Pacific Sardine

Sardinops sagax

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US Pacific and Canada Pacific

Purse Seine

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Final Seafood Recommendation

The Pacific sardine (*Sardinops sagax*) is a pelagic schooling finfish with stocks in the subtropical and temperate waters of the Pacific and Indian Oceans and in the Atlantic off of South Africa. The California Current population ranges from the Gulf of California to southeastern Alaska. This report will focus on the United States (US) Pacific and Canada Pacific purse seine fisheries.

Stock	**Fishery**	**Impacts on the Stock** Rank (Score)	**Impacts on Other Species** Lowest scoring species Rank* (Subscore, Score)	**Manage-ment** Rank (Score)	**Habitat and Ecosystem** Rank (Score)	**Overall** Recommendation (Score)
Pacific Sardine	United States Pacific	Yellow (3.05)	Pacific Mackerel Green (4.47,4.47)	Yellow (3)	Green (3.87)	**BEST CHOICE (3.55)**
Pacific Sardine	Canada Pacific	Yellow (3.05)	Pacific Mackerel Green (4.47,4.47)	Yellow (3)	Green (3.87)	**BEST CHOICE (3.55)**

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Executive Summary

The Pacific sardine (*Sardinops sagax*) is a pelagic schooling finfish with stocks in the subtropical and temperate waters of the Pacific and Indian Oceans and in the Atlantic off of South Africa. The California Current population ranges from the Gulf of California to southeastern Alaska. This report will focus on the United States (US) Pacific and Canada Pacific purse seine fisheries.

Since 2000, annual stock assessments show that the US landings of Pacific sardine have remained below the harvest guidelines (HG) set forth by the PFMC (with the exception of 2009), and Canada Pacific landings have remained below the total allowable catch (TAC) since reopening in 2002. However, coast-wide harvest (US, Canada and Mexico) has exceeded coast-wide HG in 6 of the 12 years since 2000. Biomass has remained well above the lowest level of estimated biomass at which the PFMC allows harvest. This fishery is vulnerable to natural fluctuations in populations due to changes in sea surface temperature; when combined with fishing pressure, changes in oceanic conditions have the potential to cause steep declines in the Pacific sardine stocks even if current best management practices are followed.

The Pacific sardine fishery has both incidental catch (retained and sold) and bycatch (discarded) species, but the rate of discards of non-target species is very low (less than 1% of total landings). Though the Pacific sardine fishery does not have significant impacts on the biomass of any incidental or bycatch species, this assessment addresses the impact on Pacific mackerel (*Scomber japonicus*), which are captured and retained in the fishery. Pacific Mackerel is not considered overfished or experiencing overfishing. Other species are intercepted by the Pacific sardine fishery at such low rates that they are not considered to be substantially impacted by the fishery and are not addressed in this assessment.

The Pacific sardine stock assessment uses fishery-dependent data (e.g. landings and biological samples) and fishery-independent data (e.g. trawls and aerial surveys) to conduct annual assessments. Recent literature questions the management strategy of the US and Canadian Pacific sardine fisheries in regards to appropriateness of harvest rates and use of a temperature-recruitment relationship to determine exploitation rates. Although management in both the US and Canada works to use the best available science to manage the fishery, the harvest control rule that is currently used does not yet reflect the findings of this literature. Additionally, there is a lack of an international agreement among the US, Canada, and Mexico to require the coordination of resource allocation to ensure that coast-wide HGs are not exceeded. Though management has enacted measures to maintain long-term stock abundance, the cyclical nature of this fishery, a current decline in biomass, and scientific literature that questions management leaves uncertainty as to the effectiveness of these measures.

Pacific sardine fisheries use purse seines, which target schools of fish and do not touch the seafloor. Because this type of fishing gear does not touch the sea floor, the Pacific sardine fishery does not have a significant impact on the substrate or need to mitigate gear impacts. The Pacific sardine is considered a forage fish, which is defined in terms of its functional role in providing a critically important route for energy transfer from plankton to higher trophic levels in marine ecosystems. Reduction in forage fish biomass can change the functioning of entire ecosystems. Management maintains a minimum biomass to allow for a forage reserve, and to provide a maximum catch to maintain a higher average biomass, a more stable, smaller average yield, and to prevent overcapitalization of the fleet. However, the Pacific sardine is currently managed as a single species and several scientific sources question the appropriateness of Pacific sardine harvest in consideration of ecosystem impacts; the findings of a recent comprehensive review of forage fish science and management suggest fishing pressure should be reduced. Management in the US recognizes the significance of the Pacific sardine as a forage fish and as part of the California Current ecosystem and, in February 2013, the PFMC published a public draft review of the fishery ecosystem plan for the California Current (PFMC 2013).

Introduction

Scope of the analysis and ensuing recommendation

The Pacific sardine (*Sardinops sagax*) is a pelagic schooling finfish with stocks in the subtropical and temperate waters of the Pacific and Indian Oceans and in the Atlantic off of South Africa. The California Current population ranges from the Gulf of California to southeastern Alaska. This report will focus on the United States (US) Pacific and Canada Pacific purse seine fisheries.

Species Overview

Overview of the species and management bodies
Pacific sardines are an important forage species in the California Current (Pikitch et al. 2012). In the US, the Pacific Fishery Management Council (PFMC)—created pursuant to the Magnuson-Stevens Fishery Conservation and Management Act—manages the Pacific sardine fishery under the Coastal Pelagic Species Fishery Management Plan (CPS FMP), with cooperation from the National Marine Fisheries Service (NMFS) Northwest Fisheries Science Center (NWFSC) and Southwest Fisheries Science Center (SWFSC), California Department of Fish and Wildlife (CDFW) (formerly Fish and Game, CDFG; referred to as both in this report), Oregon Department of Fish and Wildlife, and Washington Department of Fish and Wildlife. Fisheries and Oceans Canada (DFO) manages the Canadian fishery. The US and Canada have a collaborative strategy that includes sharing research findings and integrating the best available science. The NMFS's SWFSC is responsible for annual stock assessments (PFMC 2011a), which are used by DFO after peer-review by the Center for Science Advice Pacific (CSAP) to determine the annual harvest yield in Canada (DFO 2011a). Though collaboration between the US and Canada strengthens the Pacific sardine stock assessments, the two countries do not have an international agreement to require the coordination of resource allocation (SWFSC 2012).

Prior to PFMC management of CPS along the US West Coast, individual states regulated the Pacific sardine fishery. Scientific investigations of the fishery began in 1918 by the CDFG, followed by the Fishery Research Board of Canada in the late 1920s, and then in 1937 by the Bureau of Commercial Fisheries and the states of Oregon and Washington. Research was expanded in 1949 by the creation of the California Cooperative Oceanic Fisheries Investigations (CalCOFI), a cooperative effort of government and research institutes. Prior to 1942, legal regulations were restricted to fishing gear requirements, seasonality of fishing, and limits on quantities of sardines that could be used for reduction, but not on landings. In 1942, legal restrictions were placed on reduction because of the controversy between canners and conservationists; canners saw greater profits from reduction than selling whole fish and therefore wanted to divert plants to reduction, and conservationists wanted to see fresh sardine catch used for human consumption (Ahlstrom & Radovich 1970).
In 1978, the PFMC approved and submitted the final draft of the FMP for northern anchovy. In 1998, the Council expanded the scope to include all coastal pelagic species (CPS) and adopted the Coastal Pelagic Species Fishery Management Plan (CPS FMP) (PFMC 2011d). The CPS FMP

was implemented by the NMFS in 2000 (PFMC 1998; PFMC 2011d; CDFG 2001). In addition to Pacific sardine, CPS managed in this plan include Pacific mackerel (*Scomber japonicus*), jack mackerel (*Trachurus symmetricus*), northern anchovy (*Engraulis mordax*), market squid (*Loligo opalescens*) and krill (*euphausiid spp*.). Through Amendment 13 to the CPS FMP, Pacific herring (*Clupea pallasii pallasii*) and jacksmelt (*Atherinopsis californiensis*) were added as ecosystem component species in the assessments (PFMC 2011c).

The PFMC considers the Pacific Sardine Resource from central Baja California to British Columbia as a single stock, but assesses landings from four commercial fisheries in its annual stock assessment: Ensenada (Mexico), Southern California (San Pedro to Santa Barbara), Central California (Monterey Bay region), and the Pacific Northwest (Oregon, Washington, and British Columbia) (Hill et. al. 2010). This is a recent change; previously, Pacific sardine was considered to have two distinct stocks: northern (Pacific Northwest) and southern (California/Mexico) (Radovich 1982). When management began in the US, the initial harvest allocation was divided into two subareas, which were designed to maintain balance between the Southern California and the Monterey fisheries. As the sardine population expanded north, need for a new allocation formula within the US became evident and a long-term, seasonal allocation framework was adopted in 2005 as Amendment 11 to the CPS FMP. The amendment divided the harvest into three time periods when a percentage of harvest is allocated coast wide (PFMC 2005).

Pacific sardine have long been considered vulnerable to population decline due to natural oceanic conditions. The PFMC and DFO manage for cyclical fluctuations in abundance that correlates with sea surface temperature. Pacific sardines historically experience “boom and bust” periods on a time scale of approximately 60 years, with average collapse and recovery time of approximately 30 years (Baumgartner et al. 1992). Management has correlated sardine biomass to the Pacific decadal oscillation (PDO), which had similar periods from 1920 to 2010 (40-76 years for the PDO and 40-70 years for Pacific sardine biomass). From this, managers have used the PDO, or more specifically, SST taken from the Scripps Institute of Oceanography in San Diego to help determine harvest guidelines (HG), or fishing quota, each year (McClatchie 2012; PFMC 1998; PFMC 2011a; see Criterion 1.3 for more details).

McClatchie (2012) used a 370-year record of paleoclimatic proxies (as opposed to the 90-year record previously used) and found that the PDO is not significantly correlated with Pacific sardine biomass off California. This suggests that the temperature/recruitment relationship used to determine exploitation rate does not accurately represent the factors that drive the cyclical nature of the fishery and a more up-to-date environmental index is needed to account for the influence of natural variability on sardine stocks (McClatchie 2012; McClatchie et al. 2010). This has created the need for management to reassess its harvest control rule (HCR); the US began this process in its 2011 stock assessment and fishery evaluation by evaluating the HCR in the absence of an environmental covariate (Hill et al. 2011). Additionally, the PFMC’s Coastal Pelagic Species Management Team held a workshop in February 2013 to review the current Pacific sardine HCR (PFMC 2012c).

Under current US management, each state maintains a critical role in the fishery by providing fishery-dependent data and enforcement. In 2011, the PFMC reported that the CPS limited entry fishery in California had 65 permits and 58 vessels (PFMC 2011c). In 2010, Oregon had 20 limited entry sardine permit vessels that reported landings, while Washington distributed 18 limited entry licenses (PFMC 2011b).

The DFO utilizes an annual integrated fisheries management plan. The Sardine Integrated Advisory Board (SIAB) is the primary consultative body for DFO and reviews the annual management plan. This advisory board includes members from the commercial fishery, processing sector, environmental groups and the recreational fishery. The annual harvest is divided up evenly among 50 total licenses: 25 commercial and 25 communal commercial (communal are issued to First Nations organizations) (DFO 2011a). This fishery is dependent on the migration rate of sardines into Canadian waters (Flostrand et al. 2011). The DFO policy is to adopt the US harvest rate in any given year and apply this to the percentage of the stock that migrates into the area (DFO 2011a). The DFO determines this percentage by averaging the most recent three years of their annual trawl surveys and catch data (DFO 2011a). Governance for the Canadian fishery includes the *Fisheries Act*, the *Pacific Fishery Management Area Regulations*, *Fishery (General) Regulations* and the *Pacific Fishery Regulations*, the *Oceans Act*, and *The Species At Risk Act*.

