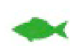
SWORDFISH – PACIFIC OCEAN

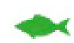
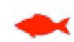
Xiphias gladius

Sometimes known as Broadbill, Espada, Emperado, Shutome

SUMMARY

Swordfish are a large, migratory fish found in temperate and tropical waters of the Atlantic, Indian and Pacific Oceans. They grow reasonably fast and mature quickly, typically within six years. Various regional fisheries management organizations manage Swordfish populations in the Pacific Ocean, recommending catch limits, fishing vessel limits and bycatch mitigation methods. Although Swordfish abundance varies between regions of the Pacific, no population is considered overfished and general abundance is at a medium level. Pelagic longlines remain the main fishing method for catching Swordfish in the Pacific, while harpoons and drift gillnets are used off the U.S. West Coast. Pelagic longlines cause little habitat damage, but bycatch of sharks, endangered sea turtles and birds is high. Chef Barton Seaver says, “This dense, steak-like seafood is a cooks’ favorite. The robust but sweet flavor is matched by a meaty texture that is perfect for the grill, roast, or broil. Best cooked medium well.”

Criterion	Points
Life History	3.75
Abundance	2.25
Habitat Quality and Fishing Gear Impacts	3.25
Management	2.50
Bycatch	1.00
Final Score	**2.55**
Color	

Final Score	Color
2.40 - 4.00	
1.60 - 2.39	
0.00 - 1.59	

LIFE HISTORY

Core Points (only one selection allowed)

If a value for intrinsic rate of increase (‘r’) is known, assign the score below based on this value. If no r-value is available, assign the score below for the correct age at 50% maturity for females if specified, or for the correct value of growth rate ('k'). If no estimates of r, age at 50% maturity, or k are available, assign the score below based on maximum age.

1.00 Intrinsic rate of increase <0.05; OR age at 50% maturity >10 years; OR growth rate <0.15; OR maximum age >30 years.

2.00 Intrinsic rate of increase = 0.05-0.15; OR age at 50% maturity = 5-10 years; OR a growth rate = 0.16–0.30; OR maximum age = 11-30 years.

3.00 Intrinsic rate of increase >0.16; OR age at 50% maturity = 1-5 years; OR growth rate >0.30; OR maximum age <11 years.

Swordfish grow fast during their first year of life, reaching 3 feet (91 cm) after 12 months (DeMartini et al 2007). Aging Swordfish is problematic, but Yabe et al. (1959) estimated that Swordfish reach maturity at 5-6 years of age when they are 5-5½ feet in length (150-170 cm). DeMartini et al. (2000) estimated that males mature at about 3-4 years, with a median body (eye-fork) length at sexual maturity of 102 cm, and females at about 4-5 years and 144 cm. Females grow larger and faster than males, and are heavier at a given length than are males (DeMartini et al 2007). The intrinsic rate of increase for Swordfish ranges from 0.14-0.20 (NMFS 2003). Maximum size of Swordfish is about 14 feet in total length (4.5 m) and maximum weight about 1,190 pounds (540 kg) (Nakamura 1985). Because the intrinsic rate of increase is reasonably high and Swordfish mature at an early age, a score of 3 was awarded.

Points of Adjustment (multiple selections allowed)

-0.25 Species has special behaviors that make it especially vulnerable to fishing pressure (e.g., spawning aggregations; site fidelity; segregation by sex; migratory bottlenecks; unusual attraction to gear; etc.).

-0.25 Species has a strategy for sexual development that makes it especially vulnerable to fishing pressure (e.g., age at 50% maturity >20 years; sequential hermaphrodites; extremely low fecundity).

-0.25 Species has a small or restricted range (e.g., endemism; numerous evolutionarily significant units; restricted to one coastline; e.g., American lobster; striped bass; endemic reef fishes).

-0.25 Species exhibits high natural population variability driven by broad-scale environmental change (e.g. El Nino; decadal oscillations).

+0.25 Species does not have special behaviors that increase ease or population consequences of capture OR has special behaviors that make it less vulnerable to fishing pressure (e.g., species is widely dispersed during spawning).

Swordfish in the Pacific Ocean do not seem to have specific spawning grounds (Fishwatch 2010). Due to their extensive range throughout the Pacific Ocean, they are widely distributed while spawning. As Swordfish are able to release their eggs over days or even months they are referred to as batch spawners (Murua and Saborido-Rey 2003). In the north and central Pacific, batch spawning occurs in surface waters warmer than 24°C from March to July and year round in the equatorial Pacific (Fishbase 2010; SWFSC 2010). In the southwestern Pacific, spawning takes place from September to December (Fishbase 2010). Such widespread spawning allows for a greater resilience to fishing pressure. However, some Swordfish populations may be inclined to local depletions around underwater features. These populations associate with underwater features like banks and seamounts that fisheries initially focus on when they first begin to develop. As a consequence, modern longliners may remove the 'resident' component of Swordfish populations at a greater rate than growth and immigration can replace them (Ward and Elscott 2000). Even so points were added here as Swordfish are a highly migratory species that spawn over large regions. These behaviors may facilitate eventual repopulation of these underwater features over time.

