Pacific Sardine (*Sardinops sagax*)

Certification Units Covered Under this Species

- Purse seine

Summary

Pacific sardine is currently one of the most abundant forage fish species along the west coast of North America, extending from the tip of Baja California to British Columbia. Populations undergo natural fluctuations over periods of approximately 60 years; these fluctuations are likely related to oceanic conditions. Sardine is federally managed under the Pacific Fishery Management Council's Coastal Pelagic Species Fishery Management Plan, which includes annual stock assessments, harvest guidelines, and limited entry permits.

Strengths:

- Well managed fishery with annual stock assessments, harvest guidelines, and limited entry permits
- Long history of monitoring data; fishery independent and dependent data collected
- Bycatch is minimal; most incidental catch is retained and consists of other coastal pelagic species

Weaknesses:

- There are extreme natural population fluctuations
- More information is needed to determine if current harvest levels impact the ecosystem as a whole

History of the Fishery in California

Biology of the Species

Pacific sardine are small, pelagic, schooling fish from the family Clupeidae, which include other coastal pelagics such as herring and menhaden. Sardine feed on plankton and help form the base of the marine food web as important forage for marine mammals, birds, and fish of higher trophic levels. Sardines exhibit counter-shading; they have silver bellies and blue-green coloring on their dorsal surface with distinctive dark spots on their side, above the lateral line. Typically sardines are found in large schools during the day (often with jack mackerel, Pacific mackerel, and northern anchovy) and disperse at night (Love 2011). Maximum size of sardines is about 41 cm in length and 0.32 kg, although most are captured below 30 cm in length (Hill et al. 2012). Sardines are generally mature at about 18 cm in length or between 2-3 years of age, however this can be dependent on biomass, latitude, and temperature (Butler 1987; Hill 1999). At relatively low biomass levels, sardine appear to be fully mature at age one, whereas at very high biomass levels only some of the two-year-olds are mature (MacCall 1979). Pacific sardine can live 13-25 years, although most captured in California are below 5 years of age (Hill et al. 2012).

Sardine populations exhibit extreme natural variation in abundance. For example, in the 1930's Pacific sardine supported the largest fishery in the Eastern Pacific ocean; however by the 1950s the fishery collapsed and caused economic ruin to canneries along the U.S. West coast. After several decades of ecological absence, the west coast sardine population rapidly started to rebuild again in the 1980s. As a result of the sardine collapse, in 1949 the California Cooperative Oceanic Fisheries Investigations (CalCOFI) was formed to study the ecological reasons behind the collapse. CalCOFI research has led to the development of quantitative fisheries models and insight into climate/fisheries interactions. Some of this research has shown that sardine populations undergo cyclical fluctuations over a period of about 60 years (Baumgartner et al. 1992). The reason for the fluctuating nature of Pacific sardine populations is still unknown, but is hypothesized to be associated with changes in sea surface temperature and upwelling (Chavez et al. 2003; Emmett et al. 2005; Herrick et al. 2007; Lluch-Belda et al. 1991; Norton and Mason 2005). Over the last 100 years, sardine populations have increased during periods of warmer than average ocean temperatures and decreased during periods of colder than average ocean temperatures. During population increases associated with warmer water, sardines can be found from the tip of Baja California to British Columbia, Canada; however, during population declines associated with colder water, sardines are rarely found north of Point Conception.

The largest spawning biomass of Pacific sardines in California occurs offshore between Monterey and Ensenada, Mexico in the transition zone between inshore upwelled waters and the offshore California Current. Recent spawning has been concentrated in the region offshore and north of Point Conception (Lo et al. 2005 & 2010 & 2013). Sardines are batch spawners, releasing about 9,000 – 100,000 eggs at a time and spawn between February and August off the California coast. Peak spawning temperatures off California are between 13°C – 15°C (Hill et al. 2012). As juveniles and sub adults, sardine reside primarily nearshore, but as they grow older and larger they move further offshore, ultimately initiating seasonal migratory behavior north in summer months to feed. Despite large-scale movements, adult sardine return to previously mentioned offshore spawning areas in the fall for spawning in spring months. Pacific sardine have been observed from the surf zone out to 350 miles offshore.

