Swordfish (*Xiphias gladius*)

Certification Units Covered Under this Species

- Southern California, Harpoon

Summary

Swordfish is a highly migratory species (HMS) distributed throughout the world's oceans. In the North Pacific, these stocks are monitored and assessed by the International Scientific Committee for Tuna and Tuna-like Species (ISC) and the Inter-American Tropical Tuna Commission (IATTC). Along the U.S. West Coast, swordfish are managed under the Pacific Fishery Management Council's Highly Migratory Species Fishery Management Plan. Swordfish are fished commercially primarily using harpoons, drift gillnets, and pelagic longlines. Stocks of Western and Central North Pacific (WCNPO) and Eastern North Pacific (EPO) swordfish are considered healthy and above the level required to sustain recent catches. Bycatch in the harpoon fishery is close to zero.

Strengths:

- North Pacific and Eastern Pacific stocks are considered healthy
- Stock assessments are conducted by international organizations; the information is reviewed annually by the PFMC
- Almost no bycatch in the harpoon fishery

Weaknesses:

- Harpoon fishery is small; may not be economical to pursue MSC certification

History of the Fishery in California

Biology of the Species

Swordfish (*Xiphias gladius*) is the sole member of the family Xiphiidae. It is a highly migratory species (HMS) distributed throughout the world's oceans. Swordfish are large fish with a maximum weight of over 650 kg and length of 457 cm. Swordfish have a distinctive sharp pointed bill which is a flattened extension of the upper jaw. Another distinctive characteristic of swordfish is they do not have pelvic fins. Adult swordfish feed opportunistically on a wide range of squids, fish and crustaceans. Off California, northern anchovy, squid, hake, jack mackerel, rockfish, barracudas, black smelt, ribbonfish, and shrimp are common prey items (PFMC 2003). Larval and young swordfish actively feed on zooplankton and by 11-12 mm in length start feeding on a variety of epipelagic fish larvae (PFMC 2003).

Swordfish can live between 9-14 years for males and 15-32 years for females (Wilson and Dean 1983; Radtke and Hurley 1983). Females are believed to mature at 4-5 years and males at 3-4 years old (Love 2011). Swordfish do not seem to have a discrete spawning ground or spawning season (PFMC 2003), however, larvae and juveniles tend to occur in warmer tropical and subtropical regions. The geographical distribution of larvae suggests that spawning occurs in waters where SSTs are above 24°C; this isotherm rarely extends north of 35° N or south of 35° S. Spawning occurs throughout the year in equatorial waters, but is progressively restricted to spring-summer at higher latitudes. Females are batch spawners; a 68 kg female is estimated to release 16,130,400 eggs (Love et al. 2011). Eggs hatch in 2.5 days. Larval abundance is high along sharp thermal and salinity gradients. Swordfish grow extremely fast during their first year of life, and by one year of age may reach 90 cm (3 feet) (Uchiyama et al. 1998; Ward and Elscot 2000). Growth is highly variable among fish of the same age and sex, and there is a marked difference in growth rate between males and females. After two years of age, females tend to grow faster than males, grow to a larger size, and are proportionately heavier at the same length (Palko et al. 1981). Most large-sized fish are females, and they appear to be more common in cooler waters. According to Beckett (1974) and Palko et al. (1981) few males tend to occur in waters below 18°C, and males make up the majority of warm water landings.

[From PFMC 2003]: Stock structure of swordfish in the Indian and Pacific oceans is unclear. Some genetic analyses (Reeb et al 2000; Kasapidis et al. 2008) suggest that swordfish comprise a single, homogenous population in the Pacific, and that gene flow occurs through a horseshoe-shaped corridor, running between the north-western Pacific, across to the eastern Pacific and back to the south-western Pacific. However other genetic analyses (Alvarado Bremer et al. 2006) and fisheries data (Hinton and Deriso 1998, Hinton 2003) indicate that the swordfish population in the Pacific is comprised of three or more distinct groups. The latest stock assessments by the ISC divide the North Pacific swordfish population into two groups: Western and Central North Pacific, and Eastern North Pacific.