+0.25 Species has a strategy for sexual development that makes it especially resilient to fishing pressure (e.g., age at 50% maturity <1 year; extremely high fecundity).

Swordfish have high fecundity (Palko et al. 1981) with egg production dependent on female size. Large females of 600 pounds (272 kg) can produce up to 29 million eggs whereas small females at 370 pounds (168 kg) produce 1 million to 16 million eggs (Fishwatch 2010).

+0.25 Species is distributed over a very wide range (e.g., throughout an entire hemisphere or ocean basin; e.g., swordfish; tuna; Patagonian toothfish).

Swordfish are distributed worldwide in tropical, subtropical and temperate waters in the Indian, Pacific and Atlantic oceans (Fishbase 2010). They are ubiquitous throughout the Pacific Ocean from 50°N-50°S, with areas of high and low abundance (IATTC 2010; SWFSC 2010). Areas of greater abundance occur north of Hawaii along the North Pacific transition zone, along the west coasts of the U.S., Mexico and South America, in the western Pacific, east of Japan (IATTC 2010; SWFSC 2010) and in the southwest and south-central Pacific. There are conflicting hypotheses as to the genetic population structure of Swordfish in the Pacific Ocean. Studies using mitochondrial DNA (mtDNA; Reeb et al 2000; Kasapidis et al. 2008) conclude that Swordfish comprise a single, continuous population throughout the Pacific, with limited genetic variation between the north and the south western Pacific (Reeb et al. 2000), implying that gene flow exists across a U-shaped corridor in the Pacific. These studies have provided a basis for assuming that the population is large and mobile enough to prevent local depletion (SWFSC 2010). However studies evaluating both mtDNA, nuclear DNA (nDNA: 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. Although Swordfish may be separated into regional populations, they are found in much of the world's oceans so points were added.

+0.25 Species does not exhibit high natural population variability driven by broad-scale environmental change (e.g., El Nino; decadal oscillations).

3.75 Points for Life History

ABUNDANCE

Core Points (only one selection allowed)

Compared to natural or un-fished level, the species population is:

1.00 Low: Abundance or biomass is <75% of BMSY or similar proxy (e.g., spawning potential ratio).

2.00 Medium: Abundance or biomass is 75-125% of BMSY or similar proxy; OR population is approaching or recovering from an overfished condition; OR adequate information on abundance or biomass is not available.

Within the Pacific Ocean a number of Regional Fisheries Management Organizations (RFMOs) are responsible for population assessments of commercial fish species. These organizations recognize different subpopulations of Swordfish in the Pacific Ocean and accordingly assess population status.

Presently Swordfish populations in the north Pacific Ocean are thought to be in a good condition and are not overfished. These populations are considered to be close to or even very likely above the biomass at maximum sustainable yield (BMSY) (Brodziak and Ishimura 2010). Populations in the eastern Pacific Ocean are similarly in a healthy condition, with biomass levels of the northeastern population stable and considered above 50% of the BMSY in recent years (IATTC 2010). The spawning biomass level of the southeastern Pacific population is estimated to be well above the biomass corresponding to the MSY, and at the same time catches have been about those expected at the level of MSY (IATTC 2010). Increases in current levels of catch would not be expected to be sustainable and catch trends should be monitored in this region.

In the southwest Pacific, Swordfish abundance was declining. However due to a recent reduction in fishing effort, an increase in biomass has been observed. Currently overfishing is not occurring and the southwest population is not considered to being overfished (WCPFC 2008). Swordfish population status in the south-central Pacific is unclear. The population assessment showed no signs of significant fishery impacts and landings have increased in recent years to levels well above those in the southwest Pacific. It is cautiously concluded that overfishing is not occurring and that the population is not in an overfished state (WCPFC 2008).

Overall, Swordfish populations in the Pacific Ocean are relatively healthy and are being fished at levels close to maximum sustainable yield, thus a score of 2 was awarded.

3.00 High: Abundance or biomass is >125% of BMSY or similar proxy.

Points of Adjustment (multiple selections allowed)

-0.25 The population is declining over a generational time scale (as indicated by biomass estimates or standardized CPUE).

-0.25 Age, size or sex distribution is skewed relative to the natural condition (e.g., truncated size/age structure or anomalous sex distribution).

-0.25 Species is listed as "overfished" OR species is listed as "depleted", "endangered", or "threatened" by recognized national or international bodies.

-0.25 Current levels of abundance are likely to jeopardize the availability of food for other species or cause substantial change in the structure of the associated food web.

+0.25 **The population is increasing over a generational time scale (as indicated by biomass estimates or standardized CPUE).**

Although the southeastern Pacific Swordfish population is considered to be moderately depleted, the current spawning biomass is estimated to be well above the biomass needed to support maximum sustainable yield MSY, (current MSY levels are 13,000 -14,000 mt). There is strong evidence that one or two large cohorts entered the fishery in recent years, and due to these high recruitment levels the population has been able to support the recent annual catch rates that have averaged about 13,000 mt since 2000. However if future catches increase the population may not be able to sustain itself (IATTC 2008). Continual assessment of this region is vital in gaining a better understanding of the dynamics at work. Similarly, the abundance of Swordfish in the southwest Pacific was declining but recently an increase in biomass has been observed (WCPFC 2008). While in the south-central Pacific region, population status is unclear. Because of this uncertainty and regional increases are relatively recent and not over generational time for Swordfish, no points were added.