History of the Fishery

The Pacific sardine fishery began in the early 1900s along the West Coast and remained the largest fishery in California until its coast-wide decline and eventual collapse in the 1940s (Murphy 1966; Ahlstrom and Radovich 1970). Fishing effort and landings grew with demand and peaked at over 700,000 mt in 1936 (CDFG 2001).

The historical decline of the Pacific sardine has been attributed to several factors: unfavorable oceanic conditions leading to a natural decrease in productivity; the failure of fisheries management to respond to this decrease in productivity, which hastened and exacerbated the fishery's collapse; and competition with other CPS (Ahlstrom & Radovich 1970; Murphy 1966; Zwolinski & Demer 2012). Decadal environmental cycles influence Pacific sardine abundance (Baumgartner et al. 1992) and unfavorable oceanic conditions in the 1940s, such as low sea surface temperatures, have been connected to the poor survival of several year classes (Murphy 1966). Overfishing removed highly productive, older fish, which caused a decline in the resilience of the sardine population and led to the collapse of what was then considered the northern stock (Murphy 1966). Lastly, other CPS fish compete with the Pacific sardine and experience increases in abundance during periods when oceanic conditions decrease sardine biomass (Zwolinski & Demer 2012). During this period of sardine decline, anchovy began to increase in abundance, filling the niche sardine left behind (Ahlstrom & Radovich 1970). With the increased abundance of anchovy, it was uncertain if the sardine population would be able to recover (Murphy 1966).

The fishery faced its first closure in the Canadian Pacific in 1947. Closures continued down the coast, and in 1967 the California Legislature imposed a moratorium on landings (Radovich

1982). California stocks began to recover in the mid/late 1970s to early 1980s with the return of a warm oceanic cycle. From 1981 through 1985, California had an incidental sardine fishery in which landings of sardine were recorded when caught with jack mackerel or Pacific mackerel (Hill et al. 2011), and in 1986 the directed fishery in California was reopened (Wolf 1992). As the population recovered, sardines began to migrate north to spawn and feed (Emmett et al. 2005). Oregon reopened its fishery in 1999 (ODFW 2011) and Washington in 2000 (WDFW 2011). The DFO began a limited experimental harvest in 1996 and moved to commercial harvest in 2002 when Pacific sardines were delisted as a species of special concern (DFO 2011a).

Production statistics

After the Pacific sardine population increased in the 1990s, the US fishery was declared rebuilt in 1999 and US landings increased to an average of 83,493 metric tons (mt) from 2000 to 2010 (NMFS 2012a). Commercial landings peaked in California in 2007 (80,958 mt), in Oregon in 2005 (45,110 mt), and in Washington in 2002 (15,832 mt), and coast-wide landings peaked in 2007 (126,463 mt) (NMFS 2012a) (Figure 1 and Table 1). The Canadian fishery has historically landed between 1,500 and 4,000 mt, though a large increase in harvest occurred in 2008-2010, with 10,435 mt landed in 2008, 15,334 mt in 2009, and 22,223 mt in 2010 (DFO 2011a; DFO 2011b; DFO 2012a) (Figure 2 and Table 1).

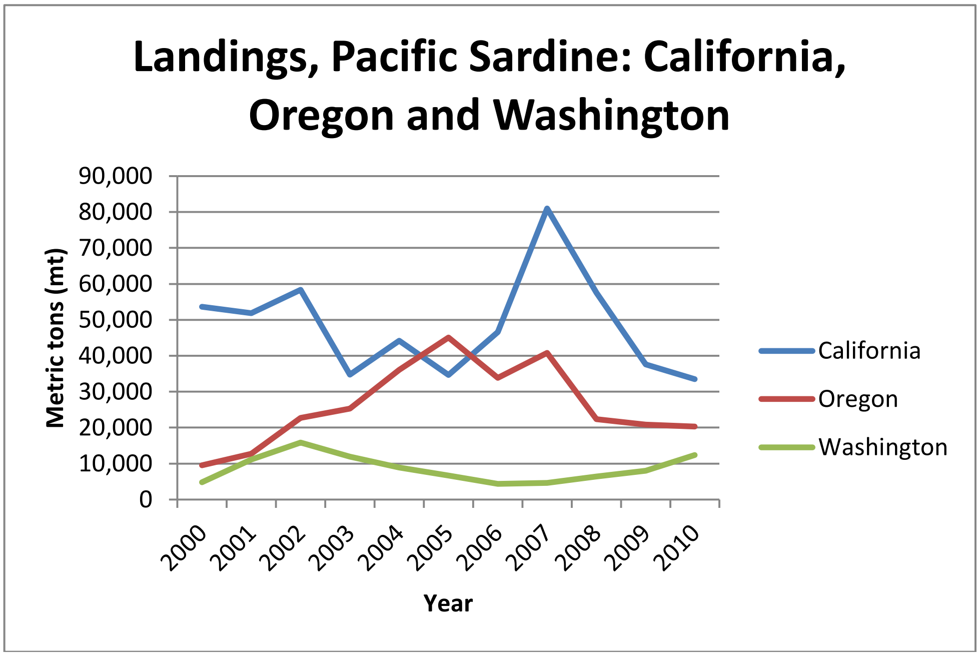

Figure 1: Annual landings in California, Oregon and Washington. Data from NOAA 2012

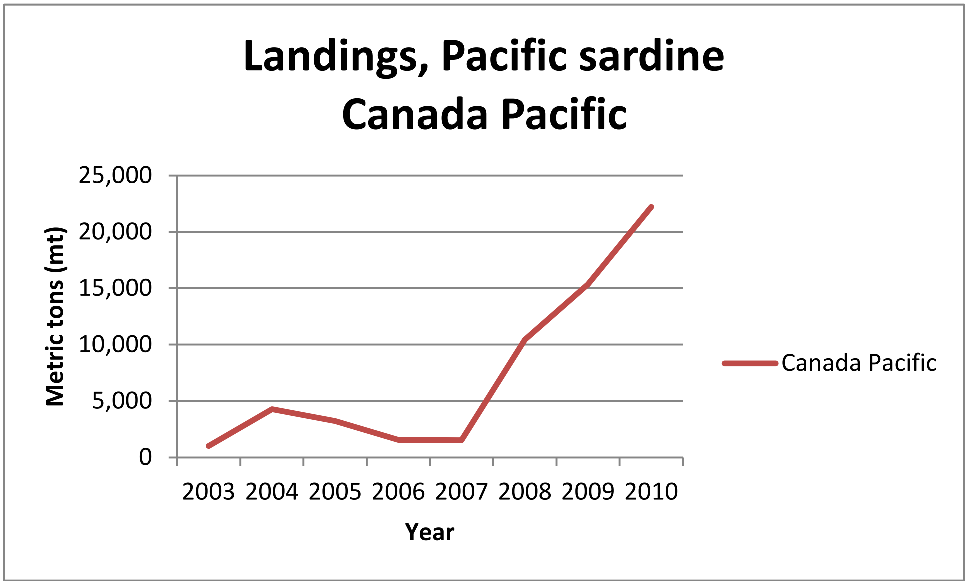

Figure 2: Annual landings in Canada Pacific. Data from DFO 2012a

Calendar year	ENS	SCA	CCA	OR	WA	BC	Total
2000	67,845	46,835	11,367	9,529	4,765	1,721	142,063
2001	46,071	47,662	7,241	12,780	10,837	1,266	125,857
2002	46,845	49,366	14,078	22,711	15,212	739	148,952
2003	41,342	30,289	7,448	25,258	11,604	978	116,919
2004	41,897	32,393	15,308	36,112	8,799	4,438	138,948
2005	55,323	30,253	7,940	45,008	6,929	3,232	148,684
2006	57,237	33,286	17,743	35,648	4,099	1,575	149,588
2007	36,847	46,199	34,782	42,052	4,663	1,522	166,065
2008	66,866	31,089	26,711	22,940	6,435	10,425	164,466
2009	55,911	12,561	25,015	21,482	8,025	15,334	138,328
2010	56,821	29,352	4,306	20,852	12,381	22,223	145,935
2011	70,336	17,642	10,072	11,023	8,008	20,719	137,801

Table 1: Annual landings coast-wide. Data from Hill et al. 2012

Importance to the US/North American market

The Pacific sardine is a forage fish that has an ecosystem role of transferring energy from plankton to upper trophic-level predators (Pikitch et al. 2012). Forage fish have large economic value and contribute to approximately 37% of global marine catch (of which Pacific sardines are a very small component). These species are mostly valued for reduction and processing, with 90% of the catch made into fish oil and fishmeal for human consumption (in small part), agriculture, aquaculture and industrial purposes (Alder et al. 2008). US-caught Pacific sardines are no longer used for reduction; most Pacific sardines captured in the US fishery are frozen and exported, in part, for use as bait in longline tuna fisheries. From 2002 to 2009, exports as a percentage of total landings increased from 60% (2002) to 90% (2009) (PFMC 2011a). Small, but increasing, amounts of sardine are canned or sold fresh for human consumption. Because most sardines caught in the US fishery are exported, the majority of sardines consumed in the US are either caught by foreign fisheries or processed by foreign countries (see below).

From 2009 to 2010, the top countries (in order by weight) to which sardines were exported included: Japan, Australia, and Thailand (receive fresh fish); Thailand, Japan, Nauru and Australia (receive frozen); and China, Sri Lanka and Japan (receive a small quantity prepared). Some of the exported sardines are processed and then imported back into the US. Multiple species of sardines are imported from a variety of nations; a large majority (95%) of these imports are processed, while 5% are fresh or frozen. From 2005 to 2010, US imports came from Canada, Thailand, Morocco, Poland, Ecuador, Mexico, the Philippines, China, and Portugal (NOAA 2012). Top US imports for 2011, totaling 31,454 mt, are shown in Figure 3.