Along the West coast of North America, there is a generally accepted hypothesis that sardines belong to three separate stocks (Vrooman 1964; Felix-Uraga et al. 2004; Felix-Uraga et al. 2005; Garcia-Rodriguez et al. 2011): a southern, “warm” stock found in the Gulf of California and Southern Baja California; a central “temperate” stock found off of Central Baja California; and a northern “cold” stock found north of Northern Baja California. All landings from California are assumed to come from the northern, “cold” stock.

Commercial Fishery

[From Hill et al. 2012]: The sardine fishery was first developed in response to demand for food during World War I. Landings increased from 1916 to 1936, peaking at over 700,000 metric tons (mt). Pacific sardines supported the largest fishery in the western hemisphere during the 1930s and 1940s, with landings in British Columbia, Washington, Oregon, California, and México. The population and fishery declined in the late 1940s, with some short-term reversals, to extremely low levels in the 1970s. During this time a 2-year moratorium on targeting sardines was enacted in 1967, followed by a partial lifting of the moratorium in 1969 (allowed 250 tons of sardines to be targeted annually as bait), followed by a final moratorium in 1974 where no targeted sardine fishing could occur until the sardine spawning biomass reached 20,000 tons (Wolf 1992). In the early 1980s, sardines started showing up as incidental catch with Pacific and jack mackerel in the southern California mackerel fishery. As sardines continued to increase in abundance, a directed fishery was reestablished and the incidental fishery ended (in 1991). Besides San Pedro and Monterey, California, substantial Pacific sardine landings are now made in the Pacific Northwest and in Baja California, Mexico.

In California, the principal port areas for landing sardine are Monterey and Los Angeles. Landings increased in the mid 1990s, but declined from 2008 - 2011 because of decreased quotas as result of estimated stock declines (Figure 1). Landings and ex-vessel revenue for the entire West coast from 1981-2012 are shown in Figure 1. In 2010, over 85% of the annual sardine catch was exported overseas; the primary export countries were Japan, Thailand, China, Malaysia and South Korea (PFMC 2011). Domestically, sardines are mainly used as bait. There is an active commercial live bait fishery that operates primarily in southern California (PFMC 2011). The commercial live bait fishery for sardine provides an important source of bait to both commercial passenger fishing vessels and private boats. Landings data from this fishery are currently available through a voluntary logbook program.

Pacific sardine are primarily captured by purse seine, although since the 1990s, purse seiners began converting to drum seines which are easier to deploy and retrieve. There is also some incidental catch by mid-water trawl fisheries.

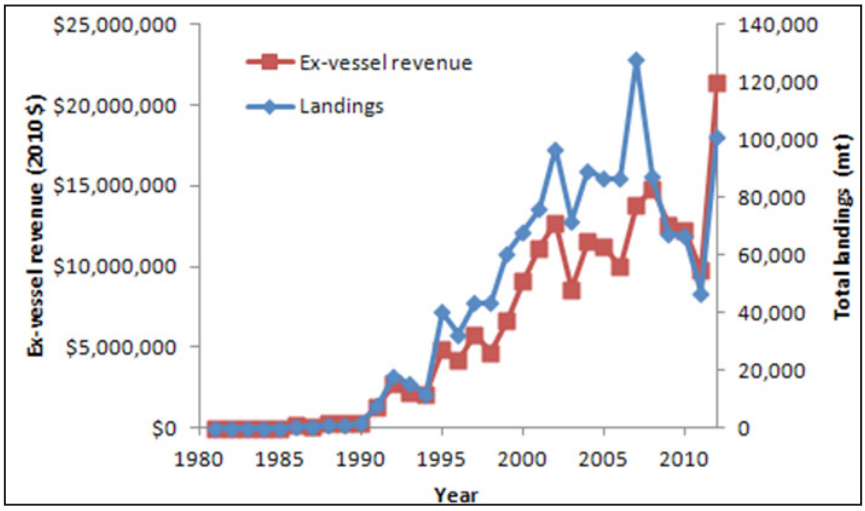

Figure 1. Total landings and ex-vessel revenue of Pacific sardine along the U.S. West coast 1981-2012 (data from PFMC 2011, PacFIN 2013).