+0.25 Age, size or sex distribution is functionally normal.

+0.25 Species is close to virgin biomass.

+0.25 Current levels of abundance provide adequate food for other predators or are not known to affect the structure of the associated food web.

In their species synopsis, Palko et al. (1981) noted that Swordfish adults have few predators, though juveniles are vulnerable to predation and are most often taken by large pelagic vertebrates like mako sharks, blue sharks, orcas, and sperm whales. At current levels of Swordfish abundance, it can be assumed that juvenile Swordfish in the Pacific Ocean provide adequate food for these predators.

2.25 Points for Abundance

HABITAT QUALITY AND FISHING GEAR IMPACTS

Core Points (only one selection allowed)

Select the option that most accurately describes the effect of the fishing method upon the habitat that it affects

1.00 The fishing method causes great damage to physical and biogenic habitats (e.g., cyanide; blasting; bottom trawling; dredging).

2.00 The fishing method does moderate damage to physical and biogenic habitats (e.g., bottom gillnets; traps and pots; bottom longlines).

3.00 The fishing method does little damage to physical or biogenic habitats (e.g., hand picking; hand raking; hook and line; pelagic long lines; mid-water trawl or gillnet; purse seines).

Swordfish in the Pacific Ocean are predominantly caught with shallow-set surface longlines (Fishwatch 2010). The U.S. prohibits pelagic longline fishing within its EEZ (Exclusive Economic Zone extending 200 miles out to sea from the shoreline) off the U.S. west coast and on the high seas. Within the U.S. EEZ, Swordfish may only be taken using harpoons and drift gill nets, and in recreational fisheries. Shallow-set longlines may only be used on the high seas by U.S.-flag vessels that have a Hawaii longline limited entry permit and set certificates (Fishwatch 2010; PFMC 2009). The coastal drift gill net fishery is tightly regulated: it is a limited entry program, managed with gear, season, and area closures (PFMC 2009). The U.S. prohibits the use of drift gill nets on the high seas

(Fishwatch 2010). Because surface longlines, gillnets and harpoons do very little damage to physical habitats (Chuenpagdee et al. 2003), a score of 3 was awarded.

Points of Adjustment (multiple selections allowed)

-0.25 Habitat for this species is so compromised from non-fishery impacts that the ability of the habitat to support this species is substantially reduced (e.g., dams; pollution; coastal development).

-0.25 Critical habitat areas (e.g., spawning areas) for this species are not protected by management using time/area closures, marine reserves, etc.

Fewer juveniles have been caught in the Hawaiian Islands since a 50 nautical mile closure to longlining was established, suggesting that this area includes important nursery grounds (Dalzel 2004). Several critical nursery areas have been identified in the Atlantic (Ward and Elscot 2000), indicating that although there has been little assessment of critical habitat in the Pacific, it is likely that there are critical nursery areas throughout the Pacific which are not being protected so points were subtracted.

-0.25 No efforts are being made to minimize damage from existing gear types OR new or modified gear is increasing habitat damage (e.g., fitting trawls with roller rigs or rockhopping gear; more robust gear for deep-sea fisheries).

-0.25 If gear impacts are substantial, resilience of affected habitats is very slow (e.g., deep water corals; rocky bottoms).

+0.25 Habitat for this species remains robust and viable and is capable of supporting this species.

The pelagic (mid-water) habitat for Swordfish in the Pacific Ocean remains robust and viable.

+0.25 Critical habitat areas (e.g., spawning areas) for this species are protected by management using time/area closures, marine reserves, etc.

+0.25 Gear innovations are being implemented over a majority of the fishing area to minimize damage from gear types OR no innovations necessary because gear effects are minimal.

There is little potential for longline and drift gill net fishing gear to damage physical habitat, as they do not come into contact with the ocean floor (Fishwatch 2010).

+0.25 If gear impacts are substantial, resilience of affected habitats is fast (e.g., mud or sandy bottoms) OR gear effects are minimal.

3.25 Points for Habitat Quality and Fishing Gear Impacts

MANAGEMENT

Core Points (only one selection allowed)

Select the option that most accurately describes the current management of the fisheries of this species.

1.00 Regulations are ineffective (e.g., illegal fishing or overfishing is occurring) OR the fishery is unregulated (i.e., no control rules are in effect).

2.00 Management measures are in place over a major portion over the species' range but implementation has not met conservation goals OR management measures are in place but have not been in place long enough to determine if they are likely to achieve conservation and sustainability goals.