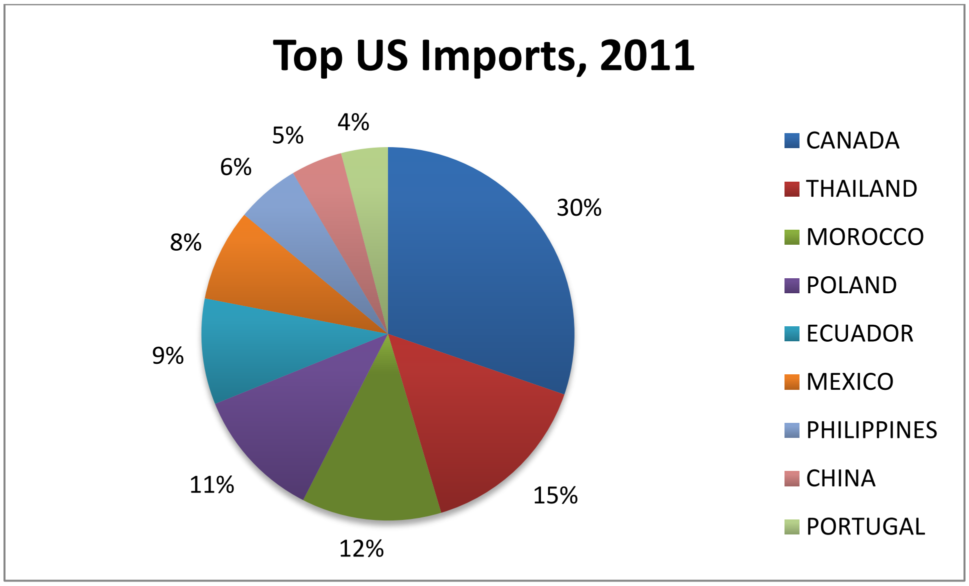

Figure 3: Top US Imports for 2011, by percent. Source NOAA 2012

The major markets for Canadian sardines are Asia, the US, the Russian Federation, and the Ukraine. A majority of sardines are sold to Asian countries, where they are used as bait for the longline tuna fishery. The Russian Federation and the Ukraine provide an emerging higher value small food market (DFO 2012a). Canada combines herring and sardine in its exports and imports data. From 2007 to 2011, Canadian exports were 316,096 mt, and imports were 27,118 mt (DFO 2012a).

Common and market names
Common: California sardine, Chilean sardine, Pacific American sardine, Pacific sardine, pilchard
Market: pilchard, sardine (Fishbase 2012)

Primary product forms
Domestic: Frozen, fresh, prepared/preserved

Exports: Frozen, fresh, prepared/preserved
Imports: Frozen, fresh, canned and smoked with and without being skinned and boned (NOAA 2012)

Analysis

Scoring guide

- All scores result in a zero to five final score for the criterion and the overall final rank. A zero score indicates poor performance, while a score of five indicates high performance.
- The full Seafood Watch Fisheries Criteria that the following scores relate to are available on our website at www.seafoodwatch.org.

Criterion 1: Stock for which you want a recommendation

Guiding principles

- The stock is healthy and abundant. Abundance, size, sex, age and genetic structure should be maintained at levels that do not impair the long-term productivity of the stock or fulfillment of its role in the ecosystem and food web.
- Fishing mortality does not threaten populations or impede the ecological role of any marine life. Fishing mortality should be appropriate given current abundance and inherent resilience to fishing while accounting for scientific uncertainty, management uncertainty, and non-fishery impacts such as habitat degradation.

Stock	**Fishery**	**Inherent Vulnerability** Rank	**Stock Status** Rank (Score)	**Fishing Mortality** Rank (Score)	**Criterion 1** Rank (Score)
Pacific Sardine	United States Pacific	Medium	Low Concern (4)	Moderate Concern (2.33)	Yellow (3.05)
Pacific Sardine	Canada Pacific	Medium	Low Concern (4)	Moderate Concern (2.33)	Yellow (3.05)

Factor 1.1 Inherent Resilience: Medium

Key relevant information:
FishBase vulnerability score is 33. For this reason, sardines inherent resilience is deemed 'medium' (Cheung et al. 2005).

Factor 1.2 Stock Status: Low Concern

Key relevant information:
Over the past decade, Pacific sardine biomass has remained well above the lowest level of estimated biomass at which the PFMC allows harvest, which is 150,000 mt (PFMC 2011a). As was discussed in the introduction, this fishery has long been understood to be vulnerable to natural fluctuations in populations due to changes in sea surface temperature (Baumgartner et al. 1992). Though this vulnerability is independent of fishing pressure, when combined, fishing and natural changes in oceanic conditions have the potential to cause steep declines in the Pacific sardine stocks, even if current best management practices are followed. Biomass is believed to be above the level at which recruitment would be impaired, although recent literature calls into question appropriateness of management's use of the PDO as a parameter in its HG (McClatchie 2012), and it has been suggested that the stock may be below a critical threshold value making it vulnerable to collapse (Zwolinski & Demer 2012). Though controversial, Zwolinski and Demer (2012) suggest this threshold level may be 750,000 mt, based on the historical pattern of collapse; but, see rebuttal by MacCall et al. (2012).

Detailed rationale (optional):
The recovery of the stock from the 1940s collapse began in the late 1970s to early 1980s (Hill et al. 2011). Since 2000, spawning stock biomass (SSB) (ages 2+) peaked in 2007 at 1,047,250 mt, and the most recent assessment estimates a decline in SSB to 435,351 mt (Hill et al. 2012) (Figure 4). Historically, the Pacific sardine population has a boom-and-bust cycle of abundance on a time scale of approximately 60 years, independent of fishing pressure, with average recovery time after a collapse of approximately 30 years (Baumgartner et al. 1992). According to the methods used by Baumgartner et al. (1992), Pacific sardine biomass peaked at over 4 million mt before the collapse in the 1940s, and at over 8 million mt twice in the century prior to the collapse. Because methods used by current management differ from these historical methods, it is difficult to relate the estimates of biomass.

Zwolinski & Demer (2012) find that oceanographic conditions have shifted to a colder period in the north Pacific, that the coast-wide fishery is targeting larger, oldest, and most fecund fish, and that reproduction is poor. From this, they warn that the coast-wide fishery is in a decline and, under current management, the population is unlikely to recover. The methods used to reach these conclusions have been rebutted; MacCall et al. (2012) noted inconsistencies in the findings and asserts that by omitting available data the decline is overstated.

Figure 4: Stock biomass, sum of the biomass of Pacific sardine ages 1 and older. Data from Hill et al. 2011

Factor 1.3 Fishing Mortality: Moderate Concern

Key relevant information:
According to management standards, overfishing is not occurring (Hill et al. 2011). However, questions remain in regards to the appropriateness of the use of SST in the HCR, though management is actively working toward updating its HCR to reflect best available science (as discussed in the introduction). Additionally, potential exists for a coast-wide harvest to exceed the recommendation of the HCR due to the absence of an international agreement (between the US, Canada, and Mexico) to ensure harvest remains below the HG.

Detailed Rationale:

The Pacific sardine fishery relies on annual stock assessments and HG. The 2012 assessment for management in 2013 determines HG as follows:

$$HG_{2013}=(BIOMASS_{2012}-CUTOFF)*FRACTION*DISTRIBUTION$$

Where HG_{2013} is the total US quota for 2013, BIOMASS is the estimated stock biomass (ages 1+) from the July 1, 2012 stock assessment (659,539 mt), CUTOFF is the lowest level at which harvest is allowed (150,000 mt), FRACTION is an environmentally-based percentage of biomass above CUTOFF that can be harvested, and DISTRIBUTION is the average portion of BIOMASS that is assumed to be in the US (Hill et al. 2012). The maximum harvest (MAXCAT) is 200,000 mt. CUTOFF, FRACTION and MAXCAT were determined by comparing more than 10,000 options of combinations of variables in the HCR. Management's goal was to maximize catch and biomass while minimizing years of fishery closure; with these criteria, the optimal combination of the three was chosen (Parrish 2012; see Table 2). The maximum FRACTION in the HG varies between 5% and 15% depending on sea surface temperature; in recent years the PFMC has consistently determined 15% (ages 1+) as the appropriate fraction due to higher than average sea surface temperatures (PFMC 2011a; Hill et al. 2012). DISTRIBUTION has consistently been estimated at 87% (Hill et al. 2012)

TABLE 4.2.5-1. MSY control rule options for Pacific Sardine. All options evaluated in a stochastic model.

	Option A (Status Quo)	Option B	Option C	Option D	Option E	Option F	Option G	Option H	Option I	Option J	Option K	Option L (Stochastic F_{MSY})	Option M (Determ. Equil. F_{MSY} in a Stochastic Model)
Overfishing Definitions													
Overfishing Rate	Catch> ABC	Catch> ABC	Catch> ABC	Catch> ABC	Catch> ABC	Catch> ABC	Catch> ABC	Catch> ABC	Catch> ABC	Catch> ABC	Catch> ABC	Catch> ABC	Catch> ABC
Overfished Threshold (mt)	50	50	50	50	50	50	50	50	50	50	50	50	50
Control Rule Parameters													
FRACTION	20%	F_{MSY} (10-30%)	20%	F_{MSY} (10-30%)	F_{MSY} (10-30%)	F_{MSY} (5-25%)	F_{MSY} (5-15%)	F_{MSY} (5-15%)	F_{MSY} (5-25%)	F_{MSY} (5-15%)	F_{MSY} (10-30%)	12%	8.8%
CUTOFF	50	50	100	100	100	100	100	100	100	150	50	0	0
MAXCAT	400	400	400	400	300	400	400	300	300	200	200	Infinite	Infinite
Performance Measure													
Average Catch	151	159	165	171	165	177	179	169	169	145	141	180	170
Std. Dev. Catch	137	140	140	143	113	143	133	105	112	67	72	180	153
Mean Biomass	936	964	1,073	1,091	1,280	1,216	1,543	1,665	1,400	1,952	1,516	1,408	1,784
StdDev Biomass	27	27	29	28	34	32	39	42	37	49	43	39	43
Mean Log Catch	4.33	4.46	4.44	4.54	4.64	4.62	4.77	4.80	4.70	4.76	4.65	4.72	4.77
Mean Log Biom	6.24	6.37	6.50	6.59	6.75	6.74	7.06	7.15	6.89	7.34	6.87	6.89	7.24
Percent Years Biomass>400	61%	64%	70%	73%	79%	81%	90%	92%	84%	96%	79%	84%	93%
Percent Years No Catch	5%	2%	7%	4%	3%	2%	1%	0%	1%	0.5%	1%	0%	0%
Median Catch	103	104	119	121	148	131	140	156	158	182	188	128	127
Median Biomass	598	600	700	748	898	850	1,248	1,349	1,048	1,648	1,099	1,500	1,049

Table 2: Comparison of HCR options for Pacific sardine. (PFMC 1998)

The US and Canada determine distribution independently. In 1999 and 2001, Canada estimated a 10% migration rate of sardine into Canadian waters. In 2009, this estimate was updated to 18.3% (DFO 2012a). While this report does not include management in Mexico, it is important to note that sardines from northern Baja to Canada are considered a single stock. DISTRIBUTION for Canada and the US currently exceeds 100% (US 87% and Canada 18.3%), without inclusion of landings in Mexico. Additionally, no international agreements exist to ensure that coast-wide HGs are met. Since 2000, coast-wide landings have exceeded coast-wide HG (calculated as the US HG as determined by US management, divided by the DISTRIBUTION parameter of 0.87 to give a coast-wide HG) six of the twelve years, including the most recent four years (Figure 5) (Hill et al. 2012). This does not necessarily indicate that overfishing is occurring, or that either the US or Canada is failing to stay within their country's HGs; this indicates that the US, Canada, and Mexico are not collaborating to ensure landings do not exceed coast-wide HG. Since 2000, US and Canadian landings have remained below their respective HG in nearly all years (US landings slightly exceeded HG in 2009; Figure 6 and Table 3; Hill 2012.

