COASTAL PELAGIC SPECIES MANAGEMENT TEAM REPORT ON SARDINE REBUILDING PLAN

The National Marine Fisheries Service (NMFS) notified the Pacific Fishery Management Council (Council) on July 9, 2019 that the northern subpopulation of Pacific sardine (NSP) was declared overfished, based on an April 2019 stock assessment indicating a biomass of 27,547 metric tons (mt). The Magnuson-Stevens Fishery Conservation and Management Act (MSA) requires a rebuilding plan to be completed within two years of the overfished notification. The Council must develop a proposed rebuilding plan within 15 months of the overfished declaration and submit the plan to NMFS. NMFS then has approximately nine months to approve and implement the proposed measures.

This document summarizes the procedural and regulatory status of the sardine rebuilding plan and provides additional background that may assist the Council's decision in adopting a range of alternatives (ROA). The Council is scheduled to adopt a rebuilding plan at its September 2020 meeting.

Regulatory requirements

The MSA and the National Standard 1 (NS1) guidelines (50 CFR §600.310(j)) provide guidance on rebuilding plans. The MSA requires Councils to develop a fishery management plan (FMP), FMP amendment, or proposed regulations to end overfishing immediately, rebuild affected stocks, and prevent overfishing from occurring in the fishery whenever such fishery is identified as approaching an overfished condition. A rebuilding plan must specify a time period for rebuilding the fishery that is as short as possible, taking into account the status and biology of the stock, the needs of fishing communities, and interaction of the stock within the marine ecosystem. The time period should not exceed 10 years, except in cases where the biology of the stock or environmental conditions dictate otherwise.

NS1 guidelines provide further details and guidance, including these required elements:

- Ttarget: the target time for rebuilding the fishery in as short a time as possible, considering the status and biology of the overfished stock, the needs of the fishing communities, and the role of the environment.
- Tmin: the amount of time the stock is expected to take to rebuild to maximum sustainable yield (MSY) biomass level in the absence of any fishing mortality.
- Tmax: the maximum time for rebuilding a stock to Bmsy. If Tmin is less than 10 years, Tmax is 10 years.
- To be approved, a rebuilding plan must identify Ttarget and state how the plan will accomplish rebuilding to Bmsy within that time (e.g., the identified harvest strategy).

NMFS is required to ensure adequate progress toward rebuilding and must review rebuilding plans at least every two years. The review "could include review of recent stock assessments, comparisons of catches with the annual catch limit (ACL), or other appropriate performance

measures" per NS1 guidelines. Revising the rebuilding timeframes (e.g., Ttarget, Tmin) is not necessary unless adequate progress is not being made.

CPS Fishery Management Plan

The CPS FMP addresses rebuilding requirements for overfished stocks in Section 4.5. Unlike some FMPs (e.g., groundfish and salmon), the CPS FMP does not include specified processes to follow when a stock is declared overfished. The CPS FMP instead provides general guidance and states that the rebuilding plans may be implicit in existing harvest control rules (HCRs).

Section 4.5 of the CPS FMP:

> *Management of overfished CPS stocks must include a rebuilding program that can, on average, be expected to result in recovery of the stock to MSY levels in ten years. It is impossible to develop a rebuilding program that would be guaranteed to restore a stock to the MSY level in ten years, because CPS stocks may remain at low biomass levels for more than ten years even with no fishing. The focus for CPS is, therefore, on the average or expected time to recovery based on realistic projections. If the expected time to stock recovery is associated with unfavorable ecosystem conditions and is greater than ten years, then the Council and the U.S. Secretary of Commerce (Secretary) may consider extending the time period as described at 50 CFR § 600.310(e)*[sic].

Rebuilding programs for CPS may be an integral part of the HCR or may be developed or refined further in the event that biomass of a CPS stock reaches the overfished level. For Pacific sardines, a conservative HCR was adopted at the time sardines came under federal management in 1998 (Amendment 8 to the CPS FMP, formerly the Northern Anchovy FMP). The HCR is:

$$\text{Harvest} = (\text{Biomass} - \text{Cutoff}) * \text{Fraction} * \text{Distribution}$$

Where Cutoff equals 150,000 mt, Fraction is temperature dependent and ranges between five and 20 percent, and Distribution equals 0.87. Thus, when Biomass falls below Cutoff, directed commercial harvest is zero. The Cutoff provides a buffer of spawning stock that is protected from fishing and available for use in rebuilding if a stock becomes overfished. The combination of a spawning biomass buffer equal to Cutoff and reduced harvest rates at low biomass levels means that a rebuilding program for overfished stocks may be defined implicitly.

The CPS FMP defines the overfished level for the NSP as a 1+ biomass of 50,000 mt on July 1 (Sec. 4.6.2.1). This is the minimum stock size threshold (MSST) status determination criteria used for this stock. As mentioned above, no directed fishery for this stock may occur in U.S. waters when the biomass falls below the Cutoff value of 150,000 mt. As a result, there has not been a directed fishery for this stock in U.S. waters since the stock was projected to fall below that level on July 1, 2015.

Evidence suggests that the NSP has undergone boom and bust population cycles for roughly 2,000 years even in the absence of commercial fishing (Soutar and Issacs 1969, Baumgartner et al. 1992). In a later higher resolution analysis McClatchie et al. (2017) estimated that during the 400-year time period before commercial fishing began, the time it took for the population to recover to ⅓ of its peak biomass was approximately 22 years. These authors deemed that time period constituted

the average time period for the biomass to recover to levels that could support commercial fishing. The HCR for this stock with its Cutoff value of 150,000 mt was put in place by the Council when Amendment 8 was adopted. The concept behind the Cutoff value is to reduce harvest when the population is in decline to help ensure there are sufficient numbers of fish for the population to recover as quickly as possible. The sardine HCR is designed to reduce both the total harvest as well as the harvest rate, as the population declines towards the Cutoff value. It was also recognized at the time that since boom and bust cycles occur in the absence of commercial fishing, environmental conditions are a critical factor in the population size of this stock and in how quickly it can recover from low levels.

Factors contributing to overfished status

The sardine NSP ranges from northern Baja California, Mexico to British Columbia, Canada. In periods of lower abundance, the bulk of the biomass is found centered off southern/central California and northern Baja. Pacific sardine populations are typified by large swings in abundance over time, primarily influenced by ecosystem drivers.

Under the current sardine HCRs, fishing mortality is unlikely to have a substantial effect on the overall population. Figure 1 below is from the 2019 sardine update assessment, and demonstrates that even in the absence of fishing, the NSP would be expected to decline. In some cases, international overfishing can result in an overfished status. However, although some portion of Mexican commercial sardine harvest includes NSP, it is not clear the extent to which it may impact the NSP status.