A number of Regional Fisheries Management Organizations (RFMOs) are working within the Pacific Ocean. Their guiding objective is to assess population status of commercially important fish with the aim of ensuring long-term conservation and sustainable use of these populations. Management is not based on a single Swordfish population in the Pacific but given the likely sub-population structure of Swordfish in the Pacific, each RFMO principally manages the Swordfish sub-populations within their jurisdiction. There are several discrete sub-populations (e.g. northern Pacific, eastern Pacific, southwest and south-central Pacific). The Inter-American Tropical Tuna Commission and the Western and Central Pacific Fisheries Commission are two RFMOs that have the responsibility to assess and manage Swordfish populations in the Pacific Ocean. Accordingly, these RFMOs develop applicable conservation and management measures to regulate either fishing effort or catch. These measures include setting annual catch limits, regulating vessel entry into specific areas and setting limits on the number of vessels fishing (eg. see WCPFC CMM 2009/03). Member nations have agreed to provide their scientific data to their respective RFMO, and are responsible to comply with adopted resolutions for management and conservation. Although the IATTC and WCPFC do not directly enforce regulations, they have employed measures in order to promote compliance. In the eastern and western Pacific, observers are placed on fishing vessels to collect data on fishing operations, including data which may indicate a vessel was not in compliance with management or conservation restrictions. Observers are also placed on transshipment vessels to help deter illegal, unregulated and unreported (IUU) fishing.

Fishing vessels in the eastern and western Pacific are also required to install vessel monitoring systems (VMS: transmitting devices so that vessel location can be continually recorded and monitored), and high sea patrols may board and inspect fishing vessels (WCPFC 2010). Member nations are also prohibited from engaging in fishing activities and/or trade with any vessel listed as an IUU vessel.

On a national level in the U.S., the Pacific Fishery Management Council and the Western Pacific Fishery Management Council (two of the eight councils established under the Magnuson-Stevens Fishery Act) regulate fishing activity within USA EEZ off the U.S. west coast and around Hawaii respectively. These councils through their respective Fisheries Management Plans (FMP) establish fishing gear limits, vessel entry limits through permit systems, and closed areas/seasons (Bartram et al 2010).

Although management measures are widespread throughout the Pacific Ocean, countries not participating with RFMOs may have unregulated fishing practices which do not abide by these measures. Similarly although RFMO measures are in theory binding, in practice not all member nations may comply with them. This has the potential to negatively affect regional Swordfish populations. Hence a score of 2 was awarded.

3.00 Substantial management measures are in place over a large portion of the species range and have demonstrated success in achieving conservation and sustainability goals.

Points of Adjustment (multiple selections allowed)

-0.25 There is inadequate scientific monitoring of stock status, catch or fishing effort.

-0.25 Management does not explicitly address fishery effects on habitat, food webs, and ecosystems.

-0.25 This species is overfished and no recovery plan or an ineffective recovery plan is in place.

-0.25 Management has failed to reduce excess capacity in this fishery or implements subsidies that result in excess capacity in this fishery.

+0.25 **There is adequate scientific monitoring, analysis and interpretation of stock status, catch and fishing effort.**

The RFMOs working within the Pacific Ocean are continually assessing commercial fish populations in order to make better informed conservation and management decisions. They recognize that a well managed fishery is important economically as well as environmentally. A number of population assessments have been undertaken on Swordfish populations in the Pacific over the past five years. These include two assessments of the Swordfish population in the southwest Pacific (with the most recent including data up until 2007) (Kolody et al 2009). The most recent assessment for the southeast Pacific Swordfish population was completed in 2007 and included data up to 2003 (Hinton and Maunder 2007), while the most recent assessment for the populations of Swordfish in northern Pacific was completed in 2009 and included data up until 2006 (Brodziak and Ishimura 2010). Untimely and, at times, incomplete reporting of catch data by member nations coupled with uncertainties in life history parameters account for the time delay in setting up reports. These delays add a level of uncertainty as to the present status of the Swordfish population in the Pacific Ocean. For this reason no points were awarded here. Continued assessment is vital to reduce uncertainties that preliminary populations assessments may have indicated and more effort needs to be made by member nations to deliver catch data in a timely manner.

+0.25 Management explicitly and effectively addresses fishery effects on habitat, food webs, and ecosystems.

+0.25 This species is overfished and there is a recovery plan (including benchmarks, timetables and methods to evaluate success) in place that is showing signs of success OR recovery plan is not needed.

Presently the various Swordfish sub-populations in the Pacific Ocean are considered not to be in an overfished state and hence a recovery plan is not needed.

+0.25 Management has taken action to control excess capacity or reduce subsidies that result in excess capacity OR no measures are necessary because fishery is not overcapitalized.

Regional declines in Swordfish abundance have occurred in the Pacific Ocean and management success has already been evident. The WCPFC has taken several precautionary management actions in recent years to limit increases in fishing effort and catch in relation to Swordfish in the southwest Pacific. Population assessments in recent years have shown a decline in the abundance of Swordfish in this region and projected further declines at the current fishing levels. In 2006 the WCPFC adopted a conservation resolution that limited the number of fishing vessels fishing for Swordfish in the Convention Area south of 20°S by member nations. Member nations were not to shift their fishing effort for Swordfish to the area north of 20°N as a result of this measure (see CMM-2006-03 now replaced by CMM-2009-03). Although the population has shown signs of recovery and is considered not to be in an overfished state, fishing in this area is still strictly controlled in order to keep the population above its associated reference points (WCPFC 2008).