Recreational Fishery

There is a recreational fishery for sardine by anglers who capture them primarily for consumption. The majority of fish landed are from man-made structures, such as piers and jetties, where no sports fishing license is required. If fishing from anything other than a man-made structure, a sport fishing license is needed. There are no limits on the recreational take of Pacific sardine.

The 2012 CA recreational Pacific sardine catch estimate as sampled from the California Recreational Fisheries Survey (CRFS) was 62.1 metric tons, or 853,791 fish. This was an increase from 2011 of 183% in metric tons, and 82% in numbers of fish (http://www.recfin.org/data/estimates/tabulate-recent-estimates-2004-current; catch types A+B1, all modes/areas, query date 7-5-13).

MSC Principle 1: Resource Sustainability

*Sustainability of Target Stock

[From PFMC 2011]: Sardine populations started to rebuild in the 1980s and by the 1990s, stock biomass was rapidly increasing. Sardine biomass peaked at 1.33 mmt in 1999 and 1.37 mmt in 2006 (Figure 2). As of July 2012, stock biomass was estimated at 659,539 mt (Hill et al. 2012). Recruitment is highly variable and it appears both density-dependent and environmental factors play an important role. Recruitment peaked in 1997, 2003, 2007 and 2009. Both recruitment and biomass have been declining since 2009 and 2006, respectively. Despite this recent decline, populations are considered healthy and management measures are in place to respond to changing population levels (see Harvest Strategy). Since the time federal harvest guidelines were set in 2000, sardine catch has been below or very close to the harvest guideline (Figure 3). The U.S. exploitation rate (annual catch divided by biomass) has been declining since 2002, although the total (Mexico, U.S., Canada) exploitation rate has increased in recent years (Figure 4).

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

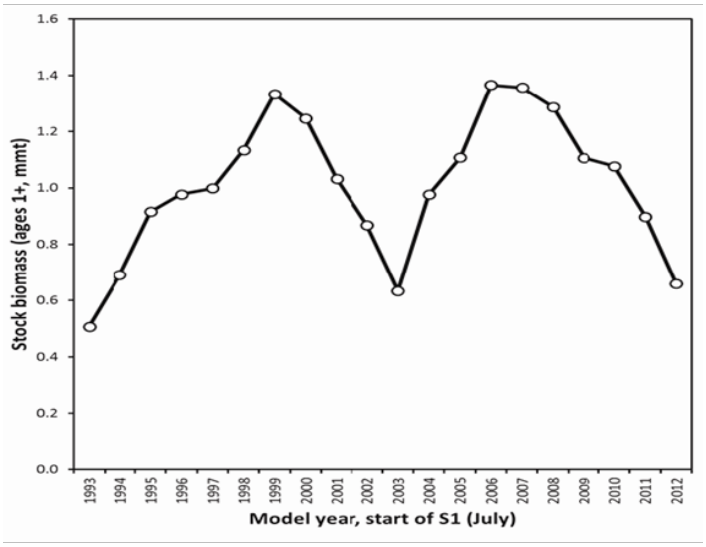

Figure 2. Stock biomass of Pacific sardine from 1993 – 2012 (figure from Hill et al. 2012).