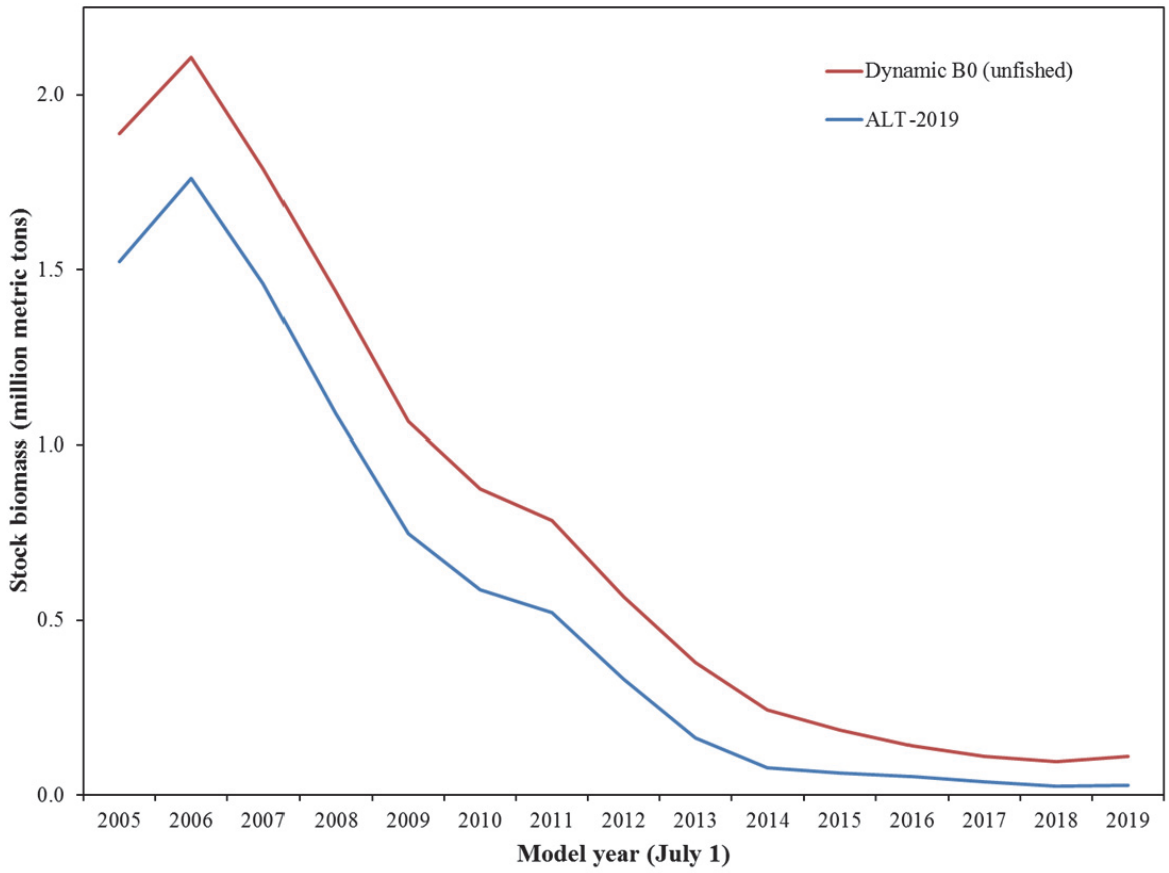

Figure 1. Estimated stock biomass (age 1+ fish, mt) time series and dynamic B_0 (unfished population) from model ALT-2019 (from 2019 Pacific Sardine stock assessment).

Range of Alternatives

The primary directed commercial Pacific sardine fishery has been closed for five years, consistent with NSP stock biomass falling below the CPS FMP's Cutoff value of 150,000 mt. Further restrictions were put in place in 2019 when the stock dropped below 50,000 mt. The small amount of harvest that still takes place is mostly in the live bait fishery. Therefore, many of the options that might have been considered under a rebuilding plan to modify fishing activities at low stock size have already been implemented. The sardine fishery is very different from groundfish or salmon, which have numerous sectors, species, or river systems all with unique impacts and characteristics. There are few interactions with other fisheries except for other CPS and a small amount of bycatch in the Pacific whiting fishery. Thus, the Coastal Pelagic Species Management Team (CPSMT) does not anticipate more than a small number of alternatives.

Substantial modeling and analyses are being done in support of establishing rebuilding targets, timelines, etc. Similar modeling may be helpful in characterizing fishery impacts of various alternatives. See Appendix A for information on the rebuilder tool, recruitment assumptions, harvest assumptions, and other model inputs that will be used to estimate rebuilding parameters. Appendix B includes a description of the approach for analyzing socio-economic impacts of the alternatives established by the Council.

The alternatives here briefly describe potential approaches the Council could take to achieve rebuilding targets. With regard to the ROA, the most conservative approach regarding harvest is a zero harvest scenario, i.e., complete closure of the live bait industry, elimination of incidental landings in other fisheries such as Pacific mackerel, market squid, northern anchovy, and Pacific whiting, and closure of the small scale fishery. The CPSMT views the upper end of the range to be harvest at the acceptable biological catch (ABC) level. Harvest specifications are not allowed to exceed the ABC, thus any higher rate is unrealistic. Because the Council has set recent ACLs equal to the ABC, the upper end of the range is essentially a status quo or no action alternative. At this point the CPSMT has not determined whether additional alternatives should be explored, given that actions to reduce fishing impacts have already taken, as described above. However, as the modeling work develops, there may be alternatives worth pursuing, within the ROA presented here, should the Council wish to explore those.

Alternative 1: Status Quo

Alternative 1 is essentially a status quo alternative and represents the upper end of the range of allowable harvest. The directed commercial fishery has been closed since 2015 because the biomass estimate fell below the Cutoff value of 150,000 mt. Limited harvest remains allowed under the CPS FMP, primarily for live bait and to a lesser extent, incidental and minor directed harvest. Under Alternative 1, management of the sardine resource would continue under the existing HCRs. Annual harvest specifications would be set based on the most recent stock assessment, and the Council would select a P* value, ACL, and other harvest specifications and management measures. There would not be a substantial change in fishery impacts expected and

the direct regulatory pressures on the socioeconomics of the CPS fishery would remain constant. However, additional effects are possible due to the potential long-term impacts of the closure.

Alternative 2: Zero Harvest

Alternative 2 would adopt a zero U.S. harvest approach, meaning that no live bait, no incidental harvest, and no minor directed harvest would be allowed in the domestic U.S. fishery. The impacts of this alternative would include socio-economic impacts and would have ripple effects to the recreational fishing sector, CPS fisheries, and other fisheries such as Pacific whiting, which have small levels of sardine incidental catch.

Next Steps

At the June meeting, the Council should adopt a ROA and should give guidance to the CPSMT regarding which, if any, additional alternatives should be analyzed. The CPSMT anticipates making a recommendation on any recommended alternatives for analysis. Alternatives identified by the Council for inclusion in the suite of alternatives would then be analyzed in advance of final action in September.

The CPSMT anticipates that rebuilding parameters (Tmin, rebuilding target, etc.) will be developed after the June Council meeting. Because the modeling approach and results have not yet been formally reviewed, the CPSMT suggests an opportunity for review by the SSC CPS Subcommittee in advance of the September Council meeting, when the sardine rebuilding plan is tentatively scheduled for final approval. This would allow the analyst and the CPSMT some time to respond to Subcommittee guidance and questions in finalizing proposed alternatives and analyses for Council consideration in September.

References

Baumgartner, T. R., A. Soutar, and V. Ferreira-Bartrina. 1992. History of Pacific Sardine and Northern Anchovy Populations CalCOFI Rep. 33:24-40.

McClatchie, S., I.L. Hendy, A.R. Thompson, and W. Watson. 2017. Collapse and Recovery of Forage Fish Populations Prior to Commercial Exploitation. Geophys. Res. Lett. 44:1877-1885.

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Soutar, Andrew and J. Isaacs. 1969. History of Fish Populations Inferred from Fish Scales in Anaerobic Sediments off California. California Marine Resources Committee, CalCOFI Rep. 13:63-70.