Commercial Fishery

[From PFMC 2003]: Broadbill swordfish support major fisheries in all oceans of the world. Major Pacific Ocean fishing areas are off Japan, the North Pacific Transition Zone north of Hawaii, the west coasts of the U.S., Mexico, Ecuador, Peru, Chile, and off Australia and New Zealand. The largest catches of swordfish in the North Pacific Ocean have been taken by Japan for more than five decades (Figure 1). Along the U.S. West Coast EEZ, swordfish are targeted primarily by the drift gillnet fishery off California and Oregon (Holts and Sosa-Nishizaki 1998, PFMC 2012),

by a small harpoon fishery operating within the Southern California Bight (Coan et al. 1998, PFMC 2012), and by a Hawaii-based longline fishery that fishes beyond the U.S. West Coast EEZ on the high seas and land their catch in California, Oregon and Washington (PFMC 2012) (Figures 2 and 3). There has also been a very small surface hook-and-line fishery in the past, but from 2003-2011 landings were less than 0.5 mt per year. In 2012, surface-hook- and-line landings increased to 10.67 mt (Elizabeth Hellmers, personal communication, 2013).

[From PFMC 2012]: California's harpoon fishery for swordfish developed in the early 1900s. Prior to 1980, harpoon and hook-and-line were the only legal gears for commercially harvesting swordfish. At that time, harpoon gear accounted for the majority of swordfish landings in California ports. In the early 1980s, a limited entry drift gillnet fishery was authorized by the State Legislature and soon afterward drift gillnets replaced harpoons as the primary method for catching swordfish. drift gillnets replaced harpoons as the primary method for catching

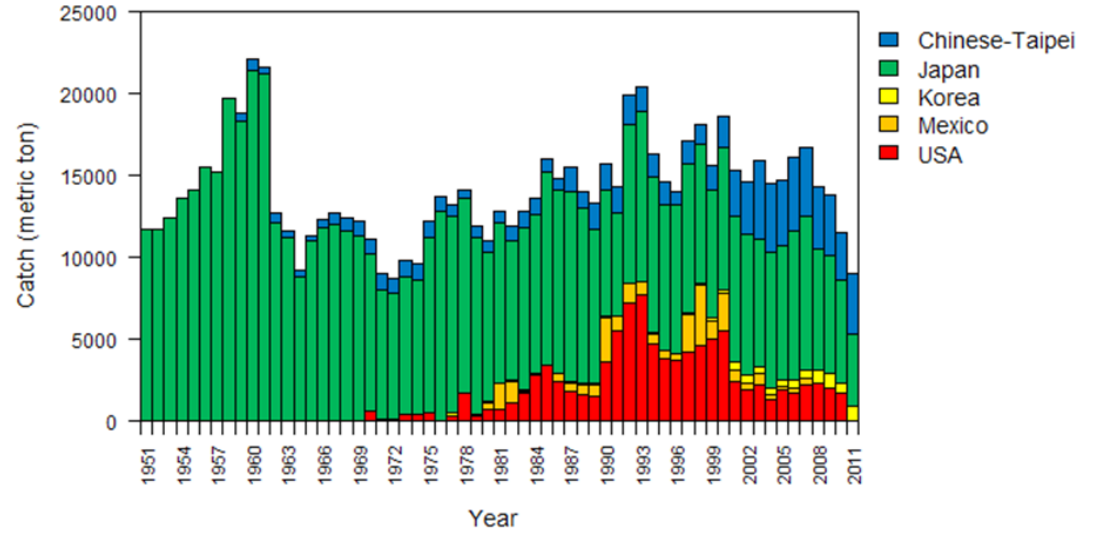

Figure 1. Annual landings of swordfish reported by ISC members in the North Pacific Ocean (figure from ISC 2013).

swordfish. Historically, the California drift gillnet fleet operated within EEZ waters adjacent to the state and as far north as the Columbia River, Oregon, during El Niño years; however, Oregon no longer issues the necessary permit to land drift gillnet catch in the state. Drift gillnet fishing activity is highly dependent on seasonal oceanographic conditions that create temperature fronts which concentrate feed for swordfish. Because of the seasonal migratory pattern of swordfish and seasonal fishing restrictions, over 90 percent of drift gillnet fishing effort occurs from August 15 through January 31.