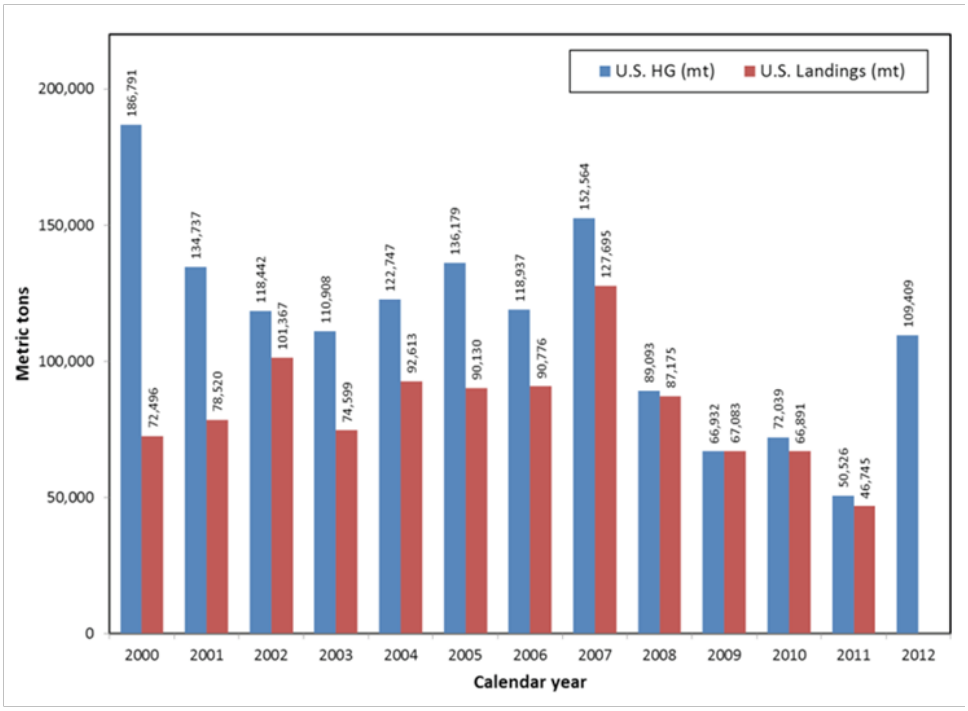

Figure 3. U.S. harvest guideline values and catches since the onset of federal management (figure from Hill et al. 2012).

Figure 4. Exploitation rate (annual catch divided by biomass) of Pacific sardine from 1993 – 2011 (figure from Hill et al. 2012).

Evaluation against MSC Component 1.1: Sustainability of Target Stock

Performance Indicators	Rating	Justification
1.1.1 Stock Status		Stock is well above the LRP* and has been consistently above the TRP* since 2000; annual stock assessments are available
1.1.2 Reference Points		Explicit reference points are used and evaluated during annual stock assessments
1.1.3 Stock rebuilding		Not triggered; stock is considered healthy

*MSC evaluations define a Limiting Reference Point (LRP) and a Target Reference Point (TRP). In the case of Pacific sardine, the cutoff point of 150,000 qualifies as the LRP and the fraction of sardine allowed to be harvested above the cutoff point (capped at 15%) qualifies as the TRP.

Harvest Strategy (Management)

The Pacific sardine population overlaps three countries: Canada, the U.S. and Mexico. No formal fishery management agreement exists among Canadian, U.S. and Mexican governing agencies; however, representatives from government, academia and industry from each country meet each year at the Trinational Sardine Forum to collaborate on improving the coast-wide stock assessment. The U.S. and Mexico harvest the majority of Pacific sardine (Figure 5).