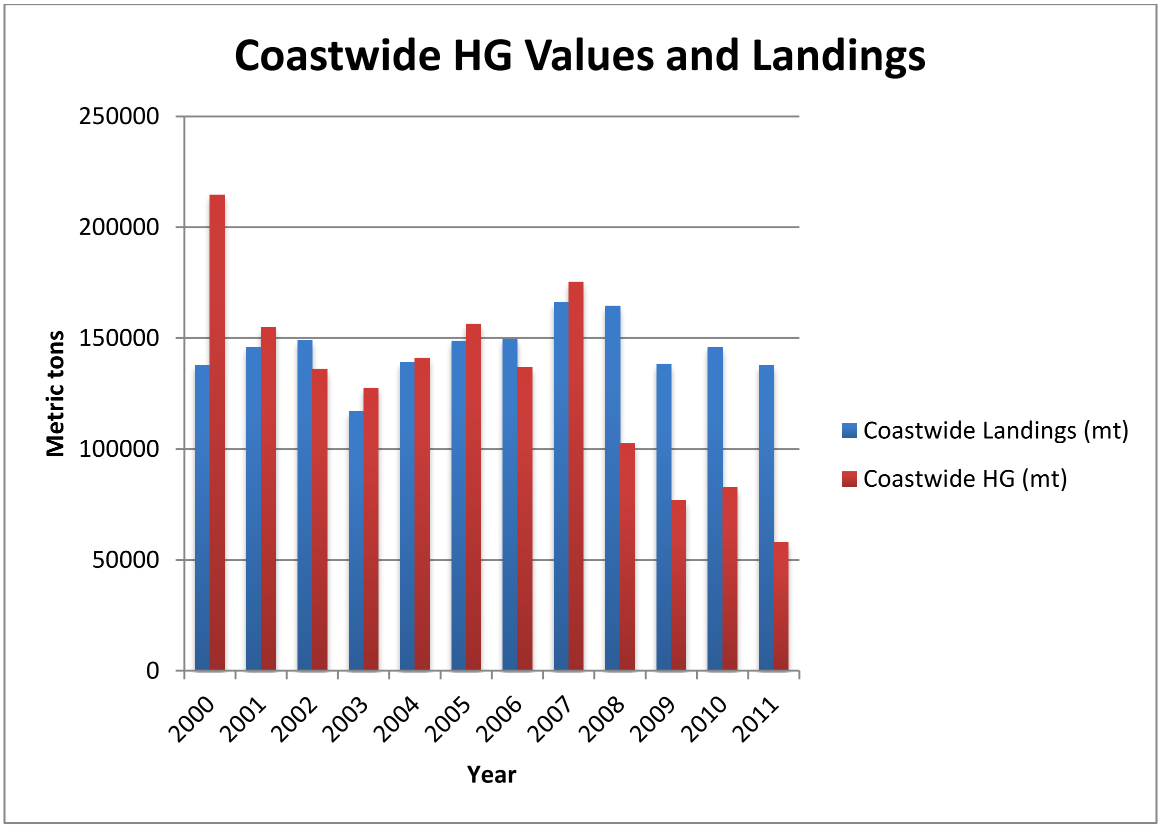

Figure 5: Coast-wide landings and HG values. Data from Hill et al. 2012

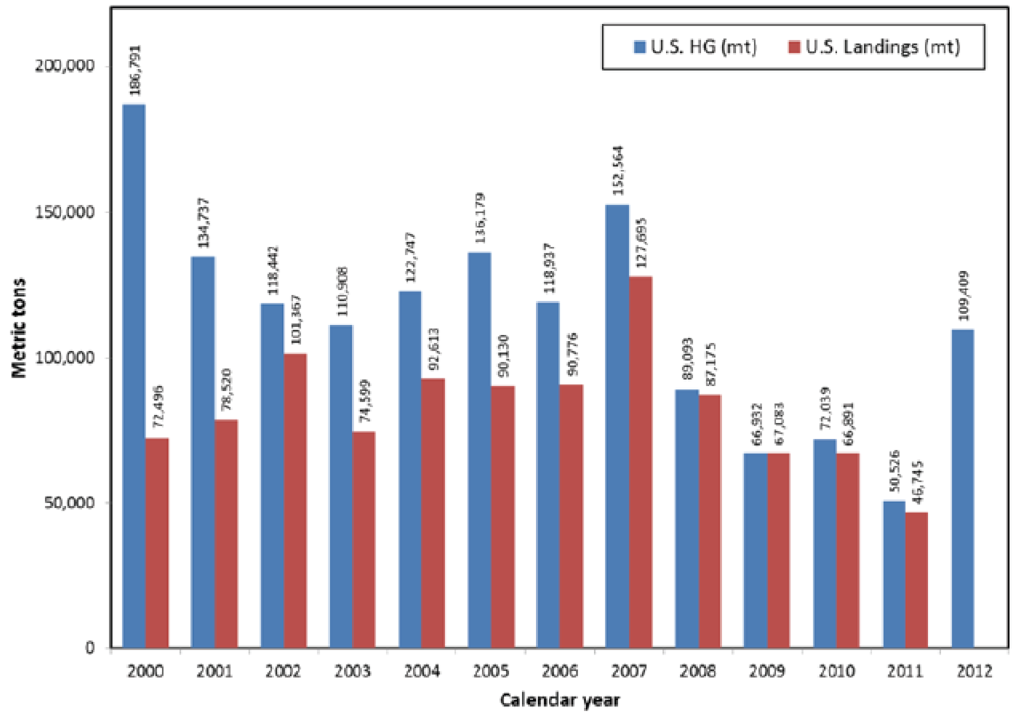

Figure 6: Performance of Pacific sardine fishery in the US from 2000-2011. 2012 landings were not available at the time this document was published. Data from Hill et al. 2012

In the Pacific sardine fishery, overfishing is determined by landings relative to the overfishing limit (OFL). The OFL is determined by biomass (ages 1+) multiplied by fishery maximum sustainable yield (F_{msy}) and DISTRIBUTION (Hill et al. 2011). F_{msy} is based on the maximum long-term average yield that occurs at an annual harvest rate of 18% (Hill et al. 2012). In order to account for scientific uncertainty, the allowable biological catch (ABC) differs from OFL.It is reduced by a buffer in order to ensure no more than a 40% chance of overshooting OFL (P* equal to 0.40), and the ABC is set at 91.3% of OFL (Federal Register 2011, Hill et al. 2011). Coast-wide total landings exceeded the coast-wide OFL in 2004 (Figure 7; Hill 2012). In addition, the 2010 stock assessment reported coast-wide landings in excess of coast-wide OFL in 2009 (although management did not classify the fishery as experiencing overfishing as a result) (Table 3; Hill et al. 2010); however, in the current assessment, biomass estimates for 2009 have been revised upward substantially, such that viewed retrospectively, this would no longer be the case (Hill et al. 2012). Apart from these exceptions, harvest has not exceeded OFLs in the past decade.

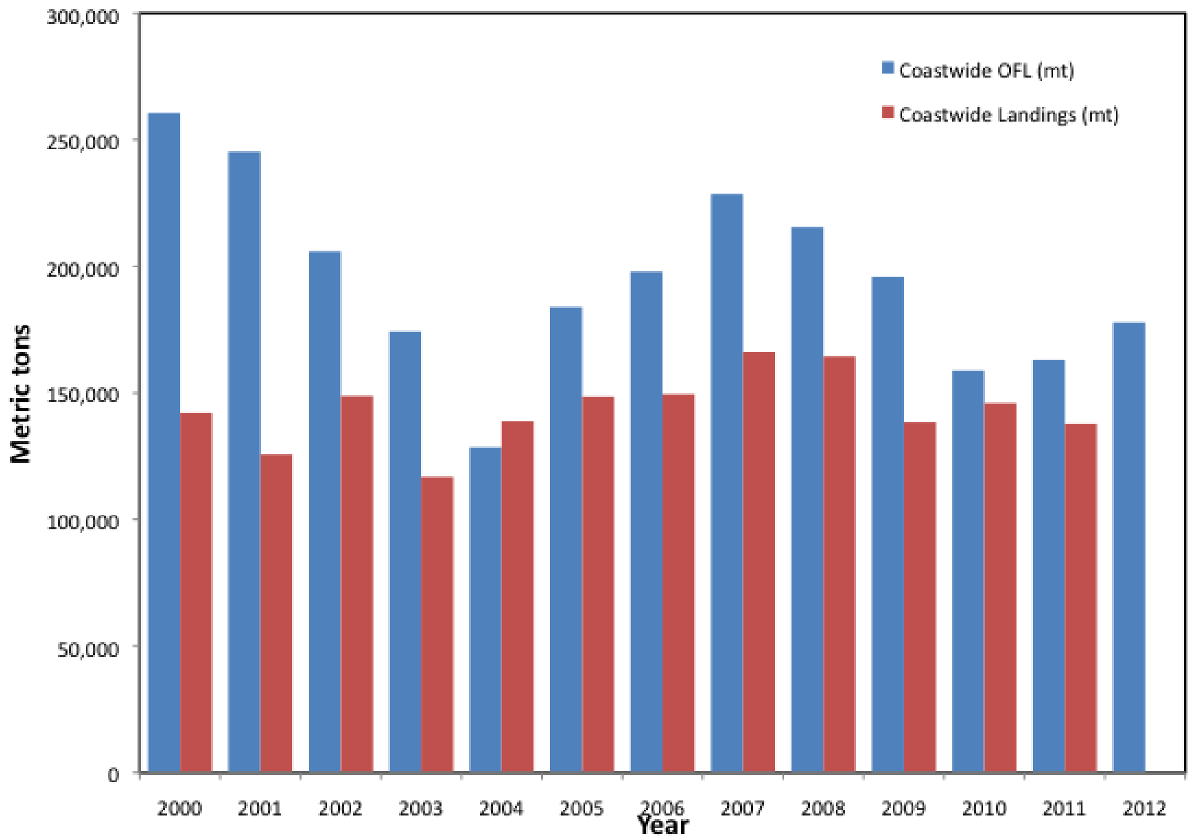

Figure 7: Coast-wide landings (Ensenada to British Columbia) and overfishing limits (OFL). Source Hill et al. 2012

Year	US OFL	US HG	US Landings	Total OFL	Total Landings
2000	273,907	186,791	72,496	314,835	142,063
2001	204,816	134,737	78,520	235,421	125,857
2002	149,585	118,442	101,367	171,937	148,951
2003	165,826	110,908	74,599	190,604	116,918
2004	188,902	122,747	92,613	217,129	138,948
2005	206,730	136,179	90,130	237,621	148,684
2006	183,845	118,937	90,776	211,316	149,588
2007	228,478	152,564	127,695	262,618	166,065
2008	144,234	89,093	87,175	165,786	164,466
2009	114,820	66,932	67,084	131,976	138,775
2010	121,598	72,039	63,066	139,768	------

Table 3. OFL and Landings, 2000-2010. Data from Hill 2010

Fishing mortality of Pacific sardine also occurs in other fisheries, as CPS are often landed together. In order to reduce bycatch, management allows CPS fishers to land and sell non-targeted CPS species (PFMC 1998; WDFW 2011). Each year, the PFMC sets limits for incidental catch. All landings of Pacific sardines in other CPS fisheries are recorded in logbooks and included in overall landings for Pacific sardine. From 2007 to 2010, incidental catch of sardines in other CPS fisheries totaled less than 10% of landed weight of those fisheries (PFMC 2011b).

Scientific literature raises uncertainty over whether fishing mortality parameters account appropriately for environmental influences on sardine recruitment. As mentioned in the introduction and again under Factor 1.2, recent analysis suggests that the temperature-recruitment relationship used to determine exploitation rate does not accurately represent the factors that drive the cyclical nature of the fishery and a more up-to-date environmental index is needed to account for the influence of natural variability on sardine stocks (McClatchie et al. 2010). The PFMC's Coastal Pelagic Species Management Team held a workshop in February 2013 to review the current Pacific sardine HCR in response to this research (PFMC 2012c).