2.50 Points for Management

BYCATCH

Core Points (only one selection allowed)

Select the option that most accurately describes the current level of bycatch and the consequences that result from fishing this species. The term, "bycatch" used in this document excludes incidental catch of a species for which an adequate management framework exists. The terms, "endangered, threatened, or protected," used in this document refer to species status that is determined by national legislation such as the U.S. Endangered Species Act, the U.S. Marine Mammal Protection Act (or another nation's equivalent), the IUCN Red List, or a credible scientific body such as the American Fisheries Society.

1.00 Bycatch in this fishery is high (>100% of targeted landings), OR regularly includes a "threatened, endangered or protected species."

Pelagic longlines are the predominant fishing gear targeting Swordfish in the Pacific Ocean and contribute to the incidental capture of non-target species that include sharks, and endangered animals such as sea turtles, marine mammals and sea birds (Fishwatch 2010).

Longlines targeting Swordfish are shallow-set lines that are more prone to incidentally catch sea turtles than the deep-set tuna longlines (Lewison and Crowder 2007). Depending on vessel movement coupled with turtle movement, incidental turtle capture has been reported to be relatively low (Lewison and Crowder 2007). The fourth meeting of the Inter American Tropical Tuna Commission (IATTC) Working Group on Bycatch in January 2004 did report that in 2000, Japan’s longline fishery in the eastern Pacific inadvertently caught 166 leatherback (*Dermochelys coriacea*) and incurred 25 mortalities; and 6,000 turtles of other species, mostly olive Ridley (*Lepidochelys olivacea*), and incurred 3,000 mortalities. The Japanese fishing effort in the eastern Pacific in 2000 was about 79,311,000 hooks (IATTC 2008). Based on these data, the mortality rate observed in the Japanese-flag longline fisheries was about 0.32 leatherback turtles per million hooks, and about 38 per million hooks for other species. At the sixth meeting of the same Working Group in February 2007, it was reported that the Spanish longline fleet targeting Swordfish in the same region averaged 65 interactions with sea turtles and averaged eight mortalities per million hooks during 1990-2005 (IATTC 2008).

Foraging sea birds are threatened worldwide by pelagic longlines (Lewison and Crowder 2003). While the hooks are being set, the foraging birds are attracted to the bait and may become hooked and drowned (Lewison and Crowder 2003). Threatened species predominantly include the wandering (*Diomedea exulans*), amsterdam (*D. amsterdamensis*), black-browed (*Thalassarche melanophrys*) and grey-headed (*T. chrysostoma*) albatrosses and white chinned (*Procellaria aequinoctialis*) and spectacled (*P. conspicillata*) petrels. Laysan (*Phoebastria immutabilis*) and black-footed albatrosses (*P. nigripes*) have been documented as bycatch in the U.S. pelagic longline fishery. (Lewinson and Crowder 2003). Bycatch estimates of black-footed albatrosses in the central North Pacific estimate that 5,000-14,000 individual birds, translating to 1.9 - 5%

of the population, per year are caught in longlines (Lewinson and Crowder 2003). Even the best case scenario of 5,200 birds caught per year, can have far reaching implications that may result in population declines within the next three generations (Lewinson and Crowder 2003).

Sharks, too, are frequently caught in longlines. It is not uncommon for the number of sharks caught to exceed that of the target species in pelagic longline fisheries targeting Swordfish (Brill et al 2009; Gilman et al. 2008). In the western Pacific, sharks comprise 27% and 18% respectively, of the total bycatch in tropical and subtropical longlines targeting tuna and Swordfish (Gilman et al 2008). Blue sharks (*Prionace glauca*) are the most common species of shark caught in longlines, followed by short fin mako sharks (*Isurus oxyrinchus*) (Gilman et al. 2008; Vega and Licandeo 2009). Where markets exist and restrictions are not in place, many sharks caught as bycatch are finned and often discarded alive back into the ocean (Gilman et al. 2008).

Driftnets are used in minimal numbers off the U.S. west coast and land far more bycatch and have a higher mortality rate than pelagic longlines (Lewison and Crowder 2007). In the 2008-09 fishing season of the California/Oregon drift gillnet fishery targeting Swordfish, a total of 491 Swordfish were landed. The bycatch included: sun fish (*Mola mola*) at 1023 individuals, blue sharks at 228 individuals, common thresher sharks (*Alopias vulpinus*) totaled 160 individuals and short fin mako at 108 individuals. Marine mammals like seals and dolphins similarly were part of the bycatch, although in smaller amounts, they totaled 21 individuals, all which were dead. (PFMC 2009). More than 90% of the sun fishes caught were still alive, however survival rate after release is not known. Roughly 35% of the blue sharks caught are released alive, with a high survival rate after release (PFMC 2009). Estimated bycatch mortality of longline fishing is 4%, while gillnet bycatch mortality is as high as 50% (Lewison and Crowder 2007).