Appendix A: Rebuilding Analysis Summary

Rebuilding Analysis

The Pacific sardine rebuilding analysis will be conducted using the 'Rebuilder' software originally designed for conducting groundfish population projections (Version 3.12e; Punt 2012). Rebuilder is an age-structured population dynamics simulator that projects the population forward in time, accounting for recruitment, growth, natural mortality, and fishing mortality. It calculates the probabilities of rebuilding the stock to SB_{MSY} (recovery) for a given range of recruitment and fishing scenarios.

Data from the 2020 benchmark assessment (Kuriyama et al. 2020) will be used to initiate rebuilding projections. Assessment data will include: population numbers-at-age in the year declared overfished (2019), population numbers-at-age in 2020, weight-at-age, fecundity-at-age, natural mortality, fishery selectivity, and historic spawning biomass (*SB*) and recruitment (*R*) estimates from 2005-2018. A single fleet (fishery) will be modeled using selectivity and weight-at-age from the MexCal Season 2 (S2). MexCal-S2 (Jan-Jun) best typifies the selectivity pattern for the overall MexCal fleet, and most of the northern sub-population (NSP) sardine catch is taken by this fishery at that time of year. The PNW fleet will not be modeled given the low probability that sardine will be taken for live bait or incidentally in the foreseeable future.

Pacific sardine productivity is highly variable and environmentally dependent, so this will be the greatest area of uncertainty in the rebuilding analysis. For the rebuilding analyses, examination of reference points will be based upon, and historic recruitments will be drawn from, two productivity time periods: 2005-2018, and 2010-2018. Recruitment was high to moderate from 2005-2010, and lowest from 2011-2018 (Figure 1). The lower productivity scenario will include 2010 to allow for at least one moderate recruitment in rebuilding projections. Rebuilder will estimate virgin spawning biomass (SB_0) using average recruitments over both ranges of years to characterize the two different productivity scenarios. Note that SB_0 will scale up or down depending on the overall average recruitment levels for each period (i.e., dynamic SB_0).

SB_{MSY}, the rebuilding target, is estimated in Rebuilder by fishing the population at F_{MSY} until the population reaches equilibrium. Pacific sardine productivity, and hence MSY, is driven by prevailing oceanographic conditions. The current harvest control rules (HCR) (OFL, ABC, HG) for Pacific sardine modulate exploitation rate based on CalCOFI sea surface temperature. The Rebuilder package is unable to incorporate environmental effects, nor do reliable environmental forecasts exist for the coming decades. Therefore, for purposes of this rebuilding analysis, the static stochastic E_{MSY} (0.18 yr^{-1}) from the recent management strategy evaluation (Hurtado and Punt 2013) will be used to estimate SB_{MSY} under both productivity scenarios. Having calculated SB_0 and SB_{MSY} for both productivity scenarios, the ratio of SB_{MSY} to SB_0 will provide the target depletion level for which probabilities of recovery are calculated.

Current CPS-FMP Pacific sardine harvest control rules will not be applied to analyze the rebuilding alternatives defined in the plan. Instead, a range of constant, fixed-catch time series will be analyzed for both productivity scenarios (e.g., Total F=0, U.S. F=0, U.S. recent average catch, recent ABC); see Table 1.). Simulations will run for 100 years and over 2000 iterations, randomly drawing recruitments throughout each simulation for the respective scenarios. Rebuilder

will provide the median *SB* trajectories and probabilities of reaching the target depletion level (SB_{MSY}) for each productivity and fishing scenario. The analyses will also provide estimates of T_{min}, T_{target}, and T_{max}.

References

Hurtado-Ferro, F., and Punt, A.E. 2013. Revised analyses related to Pacific sardine harvest parameters. PFMC March 2014 Briefing Book Agenda Item I.1.b.

Kuriyama, P.T., Zwolinski J.P., Hill, K.T., and Crone, P.R. 2020. Assessment of the Pacific Sardine resource in 2020 for U.S. management in 2020-2021. PFMC April 2020 Briefing Book Agenda Item D.3 Attachment 1. 189 p.

Punt, A.E. 2012. SSC Default Rebuilding Analysis: Technical specifications and User Manual. Version 3.12e. 29 p. http://puntlab.washington.edu/software/

Table 1. Management quantities and landings (metric tons) since the 2015-16 management year (July-June).

	U.S. Management Measures				
Mgmt Year	OFL	$ABC_{0.4}$	ACT	U.S. Total Landings (mt)	Ensenada NSP Landings (mt)
2015-16	13,227	12,074	4,000	1,919	0
2016-17	23,085	19,236	5,000	1,885	6,936
2017-18	16,957	15,479	5,000	1,775	6,032
2018-19	11,324	9,436	2,500	2,282	11,210
2019-20	5,816	4,514	4,000	1,199*	nd
2020-21	5,525	4,288	4,000	---	---
	Averages for 2015-16 to 2018-19:			1,965	6,044

* 2019-20 landings to date (4/24/2020)