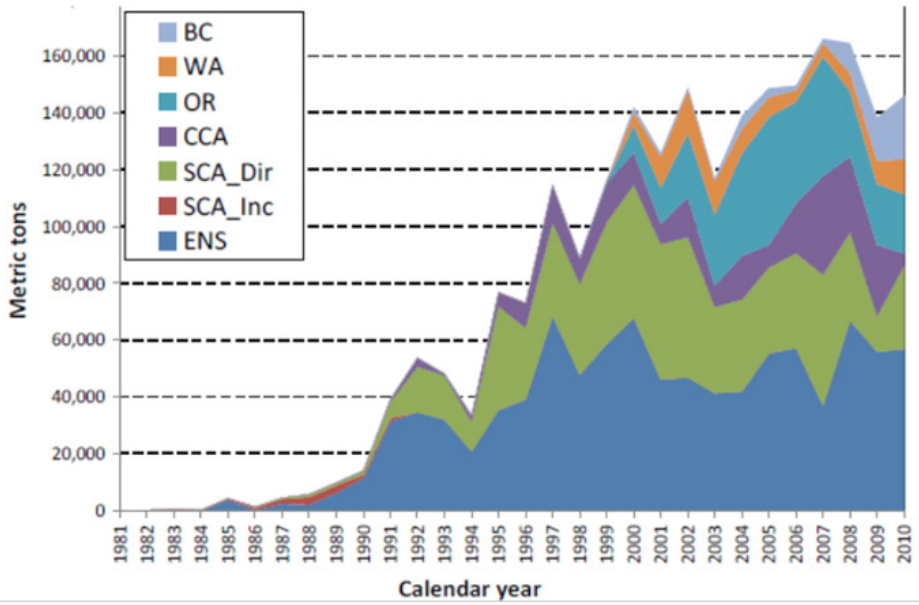

Figure 5. Sardine landings by fishing region and calendar year (from Hill et al. 2011, Fig. 1). Legend: BC= British Columbia; WA= Washington state; OR= Oregon state; CCA = central California; SCA_Dir and SCA_Inc = southern California directed and incidental fishing, respectively; ENS =Ensenada (Baja Mexico).

Prior to 2000, Pacific sardine were managed by individual states, but in January 2000, management authority was transferred to the Pacific Fishery Management Council (PFMC). Pacific sardine are now managed under the federal Coastal Pelagic Species-Fishery Management Plan (CPS-FMP; PFMC 1998). The CPS-FMP includes a limited-entry fleet and an annual coast-wide stock assessment that sets annual overfishing (OFL) and harvest guideline (HG) levels for sardine (PFMC 2011). The HG is based on a harvest control rule that accounts for scientific and management uncertainty and includes a biomass estimate informed by fishery and survey data from Mexico, the U.S. and Canada. There are several components that go into the HG calculation, including (Hill et al. 2012):

- The estimated average percentage of sardine biomass that occurs in U.S. waters; this is set at 87%[1].
- A cutoff point of 150,000 mt of sardine biomass; below this point no harvesting of sardines, except as live bait, is allowed.
- A maximum HG of 200,000 mt, regardless of how high the sardine biomass goes.
- A temperature-dependent[2] fraction of sardine biomass, above the cutoff point, that can be harvested. In recent years this has been 15%, but the fraction can vary between 5% and 15%.

Since 2006, the annual coastwide Pacific sardine HG has been divided into three allocation periods. In addition, a portion of the HG is typically set aside for incidental take in other fisheries and for exempted fishing permits (to use for industry-sponsored research).

[1]This distribution term is based on historical spotter pilot data from 1963-1992 (PFMC 1998). There have been recent discussions about updating this term, as the sardine stock has shifted with changing environmental conditions, but more recent data have not yet been synthesized to arrive at a refined estimate (PFMC 2013).

[2]In recent years the basis for the temperature data has been called into question, and subsequent analyses have supported using an offshore temperature time series (from CalCOFI cruises) over the previous static pier temperature index (from Scripps pier)(McClatchie et al 2010, PFMC 2013).

Stock assessments for sardine are informed by both fishery-dependent data and fishery independent data. Fishery dependent data includes 1) landings from Ensenada, Mexico to British Columbia, Canada and 2) biological data from port sampling programs. All three U.S. states (CA, OR, WA) monitor the commercial sardine catch utilizing port sampling programs which provide data such as age (using otoliths), length, sex, maturity, species composition of the CPS catch, and by-catch and incidental catch. Fishery-independent data includes 1) Daily Egg Production Method (DEPM) and Total Egg Production (total spawning biomass) data collected on the annual CalCOFI cruise (1994 – 2012), 2) aerial photogrammatic surveys of sardine biomass (2009 - 2012) and 3) acoustic trawl method (ATM) surveys of sardine biomass (2006 – 2012).