In the U.S. West Coast harpoon fishery, 26 vessels participated in 2010, 17 in 2011 and only 9 in 2012. (PFMC 2012; Elizabeth Hellmers, personal communication, 2013). Fishing effort was concentrated in coastal waters off San Diego and in the Southern California Bight, especially between the coast and Santa Catalina and San Clemente Islands. A total of 158 swordfish were landed in 2010 by harpoon.

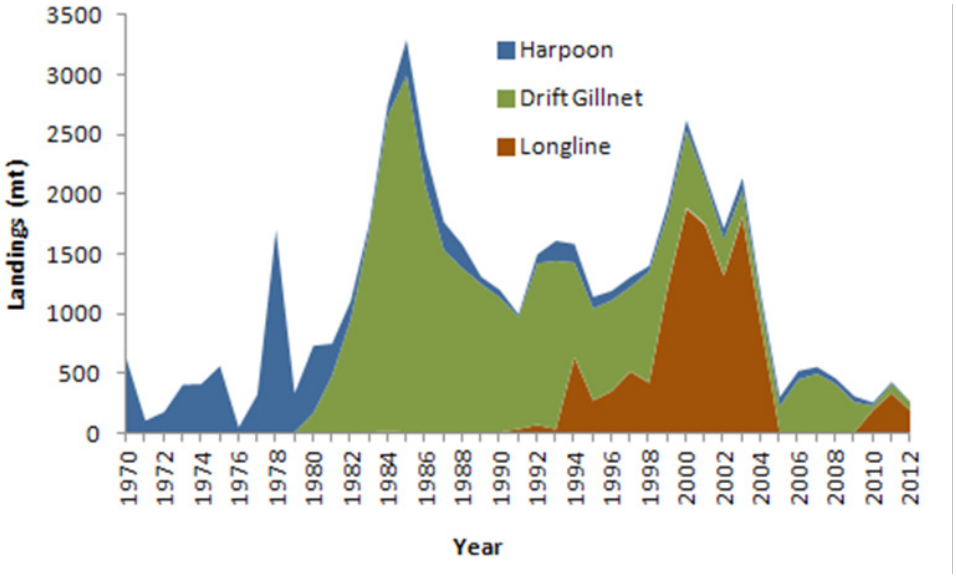

Figure 2. Swordfish landings along the U.S. West coast from 1970 to 2012 by gear type (data from ISC 2011; PFMC 2012; Elizabeth Hellmers, personal communication, 2013). Data for longline landings from 2005-2009 was not available.