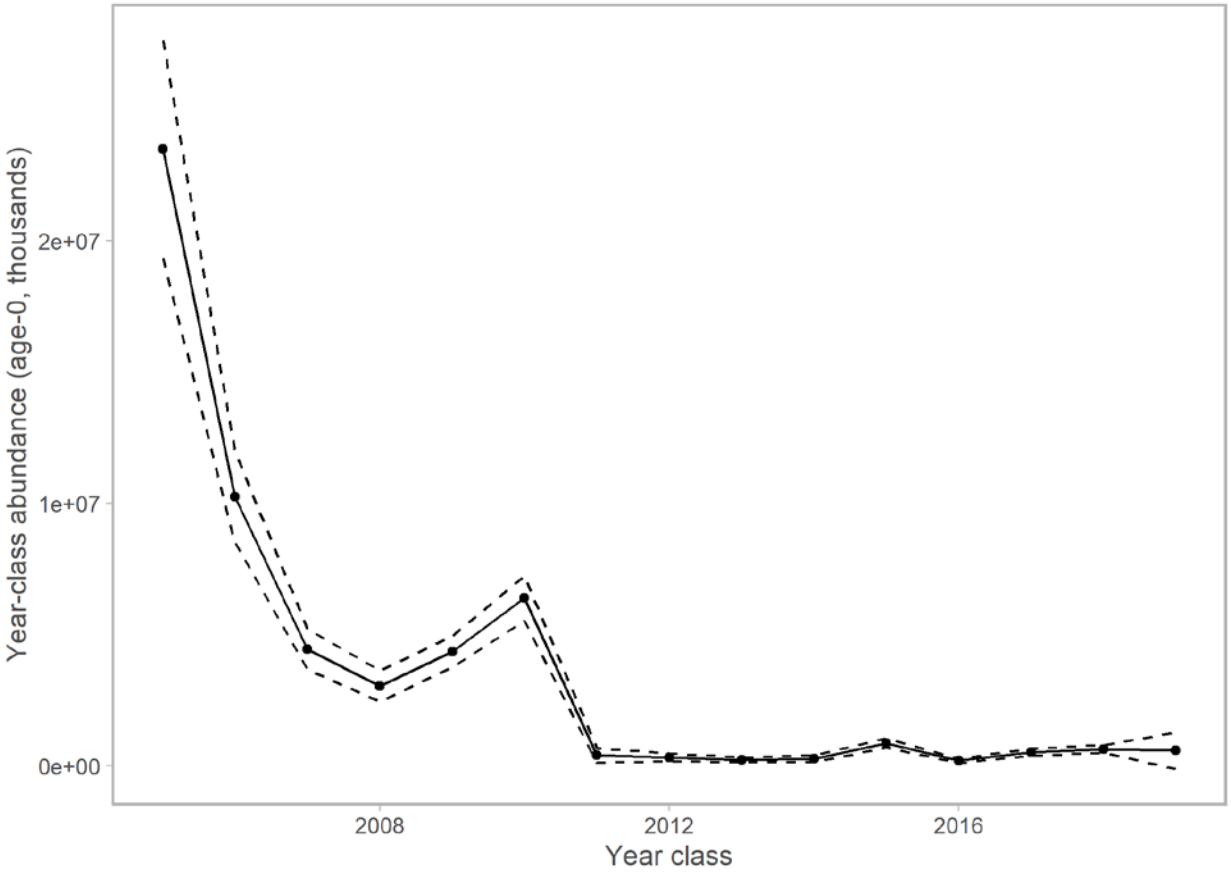


Figure 1. Estimated Pacific sardine recruitment time series (Kuriyama et al. 2020).

Appendix B: Summary of Socio-Economic Considerations

Both the continued closure and potential expanded regulations pertaining to Pacific sardine are expected to in the short run constrict economic activity and result in the loss of employment, recreational enjoyment, and international trade balances. In the long-run fishery closures may improve fishery biological health and the long-term social and economic sustainability of the fishery and related communities. There is uncertainty as to how fishery population and economic dynamics are impacted by forces outside the control of fisheries management, such as ocean conditions and domestic and global markets. This section provides an overview of CPS related fisheries and the potential socio-economic impacts of regulation; it does not provide an analysis of the socio-economic impact of potential ROA policies that are under development.

Pacific sardine is and his been an historically important component of multiple fisheries, including the commercial directed Coastal Pelagic fishery and the California recreational fishery – as supplied by the California live bait fishery. During the 2010 to 2014 period Pacific sardine made up 16 percent of total CPS landings revenues; this has shrunk to 0.2 percent during the 2016 to 2018 period (Table 1). Pacific sardine landings directly contribute to the socio-economic health of the coastal communities and the nation through multiple channels that include commercial fishing, processing, and export markets. Pacific sardine is highly utilized as live bait in the California CPFV (Commercial Passenger Fishing Vessels, or for-hire) and private boat recreational fisheries; fisheries that contributed to supporting an estimated 4,924 jobs in California during 2018. California Department of Fish and Wildlife (CDFW) CPFV logbook data shows that Pacific sardine is the only live bait utilized for 44 percent of angler days statewide during the period 2014-2018. Additionally, Pacific sardine plays a role in tribal and minor directed fisheries, that are to a degree opportunistic in species targeting selection. Finally, incidental catch in both non-Pacific sardine CPS fishery operations and several non-CPS West Coast directed fisheries contains Pacific sardine.

Introduction

Ensuring stock sustainability is a key tenant of fisheries management which helps to support economically sustainable fisheries-based communities. The Magnuson-Stevens Fishery Conservation and Management Act (MSA) mandates that fishery management plans, plan amendments, and regulations are consistent with the National Standard guidelines (https://www.fisheries.noaa.gov/national/laws-and-policies/national-standard-guidelines).
Several of the National Standards have implications for social and economic analyses of potential regulatory actions.

The economic impacts of the rebuilding alternatives for Pacific sardine will be difficult to assess and is beyond the scope of this section – that exercise will be pursued upon establishing the suite of alternatives. The objective of this section is to provide an introductory overview on the economics of CPS fisheries, and to provide context for regulatory options that may come under consideration The economic performance of wild capture fisheries is subject to market, regulatory, and environmental forces. Market conditions are in flux, as ongoing global public health concerns are impacting both market demand schedules and CPS product supply. Regulatory conditions have constrained fishery operations, and current regulatory deliberations contribute to uncertainty within the fishery sector. While environmental conditions are generally understood to impact

fisheries there is uncertainty regarding the mechanism and the degree, for instance the role that multi-decadal oceanographic factors have on CPS populations.

While past behavior can be measured and used to forecast the future, and while businesses are resilient, it is important to keep under consideration that the fishery is undergoing new conditions, and its behavioral response is to a degree unknown. This section pursues two distinct goals: (1) to provide a high-level qualitative overview of the economic and market forces that result from Pacific sardine fishery regulations; and (2) to provide a brief quantitative overview of the economics of the Pacific sardine fisheries. A detailed quantitative overview and a forecast of the economic impacts expected due to the proposed rebuilding plans is outside the scope of this section.

The Pacific sardine plays a role in multiple commercial and recreational fisheries on the West Coast. Fisheries include: directed CPS fisheries, small-scale CPS fisheries, tribal fisheries, non-CPS directed fisheries, the live bait fishery, and recreational fisheries. This section will provide an overview of each of the above fisheries and describe potential impacts of the ROA under consideration.

California Live Bait Fishery and the Recreational Fishery

California boat-based saltwater recreational fishing, both aboard CPFVs and private boats commonly utilizes live bait in the targeting and catch of a myriad of target species. Although Pacific sardine live bait is utilized throughout California, its use is spatially concentrated south of Point Conception (Southern California). This is due to a variety of factors, including target species availability and the corresponding recreational opportunities which are also dependent on external factors such as sea-state, live bait availability, and business factors.