In Canada, the sardine fishery is managed by the Department of Fisheries and Oceans, which sets an annual quota for Pacific sardine. [From DFO 2012]: The Fishery Management Framework harvest control rules for setting the annual maximum available commercial harvest are based on the product of three factors: 1) the current population biomass estimate in the NE Pacific ocean (from Ensenada, MX to B.C.) resulting from the annual U.S. assessment; 2) the three-year running average seasonal migration rate, determined as the ratio of sardine biomass in B.C. waters (based primarily on observations from the west coast of Vancouver Island) to the population biomass estimate from the stock assessment, and 3) an annual harvest rate (ranging from 5-15%) approximating what is applied in the U.S. (15% since 2002). The estimated three-year average sardine migration rate into B.C. waters (for 2012) is 18.4%.

In Mexico, the sardine fishery is managed by the Ministry of Agriculture, Livestock, Rural Development, Fisheries and Food (SAGARPA). Harvest of Pacific sardine is not regulated by a quota system, but there is a minimum legal size requirement of 150 mm standard length and measures to control the size of the fishing fleet.

Evaluation against MSC Component 1.2: Harvest Strategy

Performance Indicators	Rating	Justification
1.2.1 Harvest Strategy		A precautionary harvest strategy is in place which includes an annual harvest guideline and harvest control rules
1.2.2 Harvest Control Rules and Tools		Precautionary harvest control rules are in place and evaluated annually; Catch has been close to or below the HG.
1.2.3 Information/Monitoring		Fishery dependent and independent data are collected to support the harvest strategy; control mechanisms are in place to respond to changes in the fishery
1.2.4 Assessment of Stock Status		Annual stock assessments are conducted using reliable methods

MSC Principle 2: Environment

Retained Species

Purse Seine

[From PFMC 2011]: Most incidental catch in the sardine fishery is retained. In the purse seine fishery, fish are pumped from the sea directly into fish holds aboard the vessel. Fishermen

do not sort catch at sea or what passes through the pump. Unloading of fish at the dock also occurs with pumps. The fish are pumped into ice bins and trucked to processing facilities in another location or to a conveyor belt in a processing facility, where fish are sorted, boxed, and frozen. CDFW port samples indicate minimal incidental catch in the California sardine fishery and the catch that is observed is primarily other coastal pelagic fish species managed under the CPS FMP. Information on retained catch is available from port sampling data, observer data, and logbook data.

Retained catch in California from 2006-2010 primarily* consisted of: northern anchovy, jack mackerel, bat ray, jellyfish, and market squid. Incidental catch has not been quantified in California. In Oregon, incidental catch was primarily* Pacific mackerel, jack mackerel, Pacific herring, northern anchovy, market squid and jellyfish; incidental catch made up 0.2% of total sardine landings in Oregon in 2010. In Washington, incidental catch was primarily* mackerel and Pacific herring. Pacific mackerel, jack mackerel and Northern anchovy are all managed under the CPS FMP (although jack mackerel and northern anchovy are only monitored by the CPS FMP). Market squid is managed under the state market squid FMP. Pacific herring is managed by the individual states.

Evaluation against MSC Component 2.1: Retained Catch

Performance Indicators	Rating	Justification
2.1.1 Outcome		Retained species catch is low and primarily consists of other coastal pelagic species
2.1.2 Management		Coastal pelagic species are managed under the PFMC's CPS FMP
2.1.3 Information		Port sampling data, observer data, logbooks; Retained species catch is not quantified in CA, only frequency of appearance is recorded.

Bycatch Species

Purse Seine

[From PFMC 2011]: Bycatch is defined as incidental catch that is not retained. Bycatch is low in the sardine fishery because most species are retained; fish are pumped directly into holding tanks and not sorted until they reach the processing facility. Bycatch primarily consists of protected species (see next section). Information on bycatch is collected from logbooks and observer coverage.