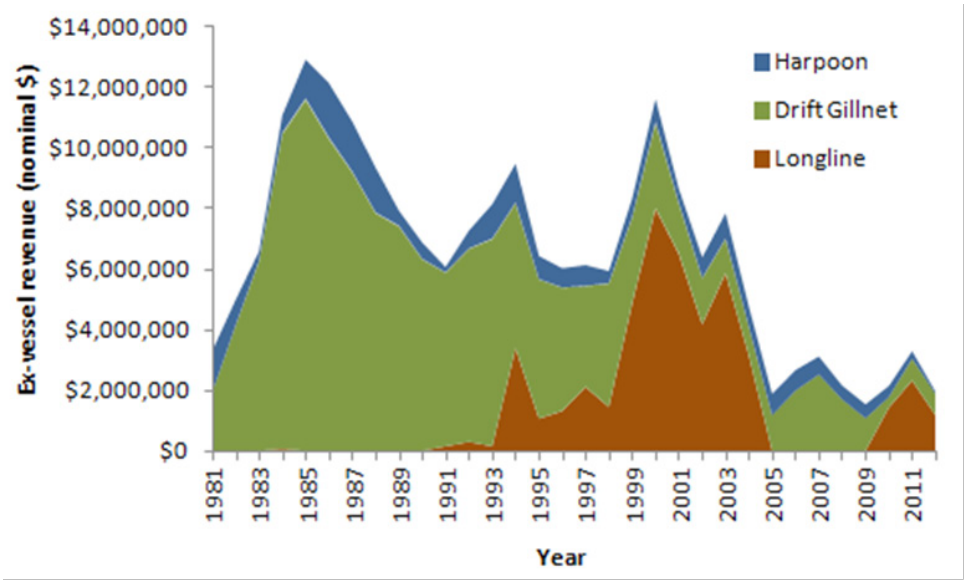

Figure 3. Annual ex-vessel revenue along the U.S. West coast from 1981 to 2012 (data from PFMC 2012; Elizabeth Hellmers, personal communication, 2013). Data for longline landings from 2005-2009 was not available.

Recreational Fishery

Recreationally caught swordfish are a rare occurrence along the West Coast. In California, recreational catch data is collected from the California Recreational Fisheries Survey (CRFS) program. Data from CRFS indicate that from 2003 to 2012, swordfish were only captured recreationally in California in 2007 (CDGF 2011; Elizabeth Hellmers, personal communication, 2013). However, this may not be an accurate reflection of total catch of swordfish by recreational anglers; the CRFS program only samples from public launch ramps. Several

billfish tournaments are held each year in the early fall, and these numbers, as well as those from private vessels launching from private marinas, are likely not captured (Elizabeth Hellmers, personal communication, 2013). There is a daily bag limit of 2 fish. Further information on recreational catch of swordfish in Southern California may be available from fishing tournament organizers.

MSC Principle 1: Resource Sustainability

*Sustainability of Target Stock

Swordfish are harvested in the North Pacific by fleets from Japan, Korea, Taiwan, and the United States. Stock assessments of the Western and Central North Pacific and Eastern North Pacific stocks of swordfish are considered healthy and above the level required to sustain recent catches (Brodziak and Ishimura 2010, IATTC 2011, ISC 2013) (Figure 4). Catch of swordfish by U.S. West Coast fisheries constitutes about 5.8 percent of the Eastern Pacific-wide catch. The PFMC uses the data from these stock assessments to inform the HMS FMP. Stock status reference points for BMSY and BMSST (minimum standing stock threshold biomass) were given in the latest stock assessment by the ISC (Brodziak and Ishimura 2010). The PFMC also has gear, permit, season, and area restrictions in place to manage bycatch.