Because of the regular incidental capture of threatened sea turtles and birds in longline fishing, which is the main method of catching Swordfish, a score of 1 was awarded.

2.00 Bycatch in this fishery is moderate (10-99% of targeted landings) AND does not regularly include "threatened, endangered or protected species" OR level of bycatch is unknown.

3.00 Bycatch in this fishery is low (<10% of targeted landings) and does not regularly include "threatened, endangered or protected species."

Points of Adjustment (multiple selections allowed)

-0.25 Bycatch in this fishery is a contributing factor to the decline of "threatened, endangered, or protected species" and no effective measures are being taken to reduce it.

-0.25 Bycatch of targeted or non-targeted species (e.g., undersize individuals) in this fishery is high and no measures are being taken to reduce it.

Shark bycatch remains high within longline fisheries and there are currently few mitigation methods in place to reduce this (Gilman et al 2008). Current investigative studies, such as employing metal repellants and modifying fishing gear, are underway to determine the best method(s) to reduce shark bycatch in these fisheries (Brill et al. 2009; Vega and Licandeo 2009). Although some countries have implemented regulations to decrease shark finning, many nations have not employed such measures and finning continues unregulated (Gilman et al 2008; Vega and Licandeo 2009).

-0.25 Bycatch of this species (e.g., undersize individuals) in other fisheries is high OR bycatch of this species in other fisheries inhibits its recovery, and no measures are being taken to reduce it.

-0.25 The continued removal of the bycatch species contributes to its decline.

+0.25 Measures taken over a major portion of the species range have been shown to reduce bycatch of "threatened, endangered, or protected species" or bycatch rates are no longer deemed to affect the abundance of the "protected" bycatch species OR no measures needed because fishery is highly selective (e.g., harpoon; spear).

Sea turtles, sea birds, sharks and marine mammals are highly vulnerable to the negative effects of bycatch due to their slow growth rate, late age at maturity and low fecundity (Brill et al 2009, Lewison et al 2004). As fishing pressure responds to target species abundance and continues irrespective of bycatch abundance it is imperative that the effects of bycatch are timely assessed (Lewison et al 2004). Once these marine vertebrate populations are depleted they have a slow recovery rate (Brill et al 2009). Pelagic longline bycatch is thought to be an immediate cause for regional declines in two threatened sea turtle populations in the Pacific Ocean namely loggerhead and leatherback sea turtles (Lewison et al 2004; Spotila et al. 2000). Dramatic declines for these two species have been observed in the last 20 years with a 95% decrease in nesting populations of leatherback turtles and an 80–86% decrease of nesting loggerhead populations (Lewison et al 2004; Spotila et al. 2000). Albatrosses have one of the highest proportions of threatened species in any bird family (Croxall and Gales 1998) and pelagic longline activity has been significantly linked to albatross population declines in the Southern Ocean (Lewinson and Crowder 2003).

Within the U.S. pelagic longline fishery tight regulations are in place to reduce bycatch of endangered and threatened species. The Hawaii based Swordfish fishery was reopened in 2004 under tight management regulations due to past estimated high sea turtle bycatch rates. New regulations dictate that vessels deploying shallow-set gear north of the equator are required to use circle hooks, mackerel type bait, to carry NOAA approved turtle de-hooking devices and on board observers. The number of shallow-set hooks has been capped at 2120 hooks (Bartram et al 2010). The fishery also operates with a real-time annual hard cap of 16 leatherback and 17 loggerhead interactions (Fishwatch 2010; STRP

2011). The hard cap states that if either species cap is reached, the fishery is immediately closed for the rest of the year. These mitigation methods have reduced sea turtle bycatch per unit effort by 89% (Bartram et al 2010). Incidentally these gear modifications within the Hawaii longline fishery have also reduced shark bycatch by 36% (Gilman et al 2008). Within the U.S. west coast EEZ longlines are prohibited. The only gears permitted to target Swordfish are harpoons and drift gillnet (PFMC 2009). National Marine Fisheries Service (NMFS) declared in 2004 that the California/Oregon Drift gillnet fishery would be closed in an El Niño event in order to protect loggerhead sea turtles populations (NMFS Federal register 2007). Similarly US vessels are required to comply with sea bird mitigation methods. These include using torilines to deter foraging sea birds, side setting the fishing gear, and using blue-dyed thawed bait. Vessels not complying with these guidelines face a penalty (NMFS 2007).

The various RFMOs working within the Pacific Ocean are well aware of the risks that high bycatch numbers pose to non-commercial species populations and have adopted conservation and management measures to help minimize these risks. These include adopting resolutions to reduce the bycatch, injury, and mortality of sea turtles in fishing operations (WCPFC-CMM-2008-03); reducing incidental catches of seabirds (WCPFC-Resolution-2005-01); and prescribing additional provisions to minimize waste and discards from shark catches and to encourage the live release of incidental catches of sharks and sea turtles (WCPFC-CMM-2006-05). Many RFMOs are also conducting their own feasibility studies to reduce, monitor and assess population status of bycatch species (ISC 2009). Whilst management measures adopted by RFMOs are binding on member and other participating nations, the ability to monitor and enforce compliance with these measures is presently limited. Points were added here due to the success the U.S. has experienced in reducing bycatch, and the formal commitment and continual effort by the RFMOs to reduce bycatch and increase release of live individuals.