Fishing mortality is a moderate concern because of this scientific debate and management's continued efforts to determine the best way to include McClatchie et al.'s findings—the concern that fishing mortality is too high in an ecosystem context given the importance of sardines as a forage fish (discussed further under Criterion 4.3), and the potential for coast-wide landings to exceed the coast-wide OFL.

Criterion 2: Impacts on other retained and bycatch stocks

Guiding principles

- The fishery minimizes bycatch. Seafood Watch® defines bycatch as all fisheries-related mortality or injury other than the retained catch. Examples include discards, endangered or threatened species catch, pre-catch mortality and ghost fishing. All discards, including those released alive, are considered bycatch unless there is valid scientific evidence of high post-release survival and there is no documented evidence of negative impacts at the population level.

- Fishing mortality does not threaten populations or impede the ecological role of any marine life. Fishing mortality should be appropriate given each impacted species' abundance and productivity, accounting for scientific uncertainty, management uncertainty and non-fishery impacts such as habitat degradation.

US and Canada Pacific:

Stock	**Inherent Vulnerability** Rank	**Stock Status** Rank (Score)	**Fishing Mortality** Rank (Score)	**Subscore**	**Score** (subscore*discard modifier)	**Rank** (based on subscore)
Pacific Mackerel	Medium	Low Concern (4)	Very Low Concern (5)	4.47	4.47	Green

Synthesis

The Pacific sardine fishery has both incidental catch (retained and sold) and bycatch (discarded) species, but the rate of discards of non-target species is very low (less than 1% of total landings). Though the Pacific sardine fishery does not have significant impacts on the biomass of any incidental or bycatch species, this assessment addresses the impact on Pacific mackerel (*Scomber japonicus*), which are retained in the fishery. Pacific mackerel is included in this report because management allows incidental catch with the Pacific sardine fishery. Pacific Mackerel has moderate resilience and is not considered overfished.

Chinook, coho, and sockeye salmon may interact with the Oregon, Washington, and Canadian Pacific fishery. However, rates of salmon bycatch are very low, such that it is not considered a conservation concern despite the depleted status of many salmon runs. In the US in 2010, bycatch of salmon was 0.0098 salmon per mt of sardine, and 59% of salmon caught were released alive (PFMC 2011b). A NMFS biological opinion issued in 2005 to evaluate the impact of the sardine fishery on threatened salmon populations estimated that the surrogate harvest rate of each threatened salmon ESU taken in the sardine fishery was substantially below 1% of the returning spawning biomass. It was determined that these rates of bycatch do not jeopardize the continued existence of the threatened ESUs (PFMC 2005). In Canada, because of the small scale of the fishery and low rates of salmon interactions (8% of bycatch by number, or 2.5% of bycatch by weight, with total bycatch amounting to only 0.26% by weight of targeted landings) (Schweigert and McFarlane 2001, Hrabok et al. 2007), salmon bycatch remains extremely low. Additionally, Oregon, Washington, and Canada each actively manage to prevent salmon bycatch mortality. PFMC reporting requirements are in place to minimize the interaction with listed salmonid stocks (PFMC 2011c); all salmonids must be recorded in fishing logs and must be released when caught (ODFW 2011). In Washington, fishermen must release salmon from purse seine nets using a dip-net before hauling in the set, and management may rescind a permit or close the fishery based on a mortality rate of greater than one Chinook salmon per 20 mt of sardine (Culver and Henry 2009). In Oregon, grates are required over the intake of the hold to sort out larger fish—including salmon (PFMC 2009c). Retention of salmon is prohibited in both states (PFMC 2005). In Canada, management measures used in recent years to constrain bycatch of Chinook on the west coast of Vancouver Island include temporary closures in the areas of concern (where interactions with Chinook salmon are most likely) during the salmon migration season, mandatory 100% observer coverage in the areas of concern (reduced as of 2012; see section 3.1) (DFO 2009; DFO 2010; DFO 2012d), and more recently, the use of excluders (DFO 2012d). These measures appear to be effective at constraining bycatch of salmon, particularly Chinook bycatch, which has remained low even as the fishery has expanded (DFO 2010). As a result of extremely low rates of bycatch and measures that allow live release of salmon, these species are not considered a conservation concern in this fishery and are not addressed further in this assessment.

Several other non-target species have been recorded on fish landing receipts and during a pilot observer program, as reported by the PFMC (2008). These species include smelt, surf perch, turbot, white croaker, yellowfin croaker, Pacific herring, American shad, Pacific hake, Pacific sanddab, dover sole and sablefish. Catch and landings of non-target species are also recorded along with sardine catch in logbooks for DFO (DFO 2012d). These species have a very low rate of bycatch (less than 1%) (PFMC 2008) and, thus, are not included in this assessment. These records also show that, on occasion, marine mammal and seabirds, which includes California sea lion, harbor seal, and unidentified gulls, are caught in purse seines (PFMC 2011a). Still, marine mammals and seabirds are not included in this assessment because these species are not considered threatened or endangered and are released alive from the nets (PFMC 2011a).

While bycatch is low, it is important to note that the Pacific sardine is a forage species that has a functional role in providing a critically important route for energy transfer from plankton to higher trophic levels in marine ecosystems. Predators rely on this resource and can be greatly impacted when populations decline (Pikitch et al. 2012). This issue is included in this analysis and discussed in greater detail under Criterion 4.

Pacific Mackerel

Factor 2.1 Inherent Resilience: Medium

Key relevant information:
FishBase Vulnerability Score = 46 (Cheung et al. 2005) = medium resilience

Factor 2.2 Stock Status: Low Concern

Key relevant information:
Pacific mackerel is actively managed by the PFMC. As with Pacific sardine, Pacific mackerel biomass is impacted by oceanic conditions and can experience drastic fluctuations. From the mid 1980s to the early 2000s, biomass declined from a total stock biomass of over 1,300,000 mt to 90,622 mt in 2002. The PFMC attributes this decline to unfavorable oceanic conditions and not to fishing pressure. Since this decline, biomass has increased and the latest stock assessment (2011) for Pacific mackerel estimated biomass at 211,126 mt (ages 1+) (Crone et al. 2011). Pacific mackerel is not considered overfished by management in the US (Crone et al. 2011, NMFS 2012b, NMFS 2012c). However, there is some uncertainty with the stock assessment, particularly because there is no fishery-independent index of abundance that reflects the status of the stock throughout its range (Crone et al. 2011).

Factor 2.3 Fishing Mortality: Very Low Concern

Key relevant information:
Fishery maximum sustainable yield (F_{msy}) is currently 30%. From 2001 to 2010 the HG ranged from 10,000 mt to over 70,000 mt. The fishery has not fully utilized the HG, with a rough average yield during this time period of only 5,000 mt (Crone et al. 2011). For 2011-2012 the HG was set at 40,514 mt.

Factor 2.4 Overall Discard Rate: 0%–20%

Key relevant information:
The discard of non-target species in comparison to landings of target species ratio is less than 1% (PFMC 2011b).

Criterion 3: Management effectiveness

Guiding principle

- The fishery is managed to sustain the long-term productivity of all impacted species. Management should be appropriate for the inherent resilience of affected marine life and should incorporate data sufficient to assess the affected species and manage fishing mortality to ensure little risk of depletion. Measures should be implemented and enforced to ensure that fishery mortality does not threaten the long-term productivity or ecological role of any species in the future.

Fishery	**Management: Harvest Strategy** Rank (Score)	**Management: Bycatch** Rank (Score)	**Criterion 3** Rank (Score)
United States Pacific	Moderate Concern (3)	All species retained (N/A)	Yellow (3)
Canada Pacific	Moderate Concern (3)	All species retained (N/A)	Yellow (3)

Factor 3.1 Management of fishing impacts on retained species: Moderate Concern

Fishery	**Critical?**	Mgmt strategy and implement.	Recovery of stocks of concern	Scientific research and monitoring	Scientific advice	Enforce.	Track record	Stakeholder inclusion	**Management of Retained Species** **Rank (Score)**
United States Pacific	No	Moderately Effective	N/A	Highly Effective	Highly Effective	Highly Effective	Moderately Effective	Highly Effective	Moderate (3)
Canada Pacific	No	Moderately Effective	N/A	Highly Effective	Highly Effective	Highly Effective	Moderately Effective	Highly Effective	Moderate (3)

Key relevant information:

Although management in both the US and Canada works to use the best available science to manage the fishery, the HCR currently used is based on a scientific assumption no longer believed to be valid (the correlation between sardine biomass and SST as currently measured), and there is a lack of agreement among the US, Canada and Mexico to ensure that coast-wide HGs are not exceeded. Due to these issues, management in both the US and Canada is considered of moderate concern. This score is based on management in a single-species context; the effectiveness of management in an ecosystem context is an important consideration for Pacific sardines and is addressed in Criterion 4.3.

Detailed rationale:

Management Strategy and Implementation: The PFMC and DFO work collaboratively to integrate best available science into their management strategies. For example, the recently published paper by McClatchie (2012) challenges management's temperature-recruitment relationship used to determine exploitation, accounting for a correlation between Pacific sardine biomass and climatic variability. As aforementioned, in response to this research, the PFMC's Coastal Pelagic Species Management Team held a workshop in February 2013 to review the current Pacific sardine HCR (PFMC 2012c). The PFMC uses its annual stock assessments to determine annual HGs in the US (PFMC 2011a). After peer-review by the Center for Science Advice Pacific (CSAP), the DFO uses the PFMC stock assessments to determine the annual harvest yield in Canada (DFO 2011a). Additionally, the US and Canada participate in the Trinational Sardine Forum, which also includes Mexico. During the forum, scientists and managers come together to discuss regional reports and updates on stock structure, regional biomass, stock assessment, age and growth assessment, and ecosystem (NOAA SWFSC 2012). Annual stock assessments and the Trinational Sardine Forum indicate that management remains current on best available science, and is continuously changing HGs to meet annual goals.

As was discussed in Section 1.3, while there is no evidence that suggests the US or Canadian fisheries are not following the HG as set forth by their respective managing bodies, potential for harvest exceeding coast-wide HG exists due to the fact that coast-wide distribution exceeds 100%. Additionally, though the HCR is not currently based on best available science (in regards to addressing the findings from McClatchie 2012), management is actively working to update the HCR (as is evident by the 2013 workshop). While management of the Pacific sardine fishery in the US and Canada has appropriate strategy and goals, more precaution is needed to ensure coast-wide overexploitation does not occur, particularly given the current uncertainties related to the HCR. Until these issues are addressed, management strategy and implementation is considered moderately effective.

Recovery of stocks of concern: The Pacific sardines, along with the other coastal pelagic species, are not currently considered stocks of concern. Because this fishery is not targeting any species considered a stock of concern, recovery of stocks of concern is not applicable.