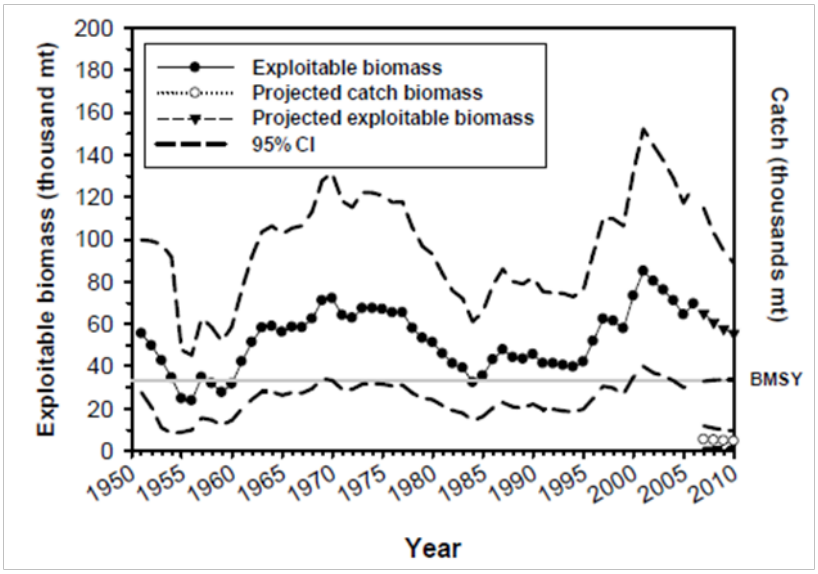

Figure 4. Time series of estimates of exploitable biomass (solid line, filled circle) of eastern North Pacific swordfish during 1952-2006, with 95% credibility intervals (dashed lines), projections of exploitable biomass (solid line, filled triangle), and 95% credibility intervals (dashed lines). Stochastic projections of exploitable biomass and catch biomass during 2007-2010 are based on production model dynamics assuming that the projected exploitation rate is normally distributed with a mean equal to the average exploitation rate during 2004-2006 and an associated standard deviation (ISC 2010).

*For California's Sustainable Seafood Program, this category must score an 80 or higher during an MSC assessment.

Evaluation against MSC Component 1.1: Sustainability of Target Stock

Performance Indicators	Rating	Justification
1.1.1 Stock Status		Stock biomass is above B_{MSY} and considered healthy
1.1.2 Reference Points		Reference points have been calculated and the stock is maintained at a level exceeding B_{MSY}
1.1.3 Stock rebuilding		Not triggered; stock is considered healthy

Harvest Strategy (Management)

Because swordfish are globally distributed, several international organizations undertake monitoring and stock assessments for swordfish. In the North Pacific, the fishery is divided into two stocks: the Western and Central North Pacific (WCNPO) and the Eastern North Pacific (EPO). The WCNPO stock is assessed by the International Scientific Committee for Tuna and Tuna-like Species (ISC) and is managed by the Western and Central Pacific Fisheries Commission (WCPFC). The EPO stock is assessed and managed by the Inter-American Tropical Tuna Commission (IATTC). The ISC and the IATTC work together under a Memorandum of Cooperation (MOC). Representatives from NOAA's Southwest Fisheries Science Center and Pacific Islands Fisheries Science Center participate in all three organizations.

[PFMC 2012]: Along the U.S. west coast, swordfish are managed under the Pacific Fishery Management Council's Highly Migratory Species Fishery Management Plan (HMS FMP). The PFMC does not assess the swordfish stock, but uses the data from the international stock assessments to inform the HMS FMP. Swordfish are targeted commercially using harpoons (in Southern California), drift gillnets, pelagic longlines, and recently after a several years hiatus, with surface hook-and-line gear. Catch of swordfish by U.S. West Coast fisheries constitutes about 5.8 percent of the Eastern Pacific-wide catch. No stock status reference points or quotas have been developed by the PFMC for swordfish because swordfish is one of eleven HMS species that fall under an "international exception" in place for stocks managed under an international agreement to which the United States is a party. However, reference points have been developed by the ISC in their latest stock assessment for swordfish (Brodziak and Ishimura 2010). The PFMC also has gear, permit, season, and area restrictions in place to manage bycatch.

For more information on management, see Section 3.2: Fishery Specific Management Objectives.

Evaluation against MSC Component 1.2: Harvest Strategy

Performance Indicators	Rating	Justification
1.2.1 Harvest Strategy		Operates under Magnuson-Stevens Act to prevent overfishing; The U.S. fishery is monitored and mgmt actions are in place to limit bycatch; There are no set harvest limits because the stock is considered healthy.
1.2.2 Harvest Control Rules and Tools		Reference points were developed by the ISC and are evaluated during stock assessments every few years
1.2.3 Information/Monitoring		Observers and logbook data are available to monitor catch in the U.S.
1.2.4 Assessment of Stock Status		Until recently, stock assessments lacked enough data for accuracy. The most recent assessment with updated data from 2010 seems to be acceptable.

MSC Principle 2: Environment

Retained Catch

Harpoon

There is almost no retained catch in the swordfish harpoon fishery. There may be an occasional shark, but this would be a rare occurrence (Elizabeth Hellmers, personal communication, 2013).