+0.25 There is bycatch of targeted (e.g., undersize individuals) or non-targeted species in this fishery and measures (e.g., gear modifications) have been implemented that have been shown to reduce bycatch over a large portion of the species range OR no measures are needed because fishery is highly selective (e.g., harpoon; spear).

+0.25 Bycatch of this species in other fisheries is low OR bycatch of this species in other fisheries inhibits its recovery, but effective measures are being taken to reduce it over a large portion of the range.

+0.25 The continued removal of the bycatch species in the targeted fishery has had or will likely have little or no impact on populations of the bycatch species OR there are no significant bycatch concerns because the fishery is highly selective (e.g., harpoon; spear).

1.00 Points for Bycatch

REFERENCES

Alvarado Bremer J.R., Hinton M.G., Greig T.W. 2006. Evidence of spatial genetic heterogeneity in Pacific swordfish (*Xiphius gladius* L.) revealed by the analysis of ldh-A sequences. Bulletin of Marine Science 79:493-504.

Bartram PK, Kaneko JJ, Kucey-Nakamura K. 2010. Sea turtle bycatch to fish catch ratios for differentiating Hawaii longline-caught seafood products. Marine Policy 34:145–149

Brill R, Bushnell P, Smith L, Speaks C, Sundaram R, Stroud E, Wang J. 2009. The repulsive and feeding-deterrent effects of electropositive metals on juvenile sandbar sharks (*Carcharhinus plumbeus*). Fisheries Bulletin. 07:298-307

Brodziak J, and Ishimura G. 2010. Stock assessment of North Pacific swordfish (*Xiphias gladius*) in 2009. Pacific Islands Fisheries Science Center. National Oceanic and Atmospheric Asministration. Administrative Report H-10-01

Croxall J P, and Gales R. 1998. An assessment of the conservation status of albatrosses. Pages 46-65 in R. Robertson and R. Gales, editors. The albatross biology and conservation. Surrey Beatty and Sons, Chipping Norton, UK.

DeMartini, E.E., J.H. Uchiyama, and H.A. Williams. 2000. Sexual maturity, sex ratio, and size composition of swordfish, *Xiphia gladius*, caught by the Hawaii-based pelagic longline fishery. United States National Marine Fisheries Service, Fisheries Bulletin, 98 (3): 489-506.

DeMartini EE, Uchiyama JH, Humphreys Jr. RL, Sampaga JD, Williams HA. 2007. Age and growth of swordfish (*Xiphias gladius*) caught by the Hawaii-based pelagic longline fishery. United States National Marine Fisheries Service, Fisheries Bulletin 105:356-367.

Fishbase 2010. Species Summary for *Xiphias gladius*. Available online at: http://www.fishbase.org/Summary/SpeciesSummary.cfm?genusname=Xiphias&speciesname=gladius. Accessed February 20, 2010.

Fishwatch 2010 – North Pacific swordfish (*Xiphias gladius*). Provided by National Marine Fisheries Service; Available online at http://www.nmfs.noaa.gov/fishwatch/species/pac_swordfish.htm. Accessed April 8, 2010

Gilman E, Clarke S, Brothers N, Alfaro-Shigueto J, Mandelman J, Mangel J, Petersen S, Piovano S, Thomson N, Dalzell P, Donoso M, Goren M, Werner T. 2008.Shark interactions in pelagic longline fisheries. Marine Policy 32:1–18

Inter-American Tropical Tuna Commission (IATTC).2008. Fishery Status Report no. 6: Tunas and billfishes in the eastern Pacific Ocean in 2007. 145 p

Inter-American Tropical Tuna Commission (IATTC).2010. Fishery Status Report no. 7: Tunas and billfishes in the eastern Pacific Ocean in 2008. 105p

Hinton, M.G. 2003. Status of swordfish stocks in the eastern pacific Ocean estimated using data from Japanese tuna longline fisheries. Marine and Freshwater Research 54: 393–399.

Hinton, M.G., and R.B. Deriso. 1998. Distribution and stock assessment of swordfish, *Xiphias gladius*, in the eastern Pacific Ocean from catch and effort data standardized on biological and environmental parameters. NOAA Tech. Rep. NMFS 142: 161–179. 276 p.

