bycatch Critical Intl LL, South American DGN 	

CRITERION 4: EFFECT OF FISHING PRACTICES ON HABITATS AND ECOSYSTEMS

Guiding Principle: Capture of a sustainable wild-caught species maintains natural functional relationships among species in the ecosystem, conserves the diversity and productivity of the surrounding ecosystem, and does not result in irreversible ecosystem state changes.

Primary Habitat Factors to evaluate

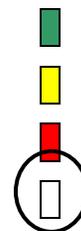
Known (or inferred from other studies) effect of fishing gear on physical and biogenic habitats

- Minimal damage (i.e. pelagic longline, midwater gillnet, midwater trawl, purse seine, hook and line, or spear/harpoon)
- Moderate damage (i.e. bottom gillnet, bottom longline or some pots/ traps)
- Great damage (i.e. bottom trawl or dredge)



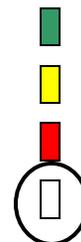
For specific fishery being evaluated, resilience of physical and biogenic habitats to disturbance by fishing method

- High (e.g. shallow water, sandy habitats)
- Moderate (e.g. shallow or deep water mud bottoms, or deep water sandy habitats)
- Low (e.g. shallow or deep water corals, shallow or deep water rocky bottoms)
- Not applicable because gear damage is minimal



If gear impacts are moderate or great, spatial scale of the impact

- Small scale (e.g. small, artisanal fishery or sensitive habitats are strongly protected)
- Moderate scale (e.g. modern fishery but of limited geographic scope)
- Large scale (e.g. industrialized fishery over large geographic areas)
- Not applicable because gear damage is minimal



Primary Ecosystem Factors to evaluate

Evidence that the removal of the targeted species or the removal/deployment of baitfish has or will likely substantially disrupt the food web

- The fishery and its ecosystem have been thoroughly studied, and studies show no evidence of substantial ecosystem impacts
- Conflicting evidence of ecosystem impacts OR Unknown **harpoon, handline, DGN**
- Ecosystem impacts of targeted species removal demonstrated **LL**



Evidence that the fishing method has caused or is likely to cause substantial ecosystem state changes, including alternate stable states

- The fishery and its ecosystem have been thoroughly studied, and studies show no evidence of substantial ecosystem impacts
- Conflicting evidence of ecosystem impacts OR Unknown
- Ecosystem impacts from fishing method demonstrated



Evaluation Guidelines

The effect of fishing practices is “**Benign**” if:

- 1) Damage from gear is minimal AND resilience to disturbance is high AND neither Ecosystem Factor is red.

The effect of fishing practices is “**Moderate**” if:

- 1) Gear effects are moderate AND resilience to disturbance is moderate or high AND neither Ecosystem Factor is red.
- 2) Gear results in great damage AND resilience to disturbance is high OR impacts are small scale AND neither Ecosystem Factor is red.
- 3) Damage from gear is minimal and one Ecosystem factor is red.

The effect of fishing practices is “**Severe**” if:

- 1) Gear results in great damage AND the resilience of physical and biogenic habitats to disturbance is moderate or low.
- 2) Both Ecosystem Factors are red.

Habitat effects are considered a **Critical Conservation Concern** and a species receives a recommendation of “**Avoid**”, regardless of other criteria if:

- Four or more of the Habitat and Ecosystem factors rank red.

Conservation Concern: Effect of Fishing Practices on Habitats and Ecosystems	
➤ Low (Fishing Effects Benign) <u>harpoon, handline, DGN</u>	
➤ Moderate (Fishing Effects Moderate) <u>LL</u>	
➤ High (Fishing Effects Severe)	
➤ Critical Fishing Effects	

CRITERION 5: EFFECTIVENESS OF THE MANAGEMENT REGIME

Guiding Principle: The management regime of a sustainable wild-caught species implements and enforces all local, national and international laws and utilizes a precautionary approach to ensure the long-term productivity of the resource and integrity of the ecosystem.

Primary Factors to evaluate

Stock Status: Management process utilizes an independent scientific stock assessment that seeks knowledge related to the status of the stock

- Stock assessment complete and robust **NAtl, SW Pac, EPO, Med** 
- Stock assessment is planned or underway but is incomplete OR stock assessment complete but out-of-date or otherwise uncertain **IO, NW Pac, SAtl** 
- No stock assessment available now and none is planned in the near future 

Scientific Monitoring: Management process involves regular collection and analysis of data with respect to the short and long-term abundance of the stock

- Regular collection and assessment of both fishery-dependent and independent data 

Med

- Regular collection of fishery-dependent data only 

NAtl, SAtl, SW Pac, NW Pac, EPO, IO

- No regular collection or analysis of data 

Scientific Advice: Management has a well-known track record of consistently setting or exceeding catch quotas beyond those recommended by its scientific advisors and other external scientists:

- No **US/Canada** 
- Yes **Med** 
- Not enough information available to evaluate OR not applicable because little or no scientific information is collected **NAtl, SW Pac, EPO, IO; Int'l SAtl, NWPac** 

Bycatch: Management implements an effective bycatch reduction plan

- Bycatch plan in place and reaching its conservation goals (deemed effective) **USLL, CA DGN** 
- Bycatch plan in place but effectiveness is not yet demonstrated or is under debate 
- No bycatch plan implemented or bycatch plan implemented but not meeting its conservation goals (deemed ineffective) **International LL** 
- Not applicable because bycatch is “low” **harpoon, handline** 

Fishing practices: Management addresses the effect of the fishing method(s) on habitats and ecosystems

- Mitigative measures in place and deemed effective 
- Mitigative measures in place but effectiveness is not yet demonstrated or is under debate 
- No mitigative measures in place or measures in place but deemed ineffective 
- Not applicable because fishing method is moderate or benign 

Enforcement: Management and appropriate government bodies enforce fishery regulations

- Regulations regularly enforced by independent bodies, including logbook reports, observer coverage, dockside monitoring and similar measures **US, Canada** 
- Regulations enforced by fishing industry or by voluntary/honor system 
- Regulations not regularly and consistently enforced **int'l** 

Management Track Record: Conservation measures enacted by management have resulted in the long-term maintenance of stock abundance and ecosystem integrity

- Management has maintained stock productivity over time OR has fully recovered the stock from an overfished condition **NAtl, EPO** 
- Stock productivity has varied and management has responded quickly OR stock has not varied but management has not been in place long enough to evaluate its effectiveness OR Unknown **SAtl, NW Pac, SW Pac, IO** 
- Measures have not maintained stock productivity OR were implemented only after significant declines and stock has not yet fully recovered **Med** 

Evaluation Guidelines

Management is deemed to be “**Highly Effective**” if the majority of management factors are green AND the remaining factors are not red.

Management is deemed to be “**Moderately Effective**” if:

- 1) Management factors “average” to yellow
- 2) Management factors include one or two red factors

Management is deemed to be “**Ineffective**” if three individual management factors are red, including especially those for Stock Status and Bycatch.

Management is considered a **Critical Conservation Concern** and a species receives a recommendation of “**Avoid**”, regardless of other criteria if:

- 1) There is no management in place
- 2) The majority of the management factors rank red.

Conservation Concern: Effectiveness of Management		
➤ Low (Management Highly Effective) <u>US, Canada</u>		
➤ Moderate (Management Moderately Effective)		
➤ High (Management Ineffective) <u>Med (except LL)</u>		
➤ Critical (Management Critically Ineffective) <u>Med LL</u>		

Overall Seafood Recommendation

Overall Guiding Principle: Sustainable wild-caught seafood originates from sources that can maintain or increase production in the long-term without jeopardizing the structure or function of affected ecosystems.

Evaluation Guidelines

A species receives a recommendation of “**Best Choice**” if:

- 1) It has three or more green criteria and the remaining criteria are not red.

A species receives a recommendation of “**Good Alternative**” if:

- 1) Criteria “average” to yellow
- 2) There are four green criteria and one red criteria
- 3) Stock Status and Management criteria are both ranked yellow and remaining criteria are not red.

A species receives a recommendation of “**Avoid**” if:

- 1) It has a total of two or more red criteria
- 2) It has one or more Critical Conservation Concerns.

Summary of Criteria Ranks

Sustainability Criteria	Conservation Concern			
	Low	Moderate	High	Critical
Inherent Vulnerability	✓			
Status of Stocks	✓ <ul style="list-style-type: none"> • Eastern Pacific • North Atlantic 	✓ <ul style="list-style-type: none"> • NW Pacific • South Atlantic • SW Pacific 	✓ <ul style="list-style-type: none"> • Mediterranean • Indian Ocean 	
Nature of Bycatch	✓ <ul style="list-style-type: none"> • Harpoon • Handline 		✓ <ul style="list-style-type: none"> • Hawaii longline • U.S. Atlantic longline • California drift gillnet 	✓ <ul style="list-style-type: none"> • International longline • South Am. gillnet
Habitat & Ecosystem Effects	✓ <ul style="list-style-type: none"> • Harpoon • Handline • Drift gillnet 	✓ <ul style="list-style-type: none"> • Longline 		
Management Effectiveness	✓ <ul style="list-style-type: none"> • U.S. • Canada 	✓ <ul style="list-style-type: none"> • International (EPO, NW Pacific, North Atlantic, South Atlantic) • Indian Ocean • SW Pacific 	✓ <ul style="list-style-type: none"> • Mediterranean (harpoon & handline) 	✓ Mediterranean (longline)