Evaluation against MSC Component 2.1: Retained Catch

Performance Indicators	Rating	Justification
2.1.1 Outcome		No retained species
2.1.2 Management		Not applicable because no retained species
2.1.3 Information		Logbook data

Harpoon

Bycatch in the swordfish harpoon fishery is expected to be almost non-existent (NMFS 2012).

Evaluation against MSC Component 2.2: Bycatch

Performance Indicators	Rating	Justification
2.2.1 Outcome		Bycatch is close to zero
2.2.2 Management		Not applicable because no bycatch
2.2.3 Information		Logbook data

*Endangered, Threatened, & Protected Species

Harpoon

No ETP species are known to be captured in the swordfish harpoon fishery.

*For California's Sustainable Seafood Program, this category must score an 80 or higher during an MSC assessment.

Evaluation against MSC Component 2.3: Endangered, Threatened & Protected Species

Performance Indicators	Rating	Justification
2.3.1 Outcome		No ETP species
2.3.2 Management		Not applicable – no ETP bycatch
2.3.3 Information		Logbook data

Habitat

Harpoon

[From PFMC 2012]: Harpoon gear consists of a pointed dart or iron attached to the end of a line several hundred feet in length, the other end of which is attached to a flotation device. Harpoon gear is attached to a pole or stick that is propelled only by hand, and not by mechanical means.

Harpoons do not typically encounter the ocean bottom, thus there is very little or no bottom habitat impact from harpoons.

Evaluation against MSC Component 2.4: Habitat

Performance Indicators	Rating	Justification
2.4.1 Outcome		Limited to no impact on habitat
2.4.2 Management		No mgmt strategy, but should not be applicable because no habitat impacts
2.4.3 Information		Not applicable because no habitat impacts

Ecosystem

[From PFMC 2003]: Swordfish are top predators and feed opportunistically on a wide range of squids, fish and crustaceans. Off California they eat northern anchovy, squid, hake, jack mackerel, rockfish, barracudas, black smelt, ribbonfish, and shrimp. Off Baja California, Pacific hake, the flying purple squid and jumbo squid are important in their diet. Larval and young swordfish actively feed on zooplankton and by 11-12 mm in length start feeding on a variety of epipelagic fish larvae (Arata 1954; Gorbunova 1969). Swordfish can forage at great depths and have been photographed at a depth of 1,000 m by a deep diving submersible (Mather 1976). It is generally accepted that swordfish in the pelagic environment feed on squid and mesopelagic fish and forage on demersal fish when in shallower waters.

[From Palko et al. 1981]: Predators of juvenile swordfish likely include any sufficiently large piscivorous fish or marine mammal. Juvenile swordfish have been found in the stomach of blue marlin, black marlin, striped marlin, shortbill spearfish, sailfish, yellowfin tuna, albacore tuna, bigeye tuna, dolphin, and blue shark. Adult swordfish have few known natural enemies. Sperm whales, killer whales, and large sharks are perhaps the only species capable of preying on adults. Sharks are the only creatures ever seen in actual combat with swordfish.

Gears such as gillnets and pelagic longlines used in the swordfish fishery can have high levels of bycatch which include sea turtles, sharks, seabirds and marine mammals. Bycatch is strictly regulated in the U.S., but many other countries that fish the same stock do not have bycatch mitigation plans. Higher bycatch levels by other countries may impact ecosystem structure or function.

Evaluation against MSC Component 2.5: Ecosystem

Performance Indicators	Rating	Justification
2.5.1 Outcome		In countries other than the U.S., bycatch can be unregulated; this will likely have ecosystem impacts
2.5.2 Management		Strict regulations to prevent bycatch in the U.S; fewer bycatch regulations in other countries
2.5.3 Information		Observer and logbook data in the U.S.