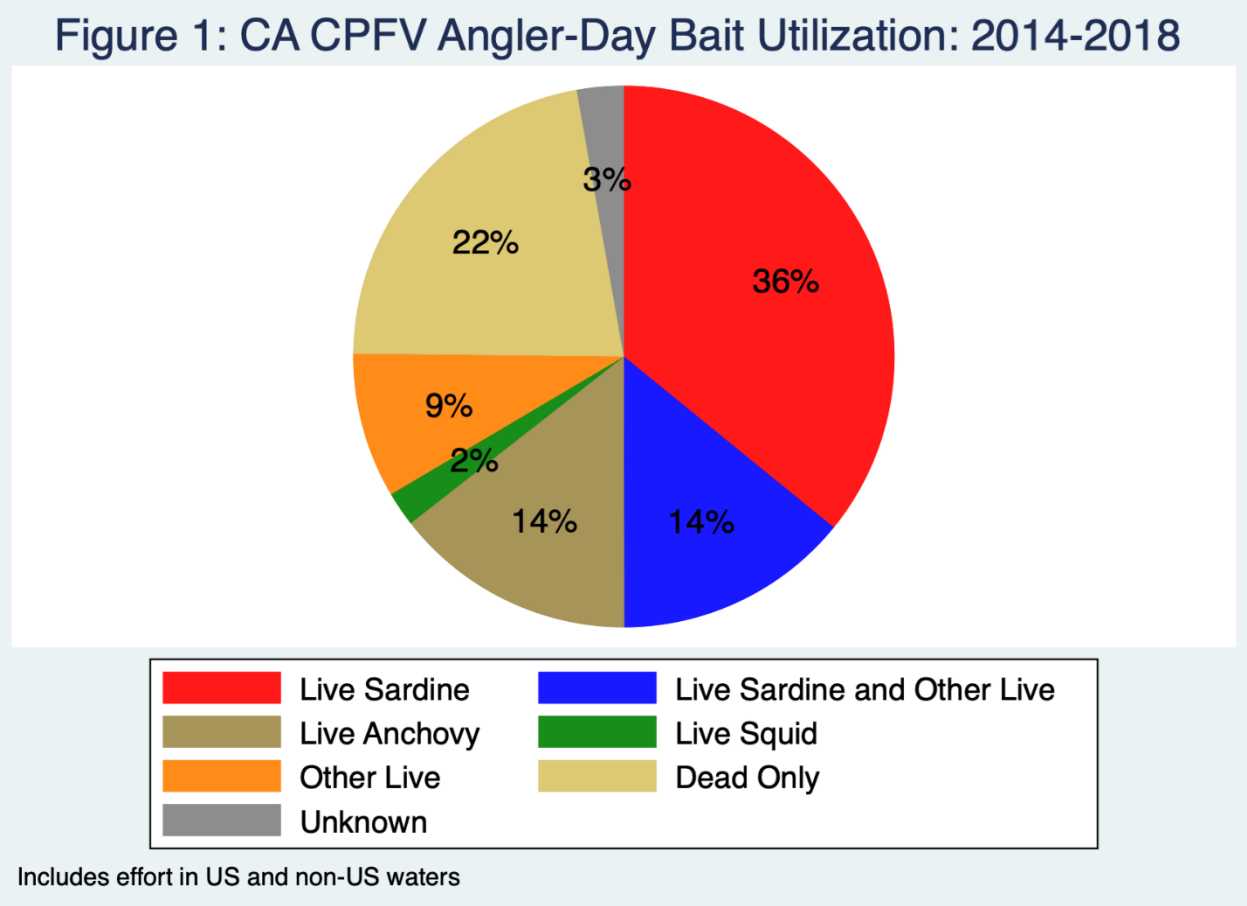
Data gaps exist in catch and economic data for live bait harvest and utilization. California live bait logs were voluntary for most years from 1939 to 2018, but with the implementation of mandatory catch reporting on fish tickets in 2019 these data gaps have been partially addressed and may provide an opportunity to further study the live bait fishery. However, data on the utilization of live bait by the CPFV industry does exist, CPFV logbooks contain data fields on the type of bait utilized on fishing trips. Using this information, we can make some general statements about bait-utilization and potential impacts.

In Southern California, boat-based recreational anglers take part in a variety of marine recreational angling trips. These trips are commonly classified: as offshore - targeting highly migratory species, such as bluefin tuna; nearshore - targeting species such as white sea bass; and groundfish trips - targeting rockfish. Offshore trips typically utilize sardine and anchovy live bait; nearshore trips utilize squid live bait in addition to sardine and anchovy; groundfish trips utilize dead bait in addition to live bait of all three species. Use of live bait in support of recreational fishing dates back to at least the 1930s; as such, the live bait fishery and both the private vessel and commercial passenger fishing vessel (CPFV) fisheries have developed together. Both private vessel owners and CPFV owners and captains consider live bait to be a necessary input to their private recreational fishing and recreational fishing businesses, respectively.

The degree of dependence on live bait of the private vessel and CPFV recreational fleets can be seen in both the development and utilization of fishing technologies, and business relationships with the live bait operators. In terms of business relationships between the live bait and CPFV industries, bait expenditures are the third highest business cost for CPFV operations statewide – behind payroll and fuel costs- accounting for an average of 9.3 percent of total vessel annual revenues based on a 2013 survey of CPFV business expenses and revenues (Hilger & Lovell, 2017 https://doi.org/10.7755/MFR.79.3-4.3). For private boat based recreational anglers, empirical data also illustrates the importance that recreational anglers place on bait. A study on angler trip expenditures reports that private-boat based anglers in California spend on average $21.59 on unspecified bait per angler day of private boat-based marine recreational fishing (Lovell et. al. 2020; https://spo.nmfs.noaa.gov/sites/default/files/TM201.pdf). These expenditures totaled an estimated $10 million in bait expenditures by private-boat recreational anglers in 2018.

Additional data illustrating the connection between the live bait fishery and the CPFV industry can be compiled through CDFW CPFV logbook data (CDFW data received 4/16/2020). CDFW logbook data contains information including the number of passengers and the classification of bait utilized for every vessel fishing day for CPFV trips to US and non-US waters departing from California. This data indicates that 36 percent of angler days utilized live Pacific sardine as their only live bait, 50 percent of angler days utilized live Pacific sardine as the only live bait or with another live bait species, and 75 percent of angler days utilized at least one species of live bait (to include: Pacific sardine, anchovy, squid, or unspecified species). Recreational angling bait utilization patterns very geographically and by target species; Pacific sardine live bait utilization is more prevalent on trips departing Southern California with target highly migratory species

While comparable live bait utilization data is not known to be available for private-boat anglers, the presence of live bait wells on a broad range of private vessels combined with high per angler day bait expenditures is suggestive of the importance of live bait to California private-boat based recreational fishing.



Taken together, the high percentage of operating costs which CPFV operations allocate to the procurement of live bait, and the high angler day utilization of live bait (primarily Pacific sardine) illustrate the important role that live bait plays in the CPFV industry.

Economic Contributions of California Recreational Fisheries

Participation in recreational fishing generates economic value (consumer surplus) for recreational anglers and generates regional economic impacts. In 2018, California recreational angling effort was estimated at 644 thousand angler days on CPFVs in US waters, 74 thousand angler days on CPFVs in non-US waters, and 497 thousand angler days on private boats (see Table 1).

Table 1: California Boat-Based Angler Days (thousands)

Year	CPFV		Private Boat	Total
	US Waters	Non-US Waters	Private	
2018	644	74	497	1,215

Angler Economic Value

The act of participating in a day of recreational fishing is economically valued by anglers. Anglers, like all consumers, gain economic value measured by consumer surplus, through the consumption of goods and services. Consumer surplus is defined as the difference between the price that consumers pay and the price they are willing to pay. In general, the presence of positive characteristics– such as high catch-rates – increase willingness to pay for a good or service; conversely, the presence of negative characteristics – such as low catch rates – decrease willingness to pay. To the extent that reductions in the availability of Pacific sardine live bait or live bait in general (in cases that Pacific sardine are available, but other species of live bait are not) decrease the amount that a consumer would be willing to pay for a recreational fishing trip, economic losses may be realized. A reduction the consumer surplus gained from an angler day may, but need not, reduce the number of angler days taken and angling expenditures.

The prevalence of Pacific sardine live bait utilization in the CPFV logbook records is suggestive of the possibility that angler valuations of both CPFV and private boat angling days would decline if use of Pacific sardine were constrained. The degree that anglers would be able to substitute for Pacific sardine utilizing alternative baits and the degree that live bait restrictions would impact consumer welfare and the number of angler days is unknown.

Recreational Fishing Industry

Private vessel and CPFV trips are made possible by a myriad of businesses across diverse sectors of the economy. These businesses include: CPFV operations; landing offices and marinas; fuel docks; tackle, vessel, and sporting equipment manufacturers and retailers; restaurants and bars; hotels; transportation companies; and live bait suppliers. Table 2 reports that in 2018 marine recreational anglers made $351 million in expenditures on both CPFV and private-boat based marine recreational fishing trips from California to both US and non-US waters. These expenditures supported an estimated 4,993 jobs, contributed to $602 million in sales impacts, $222 million in income, and $369 million in gross domestic product (GDP) to the state's economy. (based on Lovell et. al., 2020, Hilger et. al, 2019).