Hinton, M.G. and M.N. Maunder. 2007. Status of the swordfish stock in the southeastern Pacific Ocean. Inter-American Tropical Commission, Stock Assessment Report 7, p. 249-282. http://www.iattc.org/StockAssessmentReports/StockAssessmentReport7ENG.htm

International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean. Report of the ninth meeting of the International Committee for Tuna and Tuna-like Species in the North Pacific Ocean – ISC Plenary Revised October 2009

Kasapidis P, Magoulas A, García-Cortés B, Mejuto J. 2008. Stock structure of swordfish (*Xiphias gladius*) in the Pacific Ocean using microsatellite DNA markers. WCPFC-SC4-2008/BI -WP-4

Kolody D, Campbell R, Davies N. 2009. Final report on south-west Pacific swordfish (*Xiphias gladius*) stock assessment 1952-2007. Information Paper WCPFC-SC5-2009/GN-IP-2 presented to the 5th meeting of the Scientific Committee for the Western Central Pacific Fisheries Commission, held 10-21 August 2009, Port Vila, Vanuatu.

Lewison RL, Crowder LB. 2003. Estimating fishery bycatch and the effects on a vulnerable seabird population. Ecological Applications 13: (3) 743-753

Lewison, RL, Freeman, SA, Crowder, LB. 2004. Quantifying the effects of fisheries on threatened species: The impact of pelagic longlines on loggerhead and leatherback sea turtles. Ecological Letters 7: 221–231.

Lewinson RL, Crowder LB. 2007. Putting Longline Bycatch of Sea Turtles into Perspective Conservation Biology 21(1):79-86

Murua H, Saborido-Rey F. 2003. Fish reproductive strategies of marine fish species of the North Atlantic. Journal of Northwest Atlantic Fishery Science 33: 23-31

Nakamura, I. 1985. Billfishes of the world. An annotated and illustrated catalogue of marlins, sailfishes, spearfishes and swordfishes known to date. Rome, FAO. 65 p.

National Marine Fisheries Service (NMFS). 2003. Fishery Management Plan and Environmental Impact Statement for U.S. West Coast Fisheries for Highly Migratory Species. PFMC.

National Marine Fisheries Service (NMFS). 2007 Regulations and Related Documents: Closures of the Drift Gillnet Fishery in the Pacific Loggerhead Conservation Area during El Nino Events. Federal Register: Vol. 72 (110). Friday, June 8, 2007. Rules and Regulations. Available at: http://swr.nmfs.noaa.gov/psd/codgftac.htm

Pacific Fishery Management Council (PFMC): 2009 Status of the U.S. west coast fisheries for highly migratory species through 2008: Stock assessment and Fishery Evaluation. October 2009. Prepared by the Pacific Fishery Management Council in conjunction with the National Marine Fisheries Service

Palko B.J., G.L. Beardsley, and W.J. Richards. 1981. Synopsis of the biology of the swordfish, *Xiphias gladius* Linnaeus. NOAA Technical Report NMFS Circ 441, 25 p.

Reeb, C.A., Arcangeli L., Block B.A. 2000. Structure and migration corridors in Pacific populations of the swordfish (*Xiphius gladius*), as inferred through analyses of mitochondrial DNA. Marine Biology 136:1123-1131.

Sea Turtle Restoration Project (STRP). 2011. Endangered Sea Turtles Saved From Capture in Hawaii Swordfish Fishery. Available at: http://seaturtles.org/article.php?id=1934

Spotila JR, Reina RD, Steyermark AC, Plotkin PT, Paladino FV. 2000. Pacific Leatherback turtles face extinction. NATURE: Brief communications 405: 529-530

South West Fisheries Science Center (SWFSC): Swordfish Research. Available online at: http://swfsc.noaa.gov/textblock.aspx?Division=FRD&ParentMenuId=141&id=1127.Page Updated 6 Feb 2007; Accessed on March 10, 2010.

Vega R, Licandeo R. 2009. The effect of American and Spanish longline systems on target and non-target species in the eastern South Pacific swordfish fishery. Fisheries Research 98: 22-32

Ward, P. and Elscot, S. 2000. Broadbill swordfish: status of world fisheries. Bureau of Rural Sciences, Canberra.

Western and Central Pacific Fisheries Commission (WCPFC) Resolution 2005-01: Resolution of the incidental capture of seabirds. Available at: http://www.wcpfc.int/conservation-and-management-measures

Western and Central Pacific Fisheries Commission (WCPFC). Conservation and Management Measures CMM-2006-05. Available at: http://www.wcpfc.int/doc/12/cmm-2006-05-replaced-cmm-2008-06

Western and Central Pacific Fisheries Commission (WCPFC). Conservation and Management Measures CMM-2008-03. Available at: http://www.wcpfc.int/conservation-and-management-measures

Western and Central Pacific Fisheries Commission (WCPFC). Commission for the conservation and management of highly migratory fish stocks in the western and central Pacific Ocean. Scientific Committee Fourth Regular Session 2008

Western and Central Pacific Fisheries Commission (WCPFC). Conservation and Management Measures CMM-2009-03. Available at: http://www.wcpfc.int/conservation-and-management--measures

Western and Central Pacific Fisheries Commission (WCPFC): Frequently asked questions Available online at: http://www.wcpfc.int/frequently-asked-questions-and-brochures. Accessed on April 9, 2010

Yabe, Hiroshi, Shoji Ueyanagi, Shoji Kikawa, and Hisaya Watanabe. 1959. Study on the life-history of the swordfish. Nankai Reg. Fish. Res. Lab., Rep., 10: 107-150.