MSC Principle 3: Management System

Governance and Policy

Fisheries in the U.S. are governed by the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) of 1976. The MSFMCA requires managing at or below MSY levels, rebuilding overfished stocks and ending overfishing, minimizing bycatch and bycatch mortality, identification of essential fish habitat and mitigation of adverse fishing impacts. In addition, the Endangered Species Act, the Marine Mammal Act, the Migratory Bird Treaty Act, the Coastal Zone Management Act, and the Clean Water Act apply to or provide protection for species and/or habitat that may be affected by the target fishery.

The MSFCMA established eight regional fishery management councils to manage fishery resources in the U.S. Exclusive Economic Zone (EEZ). Along the U.S. west coast, the EEZ extends from 3 to 200 nautical miles offshore. Each council is comprised of Federal, State, and stakeholder representatives. Additionally, advisory bodies provide expert advice on matters related to the purpose of the council. The council process emphasizes public participation and involvement in fisheries management; meetings are open to the public and to public comment. Management measures developed by the each council are recommended to the Secretary of Commerce through NOAA's National Marine Fisheries Service (NMFS). Along the west coast, management measures are implemented by NMFS Northwest and Southwest Regional offices and enforced by the NOAA Office of Law Enforcement, the U.S. Coast Guard 11th District, and local enforcement agencies.

Each council develops fishery management plans (FMPs) for the stocks in their region specifying how a fishery will be managed. The Guidelines for Fishery Management Plans (NMFS 1997) require that a stock assessment and fishery evaluation (SAFE) report be prepared and reviewed annually for each FMP. SAFE reports are intended to summarize the best available scientific information concerning the past, present, and possible future condition of the stocks, marine ecosystems, and fisheries being managed under federal regulation. Regional fishery management councils use this information to determine annual harvest levels for each stock, document significant trends or changes in the resources, marine ecosystems, and fishery over time, and assess the relative success of existing state and federal fishery management programs. In California, the Pacific Fishery Management Council (PFMC) is the regional council that manages federal fisheries

Evaluation against MSC Component 3.1: Governance and Policy

Performance Indicators	Rating	Justification
3.1.1 Legal and/or Customary Framework		PFMC and NMFS operate under Magnuson-Stevens Act
3.1.2 Consultation, Roles and responsibilities		PFMC meetings are public and public participation is encouraged
3.1.3 Long-term Objectives		Magnuson-Stevens Act and FMPs
3.1.4 Incentives for Sustainable Fishing		Magnuson-Stevens Act

Fishery Specific Management System

Along the U.S. west coast, swordfish are managed under the Pacific Fishery Management Council's Highly Migratory Species Fishery Management Plan (HMS FMP). The PFMC does not assess the swordfish stock, but uses the data from the international stock assessments to inform the HMS FMP. Management and research goals for managing bycatch in the swordfish fishery are outlined in the HMS FMP. Swordfish are targeted commercially using harpoons (in Southern California), drift gillnets, pelagic longlines, and recently after a several years hiatus, with surface hook-and-line gear. No stock status reference points or quotas have been developed by the PFMC for swordfish because swordfish is one of eleven HMS species that fall under an "international exception" in place for stocks managed under an international agreement to which the United States is a party.

[From PFMC 2012]: To participate in the harpoon fishery a state permit and logbook are required in addition to a general resident or non-resident commercial fishing license. Additionally, for all U.S. vessels that fish for HMS within the West Coast EEZ and on the high seas, a federal permit with a harpoon gear endorsement is required.

The drift gillnet fishery is managed by a limited entry permit system, with mandatory gear standards and seasonal area closures used to address various conservation concerns. A logbook and observer coverage is also required; in 2010, approximately 12% of HMS drift gillnet vessels had observer coverage.

California prohibits pelagic longline fishing within the EEZ. Vessels operating outside of the EEZ on the high seas can land fish in California ports if the operator has a general resident or non-resident commercial fishing license, current CDFW vessel registration, and a federal permit with a pelagic longline gear endorsement. A logbook is also required.