Scientific Research and Monitoring: The Pacific sardine stock assessment uses fishery-dependent data (e.g. landings and biological samples) and fishery-independent data (e.g. trawls and aerial surveys) to conduct annual assessments. In the US, CDFW (formerly CDFG) has collected samples from landings since 1981, ODFG since 1999, and WDFW since 2000. CDFW collects 12 random port samples per month, whereas ODFG and WDFW collect more frequently due to a shorter fishery opening (PFMC 2011). DFO began collecting samples in 1998 and requires 100% dockside observer coverage (DFO 2012d). Landing samples include weight, standard length, sex, maturity and otoliths to determine age (PFMC 2011). Four fishery-independent surveys are used to model biomass. The first ship-based survey ranges from Cape Flattery, Washington to San Diego, California, and the data collected are used to estimate female spawning biomass from daily egg production. Since 2005, trawling has been conducted to sample adult sardine in high and low egg density areas to include total egg production (the product of egg density and spawning area) (Lo et al. 2011). In 2008, the industry funded a pilot aerial survey to estimate the number and surface area of schools of Pacific sardine. Fishing vessels were used to determine the biomass as it relates to surface area. Full surveys continued in 2009, 2010, and 2011 (Jagielo et al. 2011). Lastly, since 2006 the SWFSC has conducted coast-wide acoustic surveys to determine size and age composition data. Biomass projections and oceanic conditions are used to determine harvest controls (PFMC 2011). Management conducts annual stock assessments, which include input from the US, Canada, and Mexico. These scientific assessments are complete and robust, and therefore scientific research and monitoring is considered highly effective.

Scientific Advice: Both US and Canadian management of Pacific sardine fisheries do not have track records of exceeding scientific advice on HGs. Since 2000, US landings have fallen below HG in all but one year (2009), when the HG was 66,932 mt, and landings were 67,084 mt (PFMC 2011a). Since 2002, Canadian landings have not exceeded total allowable catch (TAC), and have steadily increased from 9% of TAC caught in 2002 to 95.9% in 2010 (DFO 2011a). While the US and Canada independently follow management recommendations, coast-wide HG is sometimes exceeded because of an over-allocation of coast-wide landings. Currently, distribution for Canada (18.3%) (DFO 2012a) and US (87%) (Hill et al. 2012) HG exceeds 100%; this does not include catch from Mexico. This is discussed in greater detail in Factor 1.3.

Recent literature questions the management strategy of the US and Canadian Pacific sardine fisheries. Zwolinsky and Demer (2012) conclude that “all indicators show that the northern sardine stock off the west coast of North America is declining steeply again and that imminent collapse is likely.” Indicators identified in this study include a decline in the northern sardine stock due to high exploitation rates coupled with a transition to a cold regime. Additionally, McClatchie (2012) has shown that the temperature-recruitment relationship used to determine exploitation rate does not accurately represent the factors that drive the cyclical nature of the fishery. While the PFMC’s Scientific and Statistical Committee (SSC), a group of scientists from state and federal agencies, academic institutions, and other sources, concluded that the 2011 stock assessment utilized best available science (CPSMT 2012, Pleschner-Steele 2012), they recommended that a workshop be convened to address the appropriateness of the temperature-recruitment relationship and re-evaluate the parameters of the HCR (SSC 2011). In 2012, the SSC stated that a management strategy evaluation could provide updated parameters F_{msy}, Fraction, and Cutoff. The SSC also suggested the PFMC conduct a series of workshops focusing on: 1) the environment-productivity relationship; 2) the operating model; and 3) feedback from the PFMC and stakeholders from the first two workshops, as well as a discussion of remaining issues (SSC 2012).

Another concern in regards to management's responsiveness to scientific advice is whether the recommendations from the Lenfest Forage Fish Task Force are being considered and acted upon (Pikitch et al. 2012). This is discussed in greater detail in Factor 4.3.

Though there is a discrepancy in interpretation of recent research, US management has been responsive to requests to re-evaluate their HG (e.g. PFMC 2012c). In view of this, scientific advice is considered moderately effective.

Enforcement: In the US, dockside monitoring and logbooks are used to enforce catch limits and monitor catch levels (PFMC 2005). Landings in recent years have remained below quotas and there appear to be few serious concerns with compliance, thus enforcement is considered highly effective given the needs of the fishery.

Before 2012, monitoring in Canada was conducted by an industry funded third party and included hailing in and out to the fishery, submission of catch and effort information, 100% dockside validation of catch and 100% at-sea observers in areas and times of concern for wild salmon populations (Flostrand et al. 2011). In 2012, DFO implemented a "Salmon Bycatch and Discard Policy Framework" as part of the Integrated Fisheries Management Plan. This framework was jointly developed by DFO and industry and outlines specific measures to minimize impact to local stocks of wild salmon. Although at-sea observer coverage was reduced, additional time and area closures were implemented as well as the introduction of excluders, which allow for increased "live releases" of encountered salmon at sea (DFO 2012d). Because regulations are regularly enforced and verified and sufficient observer coverage exists, enforcement in Canada is considered highly effective.

Track Record: As has been discussed throughout this report, Pacific sardine stock biomass fluctuates with changing oceanic conditions. At the turn of the century, scale deposits show an increase from a crashed stock to approximately 8 million mt (Baumgartner et al. 1992). Just prior to the collapse of the fishery in the 1940s, the stock peaked at nearly 2.5 million mt (Hill 2012). The stock began to recover in the 1970s and peaked in 1999 and again in 2006 at nearly 1.4 million mt, but has been in decline since then. The most recent stock assessment estimated a Pacific sardine biomass (ages 1+) of 659,539 mt as of July 2012 (Hill et al. 2012). It is difficult to evaluate how well the stock is faring compared to historical averages because of its cyclical nature. Zwolinski and Demer (2012) predict that oceanic conditions in the eastern Pacific have shifted to a colder period, which could lead to another collapse of the Pacific sardine fishery. In addition to a decline resulting from oceanic conditions, the authors caution that current management strategies may have delayed recovery of the Pacific sardine to historic levels and that fishing may be the cause of the current decline (Zwolinski and Demer 2012). The methods used to reach these conclusions have been rebutted; MacCall et al. (2012) note inconsistencies in the findings and assert that by omitting available data the decline is overstated. Though management has enacted measures to maintain long-term stock abundance, the cyclical nature of this fishery, the current decline in biomass, and scientific literature questioning management leaves uncertainty as to whether these measures have been or will continue to be successful. Thus, track record is considered moderately effective.

Stakeholder inclusion: The PFMC has public meetings where council members, council staff, and advisory bodies (which includes multiple stakeholder groups) engage in discussions about Pacific sardine fishery management. The public may attend these meetings and comment on decisions and council processes. Council staff actively assists the public in such participation (PFMC 2012b). More information on meeting schedules can be found on PFMC's website: http://www.pcouncil.org/council-operations/council-meetings/future-meetings/.

In 2011, the conservation representative on the PFMC's Coastal Pelagic Species Advisory Panel (Ben Enticknap of Oceana) resigned from the committee. In a statement, Mr. Enticknap stated the following: "We worked really hard in the trenches of the management process, but our grave concerns regarding forage species exploitation and our suggestions to improve management were largely ignored" (Oceana 2011).

DFO has a consultation framework to encourage stakeholder involvement in fisheries management decisions. The agency's statement on stakeholder inclusion is as follows: "DFO will undertake consultations in order to improve departmental decision making processes, promote understanding of fisheries, ocean and marine transport issues, and strengthen relationships." This framework focuses on planning and evaluation, building mutual trust, and improving consultation culture, with special considerations for consultation with Aboriginal groups (DFO 2004). The Sardine Integrated Advisory Board (SIAB) is a multi-interest group that provides advice on management and policy issues to the Pacific sardine fishery. The SIAB is intended to be an avenue for consultation between the DFO and First Nations (DFO 2012c). More information, such as the consultation schedule for the Pacific region, can be found on DFO's website: http://www.pac.dfo-mpo.gc.ca/consultation/index-eng.htm.

The management processes for both the US and Canadian fisheries include stakeholder input, but the concerns of the PFMC's CPS advisory panel conservation representative call into question whether stakeholder input is fully considered. Stakeholder inclusion is considered moderately effective.

Factor 3.2 Management of Fishing Impacts on Bycatch Species: Not Applicable

Key relevant information:
Because all species caught in the Pacific sardine fishery are retained (with a discard rate of under 1%), this factor is not applicable.

Criterion 4: Impacts on the habitat and ecosystem

Guiding principles

- The fishery is conducted such that impacts on the seafloor are minimized and the ecological and functional roles of seafloor habitats are maintained.
- Fishing activities should not seriously reduce ecosystem services provided by any fished species or result in harmful changes such as trophic cascades, phase shifts or reduction of genetic diversity.

Fishery	**Impact of gear on the substrate** Rank (Score)	**Mitigation of gear impacts** Rank (Score)	**Ecosystem-based fishery management** Rank (Score)	**Criterion 4** Rank (Score)
United States Pacific	None (5)	N/A	Moderate Concern (3)	Green (3.87)
Canada Pacific	None (5)	N/A	Moderate Concern (3)	Green (3.87)

Factor 4.1 Impact of the Fishing Gear on the Substrate: None

Key relevant information:
Both US and Canada Pacific sardine fisheries use purse seine, which targets schools of fish and does not touch the seafloor. Thus, the Pacific sardine fishery does not have any impact on the substrate.

Factor 4.2 Modifying Factor: Mitigation of Fishing Gear Impacts

Key relevant information:
N/A

Factor 4.3 Ecosystem and Food Web Considerations: Moderate Concern

Key relevant information:
The Pacific sardine is considered a forage fish, which is defined in multiple ways in scientific literature. The Lenfest Forage Fish Task Force defines forage species "in terms of their functional role in providing a critically important route for energy transfer from plankton to

higher trophic levels in marine ecosystems." Reduction in forage fish biomass can change the functioning of entire ecosystems (Pikitch et al. 2012). Predators depend on an abundance of prey and can be greatly affected when populations decline. For example, seabird declines have been directly linked to forage species declines, both from fishing pressure and environmental change (Crawford et al. 2007; Cury et al. 2011). This literature was not focused on by either the US or Canadian Pacific sardine fishery, and there is no evidence that links declines in predators in this area to the Pacific sardine fishery. Like other forage species, the Pacific sardine experiences large fluctuations in population over time due to changes in oceanic conditions and does not have a steady state in population. Because of their schooling behavior, forage fish have high catchability even at low stock levels. Catch per unit effort does not change in response to stock size, which makes these species vulnerable to collapse (Pikitch et al. 2012) and, at times, even slight changes in fishing pressure can have large impacts to the population (Enticknap et al. 2011).

The HG for Pacific sardine is based on CUTOFF, FRACTION (both described above), and MAXCAT. The MAXCAT is maximum harvest, 200,000 mt (PFMC 2009). The MAXCAT produces a higher average biomass, a more stable, smaller average yield, and prevents overcapitalization of the fleet (Parrish 2012). The TAC cannot be set above 200,000 mt, but the PFMC may recommend an annual catch target (ACT) below the HG (PFMC 2009, Parrish 2012). The CUTOFF of 150,000 mt is intended to reserve an unfished core population in large part due to the fisheries importance as a forage species (Pleschner-Steele 2012). In addition to management measures intended specifically for Pacific sardine, management has taken action to protect other forage fisheries and prey species, including: 1) a ban on the harvest of krill (Federal Register 2009), and 2) a policy on new forage fisheries, which "prevent(s) the development of new or expanded forage fisheries until Essential Fishery Information is available and applied to ensure the sustainability of target forage species and protection of its benefits as prey" (CDFG 2012).