Table 2: 2018 CA Boat Based Marine Recreational Fishing Industry Economic Contributions

Sector	Expenditures ($M)	Jobs	Sales ($M)	Income ($M)	Value Added ($M)
CPFV: US	$214	3,264	$380	$145	$232
CPFV: Non-US	$49	834	$87	$33	$52
Private Boat	$88	895	$135	$44	$85
Total	**$351**	**$4,993**	**$602**	**$222**	**$369**

Regulations that limit a firm's operations or increase costs to a firm will, in general, result in the firm decreasing services and/or raising prices. Similarly, regulations that limit an angler's ability to or expectation of having a successful recreational fishing trip can reduce an angler's willingness to spend money on the trip. Either scenario may result in a reduction of the number of trips taken, depending on the degree to which anglers choose to substitute alternative fishing activities and/ or non-fishing activities. A decrease in the number of CPFV trips taken or prices may also result in a reduction in trip expenditures and attendant multiplier effects of recreational fishing, thereby

resulting in negative economic impacts. These economic forces apply to both private vessels and CPFV-based trips.

Uncertainty in impact of closing live bait fishery

Recreational anglers have a variety of bait options to select from; these include several species of live bait, several species of dead bait, and artificial bait. Recreational bait selection is driven by a variety of factors including: what the recreational target species responds to, longevity / durability on a fishing trip, availability, established fishing methods and equipment, and cost. Sources of uncertainty in modeling the economic impact of regulations on live bait harvest include uncertainty regarding the implications of changing recreational bait utilization on catch rates and fishing behaviors, and how the relationship between bait selection and catch rates may depend on fish population levels and the predator-prey dynamics between species as the forage base of the target species changes. Uncertainty on the implications of changing bait availability on catch rates (which impact fishing effort) and fishing behaviors (which impact costs through channels such as fuel utilization), introduces uncertainty as to the degree that alternative baits can perform as substitutes for one another, and the impact that regulatory changes would have on the socio-economics of the fishery and associated businesses and community. There are several pathways in which uncertainty can enter the analysis.

First, in the case of zero incidental catch conditions there is uncertainty on the ability of the live bait fishery to operate. The restriction would likely result in an increase in the marginal cost of supplying alternative live bait species due to the additional search time and distance covered and the associated fuel utilization (both in terms of vessel fuel and aviation fuel if spotter planes are utilized). The increase in costs would lead to the decrease in live bait provision or an increase in prices to both CPFV operations and private boat anglers.

Second, there is uncertainty regarding the impact of bait substitution on target species catch rates. On the recreational angler demand side, a reduction in target species catch rates would be expected to have two primary effects, ceteris paribus: (1) it would lower the consumer surplus of recreational anglers due to a reduction in their willingness to pay (WTP) for recreational trips, (2) it would reduce angler effort welfare as measured by a decrease in target species catch rates and would be expected to decrease recreational angling effort. Reduced target species catch rates may be offset by traveling farther (at higher cost) to access fishing grounds with higher local abundance (and CPUE). More fishing time may also be needed to reach target catch levels at lower CPUE, also increasing trip costs.

There are also potential feedback effects. Live bait species restriction driven reductions in catch rates may place downward pressure on recreational effort which would in turn decrease revenues for the live bait haulers. A reduction in revenues which is accompanied by an increase in marginal operating costs could result in the scaling back or cessation of services for both live bait haulers and CPFV vessels.

Other potential scenarios may play out. For instance, substitution patterns for recreational angling trips due to changes from current and historic conditions may result in other market opportunities; there are examples of recreational fisheries less dependent on live bait targeting highly migratory

species. It is unclear to what degree these alternative methods may be successfully applied in California, and the economic impact of the transition.

Overall a decrease in the availability of Pacific sardine live bait is expected to reduce angler consumer surplus and decrease angler effort resulting in the reduction of positive economic impacts to the economy.

Commercial CPS

Overview

The directed fishery for Pacific sardine remains closed, having closed in 2015. Pacific sardine landings are currently limited to the live bait fishery, tribal fisheries, minor directed fisheries, and incidental catch. In 2018 Pacific sardine landings for California, Oregon, and Washington totaled 338 mt with exvessel revenues totaling $80,603. As a percentage of CPS totals, Pacific sardine landings accounted for 1 percent of landings and less than 1 percent revenues in 2018; a change from the five-year 2013-2017 average of 18 percent for landings and 8 percent for revenues. Relative to the pre-closure 2011-2015 period, the Pacific sardine fishery has decreased by over 99 percent in terms of landings and revenues; annual average landings for the 2011-2015 period was 47,881 mt with annual average revenues (2018$US) of $12.2 million.

Excluding the California live bait fishery, total coastal pelagic species landings for California, Oregon, and Washington totaled 57,034 metric tons (mt) in 2018, a 20 percent decrease from the 2017 landings of 71,241 mt. Total coastal pelagic species exvessel revenues totaled $41,980,524 in 2018, a 42 percent decrease from the 2017 exvessel revenues of $72,051,440 (2018$US). Relative to the 2013-2017 five-year average of 104,564 mt in landings and $67,691,964 in revenues, 2018 landings and ex-vessel revenues (2018$US) decreased by 45 percent for landings and decreased by 38 percent for revenues.

While the West coast market squid fishery has been an important component of the CPS fishery for the last 30 years, its role as the major source of CPS landings and revenues has become more pronounced since the closure of the directed Pacific Sardine fishery. Market squid landings for California, Oregon, and Washington totaled 36,375 mt in 2018 with exvessel revenues totaling $38,841,122. Relative to the 2013-2017 five (5) year average of 69,213 mt in landings and $59,176,497 in revenues, 2018 landings and exvessel revenues (2018$US) decreased by 47 percent for landings and decreased by 34 percent for revenues. As a percentage of CPS totals, market squid landings accounted for 64 percent of landings and 93 percent revenues in 2018; a change from the five-year 2013-2017 average of 66 percent for landings and 87 percent for revenues.

Table 1 reports annual west coast CPS landings, in mt, and exvessel revenues, in 2018 US$, by species. Figure 2 presents total CPS west coast landings and revenues from 1981 to 2018. Figure 2 presents annual CPS landings by species from 1981 to 2018. Figure 4 presents the percentage contribution of west coast CPS finfish and market squid to total west coast exvessel revenues from 1981 to 2018.

Figure 2: Annual West Coast Landings and Exvessel Revenues (2018 $) for all CPS Species, 1981-2018