Enforcement of fishing regulations is conducted in state waters by CDFW's Law Enforcement Division and in federal waters by NOAA's Office of Law Enforcement. Additionally tools such as port sampling, logbooks, and observer coverage are used to monitor catch and ensure vessels have the correct permits for the catch they are landing. Violators are prosecuted under the law. There is no evidence of systemic non-compliance.

Evaluation against MSC Component 3.2: Fishery Specific Management System

Performance Indicators	Rating	Justification
3.2.1 Fishery Specific Objectives		There are objectives on reducing bycatch in the HMS FMP
3.2.2 Decision-making Processes		PFMC has an appropriate decision-making process in place
3.2.3 Compliance & Enforcement		An enforcement system exists and has demonstrated an ability to enforce relevant management measures, strategies and/or rules.
3.2.4 Research Plan		Yes, HMS FMP
3.2.5 Management Performance Evaluation		Stock assessments and reference points are developed by the ISC; catch restrictions are evaluated by the PFMC

California Specific Requirements

The California voluntary sustainable seafood program requires fisheries seeking certification to meet California specific standards in addition to the standards and requirements of the Marine Stewardship Council (MSC) sustainable fisheries certification program. These include:

1. Higher scores (80 instead of 60) for two performance indicators (PI) of the MSC program: "Stock Status" (PI 1.1.1) and "By-catch of Endangered, Threatened, or Protected (ETP) Species" (PI 2.3.1). These two PIs are highlighted in the report.

2. Additional independent scientific review: The OPC Science Advisory Team will be engaged in the certification process through early consultation in reviewing minimum eligibility criteria, and review of the MSC-required pre-assessments and full assessments. The reviews will be conducted in addition to MSC's peer review, thus bringing additional credibility, transparency, and independence to California's certification process.

3. Additional traceability components: The California program will develop a unique barcode for California certified sustainable fish. This barcode can be either scanned by a smart-phone or linked to a website that will reveal additional information about the fishery, and information about toxicity when available

Recommendations

Although the harpoon fishery for swordfish has a low impact to the ecosystem and would likely score well during an MSC assessment, catch of swordfish by harpoon is low. There is a good possibility it may not be economically feasible to certify this small fishery. Alternatively, the surface hook-and-line fishery appeared to make a comeback this year; if this continues, this may be another branch of the fishery to take a closer look at to determine if it would be economically feasible to certify this gear type. Hook-and-line fisheries typically have low bycatch and almost no habitat impacts.

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Appendix A

MSC Assessment Tree			Swordfish
			Harpoon
Principle	**Component**	**Performance Indicator**	**Southern**
Principle 1: Health of Fish Stock	Outcome	1.1.1: Stock status	
		1.1.2: Reference points	
		1.1.3: Stock rebuilding	*Did not assess*
	Harvest Strategy (Management)	1.2.1: Harvest strategy	
		1.2.2: Harvest control rules	
		1.2.3: Info/ monitoring	
		1.2.4: Stock assessment	
Principle 2: Impact on Ecosystem	Retained species	2.1.1: Status	
		2.1.2: Mgmt strategy	
		2.1.3: Information	
	By-catch species	2.2.1: Status	
		2.2.2: Mgmt strategy	
		2.2.3: Info	
	ETP species	2.3.1: Status	
		2.3.2: Mgmt strategy	
		2.3.3: Info	
	Habitats	2.4.1: Status	
		2.4.2: Mgmt strategy	
		2.4.3: Info	
	Ecosystem	2.5.1: Status	
		2.5.2: Mgmt strategy	
		2.5.3: Info	
Principle 3: Management System	Governance & Policy	3.1.1: Legal framework	
		3.1.2: Consultation, roles, and responsibilities	
		3.1.3: Long term objectives	
		3.1.4: Incentives for sustainable fishing	
	Fishery Specific Mgmt System	3.2.1: Fishery specific objectives	
		3.2.2: Decision making process	
		3.2.3: Compliance & enforcement	
		3.2.4: Research plan	
		3.2.5: Management performance evaluation	