Evaluation against MSC Component 2.2: Bycatch

Performance Indicators	Rating	Justification
2.2.1 Outcome		SAFE reports state that bycatch is very low
2.2.2 Management		Low bycatch
2.2.3 Information		Observer data, logbooks

*Endangered, Threatened, & Protected Species

Purse Seine

[From PFMC 2011]: In Oregon, Washington and California, nine evolutionarily significant units (ESU) of Chinook salmon are listed as either threatened or endangered and four ESUs of Coho

*Observed at a frequency of >5.0% in any one year from 2006-2010 in California, or at > 2 mt in any one year from 2000-2010 in Oregon and Washington (PFMC 2011).

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

salmon are listed as either threatened or endangered. As vessels move north of Monterey, CA, the potential for taking Chinook and Coho salmon as bycatch increases, although salmon bycatch primarily occurs in Oregon and Washington. In Oregon, salmon bycatch (as reported in logbooks) ranged between 186 – 519 individuals per year from 2006 to 2010; between 53% to 67% of these fish were released alive. In Washington, salmon bycatch ranged between 267 – 1,774 individuals per year from 2000 through 2010. From 2000 to 2004 between 22% and 73% of the fish were released alive (observer data), but after 2004, between 18.4% and 18.7% were released alive (logbook data).

In 2010, NMFS SWR Protected Resources Division completed a formal Section 7 Biological Opinion (BO) and determined that fishing activities conducted under the CPS FMP and its implementing regulations are not likely to jeopardize the continued existence of any endangered or threatened species under the jurisdiction of NMFS or result in the destruction or adverse modification of critical habitat of any such species. Specifically, the current status of the Lower Columbia River Chinook, Snake River Fall Chinook, Upper Willamette Chinook, Puget Sound Chinook, Lower Columbia River Coho and Oregon coast Coho, were deemed not likely to be jeopardized by the Pacific sardine fishery.

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

Performance Indicators	Rating	Justification
2.3.1 Outcome		Bycatch of salmon was determined unlikely to jeopardize populations in a Section 7 BO
2.3.2 Management		Magnuson-Stevens Act, CEQA, Migratory Bird Act, Marine Mammal Protection Act, etc.
2.3.3 Information		Section 7 BO , SAFE reports, observer data

Habitat

Purse seine

Essential fish habitat (EFH) for coastal pelagic species (CPS) was defined in 1998 as all marine and estuarine waters in California, Washington and Oregon to the limits of the exclusive economic zone (EEZ) and above the thermocline where sea surface temperatures range between 10°C to 26°C (PFMC 1998). A recent review of the EFH in 2010 determined that no changes were necessary to the 1998 definition (CPSMT 2010).

Purse seines are the primary gear used to catch Pacific sardines. A purse seine is a movable net used to encircle fish. The top of the net is a float line with corks, or buoys. The net is held in a vertical position by a weighted lead line. The net also has a wire cable, run through rings on the bottom, which is used to draw the net together. Purse seine fishers often use spotter planes and sonar to locate the fish. Once the school is located, a small skiff takes one end of the net and then circles the fish with the net. The wire cable is winched in to close off the bottom of the seine. Then the other lines are pulled in as well to bring the captured school of fish closer to the mother ship, where the fish are pumped out of the net and put into fish holds filled with refrigerated sea water (Goblirsch and Theberge 2003). Drum seines are similar to purse seines except a horizontally mounted drum hauls and stores the net instead of a power block.

Appendix D of the CPS FMP (PFMC 1998) notes that contact between roundhaul gear (purse seines) and substrate is rare in fishing for CPS finfish, because fishing usually occurs in water deeper than the height of the net. Thus, the only opportunity for damage to benthos or essential

fish habitat for any species in fishing for CPS finfish is from lost gear. There is potential for fishing to impact squid spawning grounds because market squid attach their egg cases to the bottom substrate at spawning sites that include shallow, nearshore areas. Such damage is not believed to be extensive and is transitory with regard to the habitat.