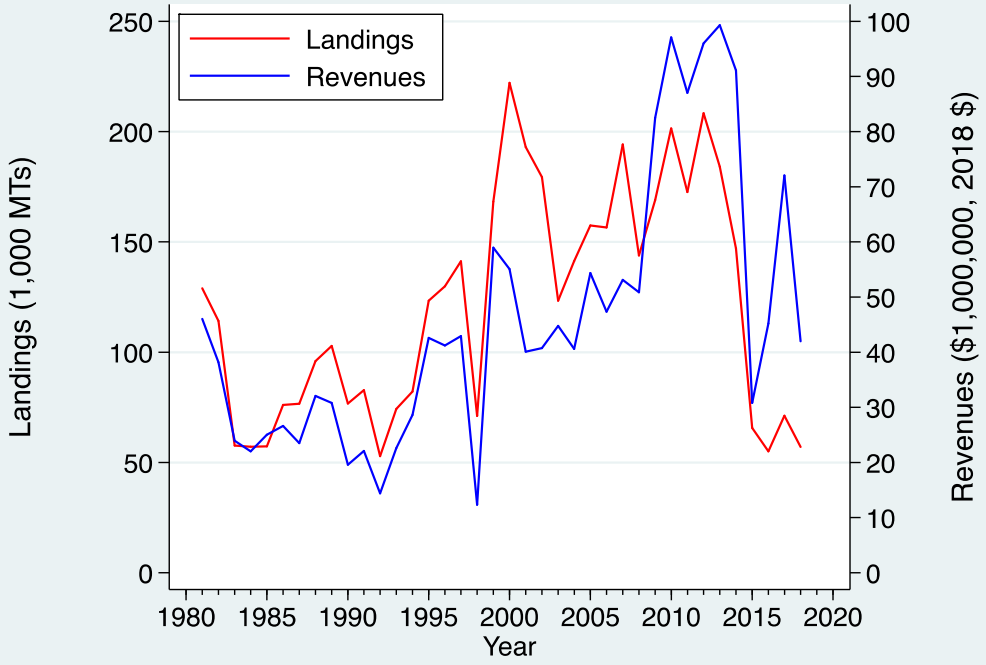


Figure 3: West Coast CPS Landings by Species, 1981-2018

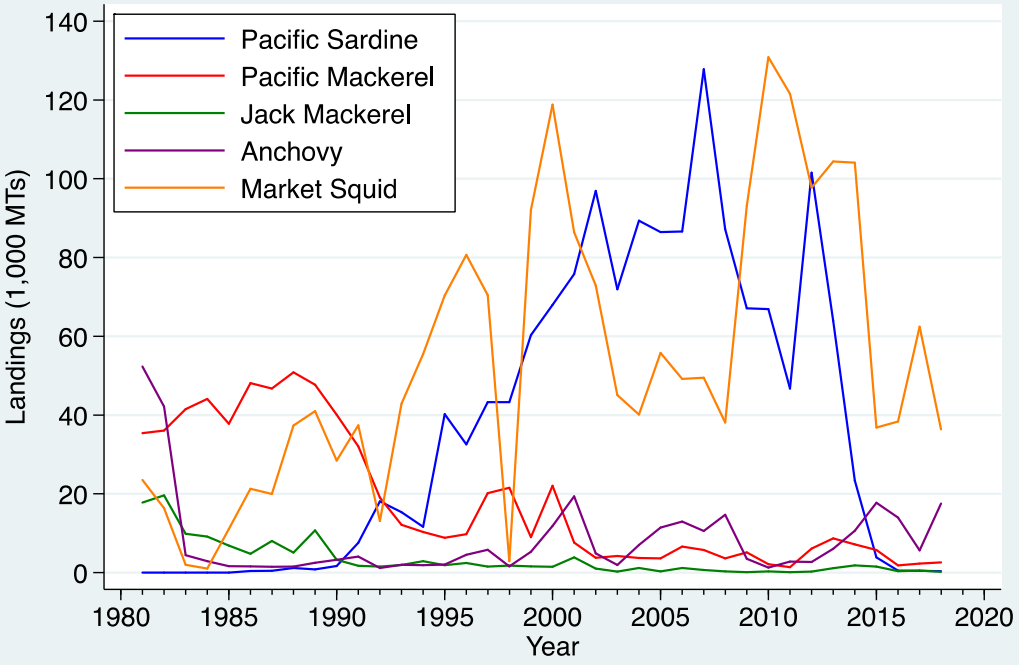


Figure 4: West Coast CPS Exvessel Revenues (2018 $) by Species, 1981-2018

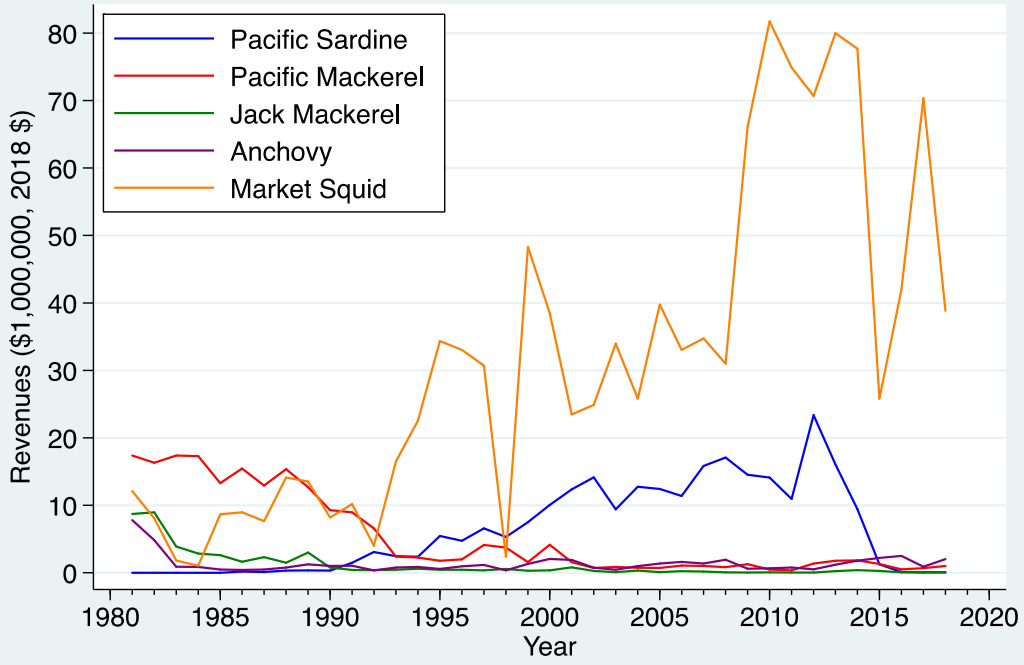
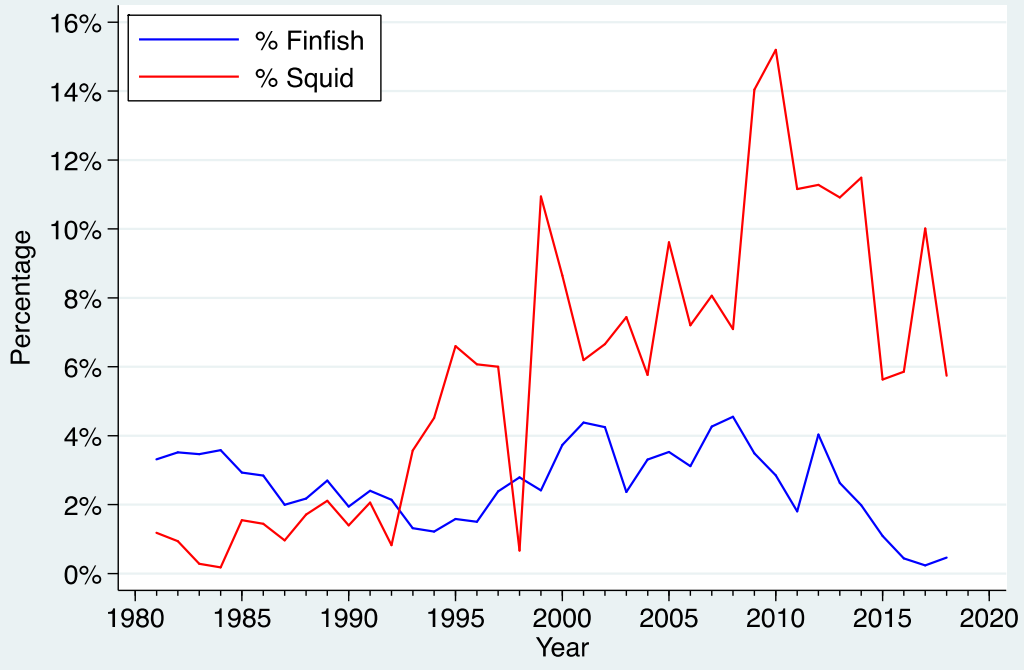


Figure 5: Percentage Contribution of West Coast CPS Finfish and Market Squid to Total West Coast Exvessel Revenues, 1981-2018



Additional fisheries

In addition to the CPS directed and California live bait fisheries, several other fisheries make landings of Pacific sardine. These include targeted landings by minor directed and tribal fisheries, and incidental landings by non-CPS directed fisheries.