In response to the NMFS's policy to integrate ecosystem management into fisheries management plans, the PFMC prepared a white paper on the development of an ecosystem fishery management plan (E-FMP) for Washington, Oregon and California (2007). The overarching goal of this plan was to create an evolutionary E-FMP that complements, but does not replace, current FMPs. This plan was directed to include a spatial planning framework, short and long-term trends in climate and oceanic conditions and trophic interactions. In June 2011, the PFMC's Ecosystem Plan Development Team decided to progress this goal with an advisory ecosystem plan rather than by establishing an E-FMP (PFMC 2011b). In February 2013, the PFMC published a public review draft of the fishery ecosystem plan for the California Current (PFMC 2013).

According to Pikitch et al. (2012), management needs to account for bycatch, interactions between fisheries that shoal together, and predator-prey interactions. At present, the Pacific sardine fishery considers bycatch as well as interactions with other CPS (PFMC 2009).

The Lenfest Forage Fish Task Force report (Pikitch et al. 2012) provides an analysis of forage fish catch by volume and contribution to ecosystem predator production for 72 ecosystems. The authors used fishery models for each of these ecosystems to quantify the supportive contribution of fisheries to their community, but not as a way to gauge sustainability. The goal of this analysis was to show the importance of non-direct contribution to the ecosystem (Pikitch 2013). For the California Current, a 2006 model was used to find that approximately 98% of forage fish production went toward supportive contribution to ecosystem predator production (Pikitch et al. 2012). While these models included the best available data at the time of publication, fishing pressures can change drastically over time and may not be representative of current contributions, so management should be cautious when using this study to analyze current conditions in the Pacific sardine fishery (Pikitch 2013).

The Lenfest task force recommends that for forage fisheries with a moderate degree of scientific information, the target F should be half of F_{msy}, and in no case should it be greater than .75 F_{msy}. This number (between 0.5 and 0.75 F_{msy}) is dependent on how much information is available for the fishery and the ecosystem it inhabits. While an analysis has not been done on the Pacific sardine fishery to know where it lies in this knowledge tier, under either scenario the fishery would be considered undergoing overfishing in an ecosystem context by this criteria because fishing pressure is higher than 0.75 F_{msy} (Pikitch 2013).

Pikitch et al. (2012) also state that in order to reduce the impacts to predators, allowable catch should consider total mortality, which includes predation mortality, rather than base it solely fishing mortality. Local depletion can negatively impact predators who then have to travel greater distances to find prey, and current management does not address local depletion or spatial impacts through its Pacific sardine HG. The State of California has implemented Marine Protected Areas (MPAs) along the entire coastline, some of which have been sited to protect forage for marine mammals and seabirds. Though the CDFW recognizes that pelagic species will not benefit significantly from MPAs that do not encompass its entire range, this effort is intended to benefit the ecosystem as a whole. And, though Pacific sardines are not considered a “species likely to benefit from MPAs,” management has sited MPAs in locations that protect forage for marine mammals and seabirds that depend on forage species such as the Pacific sardine (CDFG 2008).

While management is in the process of creating an ecosystem-based approach that intends to ensure prey availability for predators of forage species, the Pacific Coast fishery ecosystem plan is still in draft form. Because management (both in the US and Canada) is in the process of implementing, but does not yet have a completed analysis of ecosystem impacts in regards to predator/prey interactions in the fishery, and both conservation groups and scientific literature call into question the appropriateness of HG in regards to consideration of predator/prey interaction, the ecosystem and food web impacts for this fishery is deemed ‘Moderate.’

Overall Recommendation

Final Score = geometric mean of the four Scores (Criterion 1, Criterion 2, Criterion 3, Criterion 4).

The overall recommendation is as follows:

- **Best Choice** = Final Score between 3.2 and 5, **and** no Red Criteria, **and** no Critical scores
- **Good Alternative** = Final score between 2.2 and 3.199, **and** Management is not Red, **and** no more than one Red Criterion other than Management, **and** no Critical scores
- **Avoid** = Final Score between 0 and 2.199, **or** Management is Red, **or** two or more Red Criteria, **or** one or more Critical scores

Acknowledgements

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

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References

Ahlstrom, E.H. and J. Radovich. 1970. Management of the Pacific Sardine. *In* A Century of Fisheries in North America, N.G. Benson, ed. Special Publication No. 7, American Fisheries Society, Washington D.C., pp 183-193.

Alder, J., B. Campbell, V. Karpouzi, K. Kaschner and D. Pauly. 2008. Forage fish: from ecosystems to markets. Annual Reviews in Environment and Resources 33: 153-166.

Baumgartner, T.R., A. Soutar,, and V. Ferreira-Bartrina. 1992. Reconstruction of the history of Pacific sardine and Northern anchovy populations over the past two millennia from sediments of the Santa Barbara Basin, California. CalCOFI. Rep., Vol. 33.

California Department of Fish and Game (CDFG). 2001. California's Living Marine Resources: A Status Report, Pacific Sardine. The Resources Agency, The Department of Fish and Game.

California Department of Fish and Game (CDFG). 2008. California Marine Life Protection Act. Master Plan for Marine Protected Areas (Revised Draft). Appendix G. Master List of Species Likely of Benefit from MPAs.

California Department of Fish and Game (CDFG). 2011. Final California commercial landings for 2010. Table 7—Origin and poundage of commercial fish landings into California during 2010.

California Department of Fish and Game (CDFG). 2012. Draft policy on forage species. Accessed December 27, 2012. http://www.fgc.ca.gov/meetings/2012/081012MRCDraft_ForagePolicy_MRCrec.pdf

Cheung, W.W.L., T.J. Pitcher and D. Pauly. 2005. A fuzzy logic expert system to estimate intrinsic extinction vulnerabilities of marine fishes to fishing. Biol. Conserv. 124:97-111

Coastal Pelagic Species Management Team (CPSMT). 2012. Coastal Pelagic Species Management Team report on Pacific sardine stock assessment and management for 2013. Agenda Item G.3.c, Supplemental CPSMT Report, Pacific Fisheries Management Council. http://www.pcouncil.org/wp-content/uploads/G3c_SUP_CPSMT_NOV2012BB.pdf

Crawford, R.J.M., L.G. Underhill, L. Upfold and B.M. Dyer. 2007. An altered carrying capacity of the Benguela upwelling ecosystem for African penguins (*Spheniscus demersus*). ICES Journal of Marine Science, 64: 570-576.

Crone, P.R., K.T. Hill, J.D. McDaniel, and K. Lynn. 2011. Pacific Mackerel (Scomber japonicus) stock assessment for USA management in the 2011-12 fishing year. Pacific Fishery Management Council.

Culver, M. and C. Henry. 2009. Summary report of the 2008 experimental purse seine fishery for Pacific sardine (*Sardinops sagax*). Washington Department of Fish and Wildlife.

Cury, P.M., I.L Boyd, S. Bonhommeau, T. Anker-Nilssen, R.J.M. Crawford, R.W. Furness, J.A. Mills, E.J. Murphy, H. Österblom, M. Paleczny, J.F. Piatt, J.P Roux, L. Shannon and W.J. Syderman. 2011. Global seabird response to forage fish depletion, one-third for the birds. Science, Vol. 334 (6063): 1703-1706.

Department of Fisheries and Oceans Canada (DFO). 2004. Consultation framework, for Fisheries and Oceans Canada.

Department of Fisheries and Oceans Canada (DFO). 2011a. Pacific Region Integrated Fisheries Management Plan, Pacific Sardine, June 1, 2011 to February 9, 2012.

Department of Fisheries and Oceans Canada (DFO). 2011b. Evaluation of Pacific sardine (*Sardinops sagax*) stock assessment and harvest guidelines in British Columbia. Canadian Science Advisor Secretariat Science Advisory Report 2011/016.

Department of Fisheries and Oceans Canada (DFO). 2012a. Pacific Region Integrated Fisheries Management Plan, Pacific Sardine. June 1, 2012 to February 9, 2015.

Department of Fisheries and Oceans Canada (DFO). 2012b. Trade statistics. http://www.dfo-mpo.gc.ca/stats/stats-eng.htm. Accessed March 30, 2012.

Department of Fisheries and Oceans Canada (DFO). 2012c. Sardine integrated advisory board terms of reference. Accessed December 17, 2012. http://www.pac.dfo-mpo.gc.ca/consultation/fisheries-peche/pelag/sardine/torman-eng.htm

Department of Fisheries and Oceans Canada (DFO). 2012d. pers. comm. 2012.

Emmett, R.L., R.D. Brodeur, T.W. Miller, S.S. Pool, P.J. Bentley, G.K. Krutzikowsky, J. McCrae. 2005. Pacific sardine (*Sardinops sagax*) abundance, distribution and ecological relationships in the Pacific Northwest. CalCOFI Reports, 46: 122-143.

Enticknap, B., A. Blacow, G. Shester, W. Sheard, J. Warrenchuk, M. LeVine and S. Murray. 2011. Forage fish: feeding the California Current large marine ecosystem, marine forage species management off the U.S. West coast. Oceana.

Fishbase. 2012. Accessed February 11, 2012. http://www.fishbase.org/

Federal Register. 2009. Volume 74, No. 132. Fisheries off West coast states; coastal pelagic species fishery; Amendment 12 to the Coastal Pelagic Species Fishery Management Plan. Final Rule. Department of Commerce. National Oceanic and Atmospheric Administration. Docket No. 071106669-81372-03. RIN 0648-AU26.

Federal Register. 2011. Volume 76, No. 124. Fisheries off the West coast states; Coastal pelagic species fisheries; Amendment 13 to the Coastal Pelagic Species Fishery Management Plan; Annual Catch Limits. Proposed Rule. Department of Commerce. National Oceanic and Atmospheric Administration. 50 CFR Part 660. Docket No. 110606318-1319-01. RIN 0648-BA68

Flostrand, L., J. Detering and J. Schweigert. 2011. Proceedings of the 2010 Trinational Pacific Sardine Forum. Canadian Manuscript Report of Fisheries and Aquatic Sciences 2970. Department of Fisheries and Oceans Canada.

Government of Canada (GOC). Species At Risk Public Registry. Accessed March 16, 2012. http://www.sararegistry.gc.ca/approach/act/default_e.cfm

Hill, K.T., E. Dorval, N.C.H. Lo, B.J. Macewicz, C. Show, and R. Felix-Uraga. 2008. Assessment of the Pacific Sardine Resource in 2008 for U.S. Management in 2009. NOAA technical Memorandum NMFS. U.S. Department of Commerce, National Oceanic and Atmospheric Administration. National Marine Fisheries Service. Southwest Fisheries Science Center.

Hill, K.T., N.C.H. Lo, B.J. Macewicz, P.R. Crone, and R. Felix-Uraga. 2010. Assessment of the Pacific Sardine Resource in 2010 for U.S. Management in 2011. NOAA technical Memorandum NMFS. U.S. Department of Commerce, National Oceanic and Atmospheric Administration. National Marine Fisheries Service. Southwest Fisheries Science Center.

Hill, K.T., N.C.H. Lo, B.J. Macewicz, P.R. Crone, and R. Felix-Uraga. 2011. Assessment of the Pacific Sardine Resource in 2011 for U.S. Management in 2012. NOAA technical Memorandum NMFS. U.S. Department of Commerce, National Oceanic and Atmospheric Administration. National Marine Fisheries Service. Southwest Fisheries Science Center.