Evaluation against MSC Component 2.4: Habitat

Performance Indicators	Rating	Justification
2.4.1 Outcome		Limited impact with substrate because fishing usually occurs in water deeper than the height of the net.
2.4.2 Management		Limited entry permits limit the number of vessels with purse seines
2.4.3 Information		Appendix D of CPS FMP

Ecosystem

Pacific sardine are filter feeders and prey on crustaceans, copepods, fish larvae and phytoplankton. Larval sardines feed extensively on the eggs, larvae, and juvenile stages of copepods, as well as other zooplankton and phytoplankton. Sardines provide important forage for marine mammals, birds, and fish of higher trophic levels. A concern with low trophic level fisheries is the impact population fluctuations may have on species of higher trophic levels that depend on them for forage (Smith et al. 2011, Kaplan et al. 2013). More information is needed to determine if current harvest levels impact the ecosystem.

To address this concern, several management agencies have adopted policies regarding forage fish species. In April of 2013, the PFMC adopted the Pacific Coast Fishery Ecosystem Plan (FEP) to help inform FMPs with more ecosystem science. Additionally, the Council adopted the objective to prohibit the development of new, directed fisheries on forage species that are not currently managed by the Council or states, until the impacts of any proposed fishery can be fully understood. In California, the California Fish and Game Commission (FGC) also voted in November of 2012 to prevent the development of new or expanded forage fisheries until essential fishery information needed for ecosystem based management is available and applied to management. In Washington, the Washington Fish and Wildlife Commission adopted a forage fish policy in 1998 to consider ecosystem science in the management of forage fish species and to use the precautionary approach to management. Oregon does not appear to have a specific policy for forage fish species.

Evaluation against MSC Component 2.5: Ecosystem

Performance Indicators	Rating	Justification
2.5.1 Outcome		Sardine are considered a low trophic level species; more information is needed to determine if current harvest levels impact the ecosystem
2.5.2 Management		The PFMC and the FGC recently adopted policies regarding ecosystem management of forage fish species.
2.5.3 Information		Observer data on bycatch

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 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 makes recommendations to NMFS on 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

Prior to 2000, Pacific sardine were managed by individual states, but in January 2000, management authority was transferred to the Pacific Fishery Management Council (PFMC).

Pacific sardine are now managed under the federal Coastal Pelagic Species-Fishery Management Plan (CPS-FMP; PFMC 1998) Management tools include a limited-entry permit system and annual quotas. The CPS-FMP outlines fishery specific objectives, an annual coast-wide stock assessment that sets annual overfishing (OFL) and harvest guideline (HG) levels for sardine, and discusses future research needs (PFMC 2011).

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.

For further information, please see the Harvest Strategy section under Principle 1.

Evaluation against MSC Component 3.2: Fishery Specific Management System

Performance Indicators	Rating	Justification
3.2.1 Fishery Specific Objectives		Outlined in the CPS 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		CPS FMP
3.2.5 Management Performance Evaluation		Annual stock assessments are reviewed by the stock assessment review (STAR) panel

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

Additional research can further refine or improve the sardine stock assessment model. Hill et al. (2012) cited some of the following research recommendations:

- Information on temperature-at-catch could be used to differentiate between the northern and southern subpopulatons, since it is believed the southern stock inhabits warmer waters.
- Explore models that use a longer time period; this may provide a better context for evaluating changes in productivity. This broader context can also be used to test environmental time series for use in simulations that evaluate sardine harvest control rules.
- Examine fishery targeting when developing appropriate fishery selectivities.
- Look at the sex structure of the population and the catch.
- Consider using age composition instead of length and conditional age-at-length composition data.
- Explore a model that has separate fleets for Mexico, California, Oregon-Washington, and Canada.
- Considering an alternate spawner-recruit relationship that is both biologically realistic and that will stabilize the model.

References

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Appendix A

MSC Assessment Tree			Pacific Sardine
			Purse seine
Principle	**Component**	**Performance Indicator**	**All**
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	