Minor directed and tribal fisheries report making Pacific sardine landings. These fisheries may make targeting decisions based on local species availability. Minor directed fisheries are limited to landing less than one mt per day and typically harvest only on a seasonal basis due to a variety of reasons that include weather and market demand. Tribal fisheries are limited geographically and therefore reliant on sardine availability within their usual and accustomed fishing areas but are not subject to the same regulatory requirements.

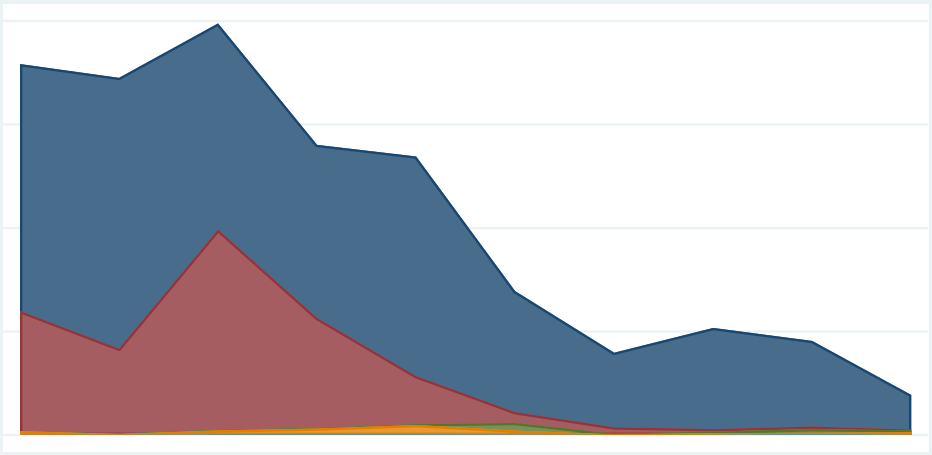
Additionally, non-CPS directed commercial fisheries make incidental landings of Pacific sardine. Small amounts of incidental take occur in non-CPS fisheries such as the Pacific whiting fishery. Recent management measures have allowed for up to 2 mt per landing in non-CPS fisheries.

Reductions in allowable catch to minor directed fisheries would potentially have negative socio-economic impacts. The extent of these impacts may be impacted by target species alternatives available to the vessel, and alternative economic opportunities available in cases where commercial fishing is no longer economically viable.

CPS Markets and International Trade

The export of US products helps support US fisheries and contributes to the nation's balance of payments. Since 2012, both export volume and export value of CPS products from the West coast have been following a downward trend (Figures 6 and 7). Regulations that limit target species availability, constrict fishery and processing operations. Over time, increased vessel and processor attrition is expected, and marketing channels and exports may be reduced - leading to socio-economic losses. However, in addition to the previously mentioned forces, the long-run sustainability of CPS fisheries, markets, and the communities they support is reliant on the long-run sustainability of the stocks which they target.

Figure 6: West Coast Export Weight

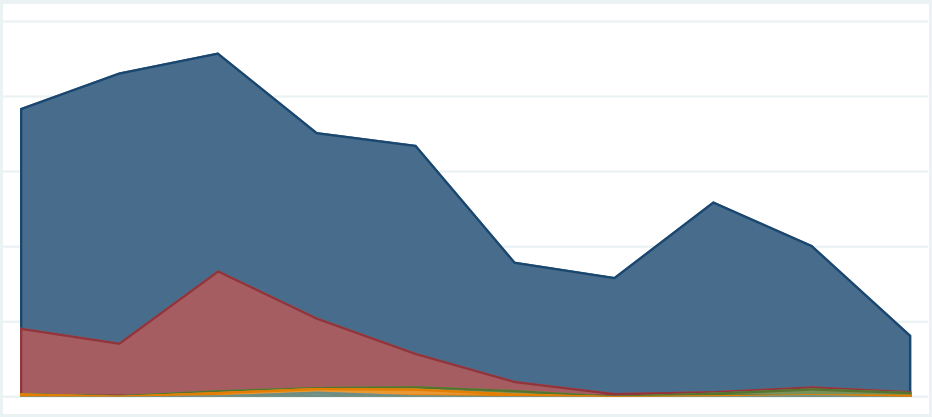


el

Jack Mackerel

Figure 7: West Coast Export Value

Value



k Mackerel

Table 3. West coast landings (mt) and real[1] exvessel revenues (2018$) for Pacific sardine, Pacific mackerel[2], jack mackerel, anchovy and market squid, 2009-2018[3].

Year	Pacific Sardine mt	Pacific Sardine Rev	Pacific Mackerel mt	Pacific Mackerel Rev	Jack Mackerel mt	Jack Mackerel Rev	Anchovy mt	Anchovy Rev	Squid mt	Squid Rev
2009	67,084	$14,527,322	5,138	$1,282,682	121	$22,355	3,480 *	$588,476 *	93,107	$66,102,454
2010	66,892	$14,133,334	2,107 *	$476,662 *	314 *	$71,983 *	1,284	$646,366	130,864	$81,754,947
2011	46,746	$10,954,443	1,364 *	$367,982 *	104	$21,075	2,792 *	$771,755 *	121,557	$74,913,427
2012	101,555	$23,383,210	6,070	$1,374,238	271	$43,071	2,705	$502,716	97,734	$70,695,834
2013	63,895	$16,089,470	8,704 *	$1,784,171 *	1,095	$227,241	6,049 *	$1,189,825 *	104,405	$80,012,672
2014	23,344	$9,445,584	7,157	$1,827,689	1,837	$379,614	10,625	$1,788,369	104,093 *	$77,676,198 *
2015	3,864	$1,232,313	5,731	$1,295,939	1,538	$264,700	17,398 *	$2,197,158 *	36,807	$25,799,388
2016	522	$109,970	1,830	$504,426	374	$65,094	13,959	$2,500,667	38,350	$42,017,892
2017	433	$63,208	2,299	$675,211	484	$58,578	5,613	$878,111	62,412	$70,376,336
2018	338	$80,603	2,591	$1,001,639	205	$29,087	17,525 *	$2,028,074 *	36,375	$38,841,122

Source: PacFIN. Extraction dates: 10/08/2019.

* Denotes that the reported figure in this cell is underreported due to confidentiality guidance.

[1] Revenue is reported in real dollars to account for inflation using the GDP implicit price deflator with a 2018 base year.

[2] Pacific mackerel landings and revenues also include landings and revenues of unspecified mackerel.

[3] 2017 & 2018 data are preliminary at time of data extraction.

PFMC
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