Hill, K.T., P.R. Crone, N.C.H. Lo, D.A. Demer, J.P. Zwolinski, B.J. Macewicz. 2012. Assessment of the Pacific Sardine Resource in 2012 for U.S. Management in 2013. NOAA technical Memorandum NMFS.

U.S. Department of Commerce, National Oceanic and Atmospheric Administration. National Marine Fisheries Service. Southwest Fisheries Science Center.

Hill, K.T. 2012. National Marine Fisheries Service, Southwest Science Center. pers. comm. July 23, 2012.

Hrabok, C., J.F. Schweigert, D. Chalmers, and D. Pepper. 2007. Proceedings of the 2006 Trinational Pacific Sardine Forum.

Jagielo, T. 2011. West Coast Aerial Sardine Survey Application for Exempted Fishing Permit in 2011.

Lo, C.H., B.J. Maceqicz, and D.A. Griffith. 2011. Spawning biomass of Pacific Sardine (*Sardinops sagax*) off US in 2011. Southwest Fisheries Science Center.

MacCall, A., K.T. Hill, P. Crone and R. Emmett. 2012. Weak evidence for sardine collapse. Proceedings of the National Academy of Sciences of the United States of America (PNAS), Early Edition.

McClatchie, S. 2012. Sardine biomass is poorly correlated with the Pacific Decadal Oscillation off California. Geophysical Research Letters, Vol. 39, L13703.

McClatchie, S., R. Goericke, G. Auad, and K. Hill. 2010. Re-assessment of the stock–recruit and temperature–recruit relationships for Pacific sardine (Sardinops sagax). Can. J. Fish. Aquat. Sci. 67: 1782–1790.

Murphy, G.I. 1966. Population biology of the Pacific sardine (Sardinops caerulea). Procedures of California Academy of Sciences. Fourth Series 34(1):1084.

National Marine Fisheries Service (NMFS). 2012a. Annual Commercial Landings Statistics. http://www.st.nmfs.noaa.gov/commercial-fisheries/commercial-landings/annual-landings/index. Accessed February 17 and December 26, 2012.

National Marine Fisheries Service (NMFS). 2012b. Annual Report to Congress on the Status of US Fisheries-2011, US Department of Commerce, NOAA, Natl., Mar. Fish. Serv., Silver Spring, MD, 20 pp.

National Marine Fisheries Service (NMFS). 2012c. 4th Quarter 2011. Table A. Summary of stock status for FSSI stocks. http://www.nmfs.noaa.gov/sfa/statusoffisheries/2011/fourth/Q4%202011%20FSSI%20and%20nonFSSI%20StockStatus.pdf

National Oceanic and Atmospheric Administration (NOAA). 2012. NOAA Fisheries: Office of Science and Technology. U.S. Foreign Trade, Fisheries Statistics. Accessed February 17, 2012. http://www.st.nmfs.noaa.gov/st1/trade/index.html

National Oceanic and Atmospheric Administration (NOAA) Southwest Regional Science Center (SWRSC). 2011. Trinational Sardine Forum. Accessed July 12, 2012. http://swfsc.noaa.gov/tsf.aspx

Oregon Department of Fish and Wildlife (ODFW). 2011. Summary of the Oregon fishery for Pacific sardine (*Sardinops sagax*). Marine Resources Program.

Pacific Fisheries Management Council (PFMC). 1998. Amendment 8 to the Northern Anchovy Fishery Management Plan incorporating a name change to: The Coastal Pelagic Species Fishery Management Plan. Prepared by the PFMC in conjunction with: Department of Commerce, National Marine Fisheries Service, Southwest Region and Southwest Fisheries Science Center.

Pacific Fisheries Management Council (PFMC). 2001. Amendment 9 to the Coastal Pelagic Species Fishery Management Plan, Coastal Pelagic Species Fishery Management Plan. Environmental assessment/regulatory impact review and determination of the impact on small business.

Pacific Fisheries Management Council (PFMC). 2005. Allocation of the Pacific Sardine Harvest Guideline. Amendment 11 to the Coastal Pelagic Species Fishery Management Plan. Prepared by the PFMC in conjunction with: Department of Commerce, National Marine Fisheries Service, Southwest Region and Southwest Fisheries Science Center.

Pacific Fisheries Management Council (PFMC). 2007. Staff white paper: Development of an ecosystem fishery management plan. Agenda Item C.5.a. Attachment 1.

Pacific Fisheries Management Council (PFMC). 2009. Status of the Pacific Coast coastal pelagic species fishery and recommended acceptable biological catches. Stock assessment and fishery evaluation.

Pacific Fisheries Management Council (PFMC). 2010. Statement of Organization, Practices, and Procedures. Adopted November 2010.

Pacific Fisheries Management Council (PFMC). 2011a. Status of the Pacific coast coastal pelagic species fishery and recommended acceptable biological catches, stock assessment and fishery evaluation 2011.

Pacific Fisheries Management Council (PFMC). 2011b. Coastal pelagic species: stock assessment and fishery evaluation (SAFE) documents. SAFE document June 2011.

Pacific Fisheries Management Council (PFMC). 2011c. Amendment 13 to the coastal pelagic species fishery management plan, address revised national standard 1 guidelines. Draft environmental assessment and regulatory impact review. National Marine Fisheries Service, Southwest region.

Pacific Fisheries Management Council (PFMC). 2011d. Coastal Pelagic Species Fishery Management Plan as Amended Through Amendment 13.

Pacific Fisheries Manangement Council (PFMC). 2012a. Ecosystem-based management timeline. http://www.pcouncil.org/ecosystem-based-management/ecosystem-management-timeline/. Accessed March 26, 2012.

Pacific Fisheries Management Council (PFMC). 2012b. Council Operations: Council Staff. http://www.pcouncil.org/council-operations/meet-the-council-staff/. Accessed March 26, 2012.

Pacific Fisheries Management Council (PFMC). 2012c. Coastal Pelagic Species Management Team report on future Council meeting agenda and workload planning. http://www.pcouncil.org/wp-content/uploads/F4b_CPSMT_NOV2012BB.pdf

Pacific Fisheries Management Council (PFMC). 2013. Pacific coast fishery ecosystem plan for the U.S. portion of the California Current large marine ecosystem—public review draft.

Parrish, Richard. 2012. Retired, NOAA. pers. comm. October 1 and December 30, 2012.

Pikitch, E. 2013. Stony Brook University School of Marine and Atmospheric Sciences. pers. comm. January 11, 2013.

Pikitch, E., Boersma, P.D., Boyd, I.L., Conover, D.O., Cury, P., Essington, T., Heppell, S.S., Houde, E.D., Mangel, M., Pauly, D., Plagányi, É., Sainsbury, K., and Steneck, R.S. 2012. Little Fish, Big Impact: Managing a Crucial Link in Ocean Food Webs. Lenfest Ocean Program. Washington, DC. 108 pp.

Pleschner-Steele, D. 2012. California Wetfish Producers Association. pers. comm. October 1 and December 16, 2012.

Radovich, J. Collapse of the California Sardine Fishery. CalCOFI Rep., Vol. XXIII, 1982.

Schweigert, J.F., and McFarlane, G.A. 2001. Stock assessment and recommended harvest for Pacific sardine in 2002. DFO Can. Sci. Advis. Sec. Res. Doc. 2001/126: 13p. http://www.dfo-mpo.gc.ca/CSAS/Csas/DocREC/2001/RES2001_126e.pdf

Scientific and Statistical Committee (SSC). 2011. Scientific and Statistical Committee report on Pacific sardine assessment and coastal pelagic species management measures for 2012. Agenda Item F.2.c, Supplemental SSC Report, Pacific Fisheries Management Council.

Scientific and Statistical Committee (SSC). 2012. Scientific and Statistical Committee report on future council meeting agenda and workload planning. Agenda Item F.4.b, Supplemental SSC Report, Pacific Fisheries Management Council.

Southwest Fisheries Science Center (SWFCS). 2012. International efforts to assess the status of Pacific sardine stocks. 7/2/2012. Accessed December 1, 2012. http://swfsc.noaa.gov/news.aspx?id=18113

Sweetnam, D., K. Barsky, T. Buck, P. Kalvas, L. Laughlin, C. McKnight, B. Miler, J. Phillips, L. Rogers-Bennett, W. Taylor, P. Ton. 2011. Review of selected California fisheries for 2010: coastal pelagic finfish, market squid, ocean salmon, groundfish, highly migratory species, Dungeness crab, spiny lobster, spot prawn, kellet's whelk, and white seabass. Calif. Coop. Oceanic Fish. Invest. Rep. 52:13-35.

US Fish and Wildlife Service (USFWS), Endangered Species Program. Accessed March 16, 2012. http://www.fws.gov/endangered/

Washington Department of Fish and Wildlife. 2011. Summary of the Washington purse seine fishery for Pacific sardine (*Sardinops sagax*). Agenda Item F.2.c, Supplemental WDFW Report.

Whitehead, P.J.P. 1985. FAO Species Catalogue. Vol. 7. Clupeoid fishes of the world (suborder Clupeioidei). An annotated and illustrated catalogue of the herrings, sardines, pilchards, sprats, shads, anchovies and wolf-herrings. Part 1-Chirocentridae, Clupeidae and Pristigasteridae. FAO Fish. Synop. 125(7/1):1-303

Wolf, Patricia. 1992. Sardine Recovery and the California Fishery. Calif. Coop. Oceanic Fish. Invest. Rep. Vol. 33.

Zwolinski, J.P. and Demer, D.A. 2012. A cold oceanographic regime with high exploitation rates in the Northeast Pacific forecasts a collapse of the sardine stock. Proceedings of the National Academy of Sciences of the United States of America. 10.1073/pnas.1113806109

Appendix A: Review Schedule

Annual assessments are released by PFMC and DFO and can be accessed on their websites:
PFMC: http://www.pcouncil.org/coastal-pelagic-species/background-information/
DFO: http://www.dfo-mpo.gc.ca/index-eng.htm

About Seafood Watch®

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

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

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

Disclaimer

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

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Guiding Principles

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

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

- *Stocks are healthy and abundant.*
- *Fishing mortality does not threaten populations or impede the ecological role of any marine life.*
- *The fishery minimizes bycatch.*
- *The fishery is managed to sustain long-term productivity of all impacted species.*
- *The fishery is conducted such that impacts on the seafloor are minimized and the ecological and functional roles of seafloor habitats are maintained.*
- *Fishing activities should not seriously reduce ecosystem services provided by any fished species or result in harmful changes such as trophic cascades, phase shifts, or reduction of genetic diversity.*

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

1. Impacts on the species/stock for which you want a recommendation
2. Impacts on other species
3. Effectiveness of management
4. Habitat and ecosystem impacts

Each criterion includes:
- Factors to evaluate and rank
- Evaluation guidelines to synthesize these factors and to produce a numerical score
- A resulting numerical score and **rank** for that criterion

Once a score and rank has been assigned to each criterion, an overall seafood recommendation is developed on additional evaluation guidelines. Criteria ranks and the overall recommendation are color-coded to correspond to the categories on the Seafood Watch pocket guide:

Best Choices/Green: Are well managed and caught or farmed in environmentally friendly ways.

Good Alternatives/Yellow: Buy, but be aware there are concerns with how they're caught or farmed.

Avoid/Red: Take a pass on these. These items are overfished or caught or farmed in ways that harm other marine life or the environment.