Summary of Socio-Economic Considerations Related to the Pacific Sardine Rebuilding Plan

Both the continued closure of the primary directed fishery and potential expanded regulations pertaining to fisheries that harvest Pacific sardine are expected to constrict economic activity in the short run and result in a loss of employment and recreational enjoyment, and an increase to the U.S. seafood trade deficit. 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 the sardine 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 economic overview of coastal pelagic species (CPS)-related fisheries and the potential socio-economic impacts of regulation; it provides a qualitative comparative discussion of the socio-economic impacts of potential policies under the range of alternatives (ROA). This document updates information provided in Appendix B of G.1.a, CPSMT Report 1 for the June 2020 PFMC meeting briefing book. Major additions include information on: California sardine landings in the live bait fishery, details on state level catch of Pacific sardine, incidental catch of Pacific sardine in the groundfish fishery, forage and other non-fishery values, and a qualitative comparative economic discussion of the ROA under consideration.

Pacific sardine is and has been a historically important component of multiple West Coast fisheries, including directed CPS fisheries, small-scale CPS fisheries, tribal fisheries, non-CPS directed fisheries, the live bait fishery, and recreational fisheries. During the 2010 to 2014 period, Pacific sardine made up 16 percent of total West Coast CPS landings revenues; this has shrunk to 0.2 percent during the 2016 to 2018 period. West Coast Pacific sardine landings directly contribute to the socio-economic health of the coastal communities and the nation through multiple channels that have included 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 supported an estimated 4,924 jobs in California during 2018. California Department of Fish and Wildlife (CDFW) CPFV logbook data show Pacific sardine utilized for 44 percent of angler days statewide during the period 2014-2018. Additionally, Pacific sardine plays a role in West Coast 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 contain Pacific sardine.

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). The MSA states:

(4) For a fishery that is overfished, any fishery management plan, amendment, or proposed regulations prepared pursuant to paragraph (3) or paragraph (5) for such fishery shall—

(A) specify a time period for rebuilding the fishery that shall—

(i) be as short as possible, taking into account the status and biology of any overfished stocks of fish, the needs of fishing communities, recommendations by international organizations in which the United States participates, and the interaction of the overfished stock of fish within the marine ecosystem; and

(ii) not exceed 10 years, except in cases where the biology of the stock of fish, other environmental conditions, or management measures under an international agreement in which the United States participates dictate otherwise;

(B) allocate both overfishing restrictions and recovery benefits fairly and equitably among sectors of the fishery; and

(C) for fisheries managed under an international agreement, reflect traditional participation in the fishery, relative to other nations, by fishermen of the United States. (MSA Section 304(e)(4)).

In reference to subsection (i)'s mandate, the United States Court of Appeals, Ninth Circuit wrote, "The natural reading of this language, however, is that Congress intended to ensure that overfished species were rebuilt as quickly as possible, but wanted to leave some leeway to avoid disastrous short-term consequences for fishing communities (Natural Resources Defense Council v. NMFS, 421 F.3d 872 (9th Cir. 2005)." 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 are difficult to assess. This report provides a qualitative comparative discussion of impacts of the rebuilding alternatives. The objective of this report is to provide an introductory overview on the economics of West Coast CPS fisheries, and to provide context for regulatory options 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 mechanisms, but there is evidence that both sardine and anchovy populations along the West Coast have undergone orders of magnitude population fluctuations long before there were commercial fisheries targeting these stocks that are thought to be environmental driven (Soutar and Issacs 1969, Baumgartner et al. 1992, McClatchie et al. 2017).

While past behavior can be measured and used to forecast the future, and while businesses are resilient, it is important to consider that the fishery is undergoing new conditions, and its behavioral response is to a degree unknown. This section pursues several distinct goals: (1) to provide a high-level qualitative overview of the economic and market forces that may impact fisheries that target or land CPS in the context of rebuilding plan development for Pacific sardine; (2) to provide a brief quantitative overview of the economics of the Pacific sardine fisheries; and (3) to provide a comparative discussion of the alternatives under consideration.

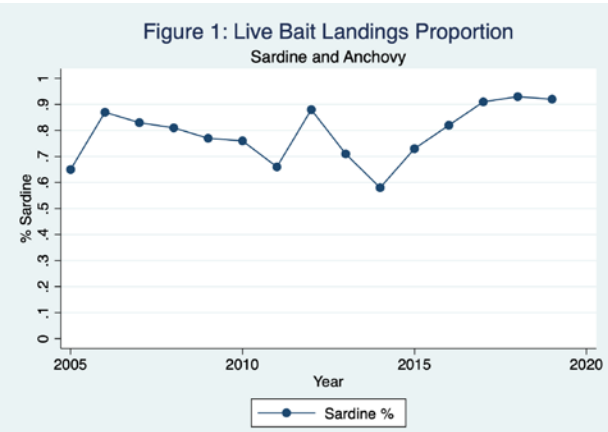
Live Bait Fishery and the Recreational Fishery

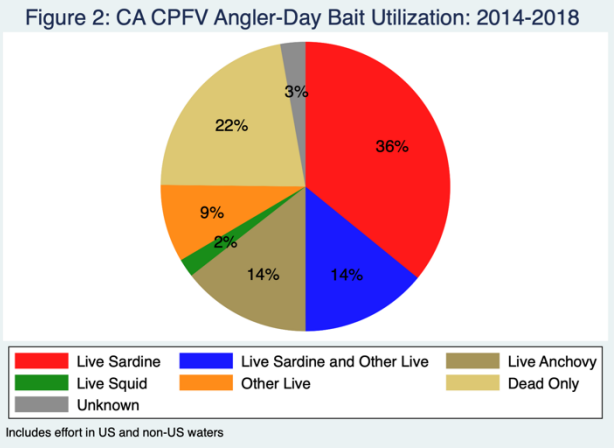
California boat-based saltwater recreational fishing, both aboard CPFVs and private boats, commonly utilizes live bait in the targeting and catch of a myriad of target species. Although Pacific sardine utilization for live bait occurs throughout California, its use in the states of Oregon and Washington is *de minimus*, and its use in California is spatially concentrated south of Point Conception (Southern California). The distribution of live bait usage 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 regulatory and business factors. In 2018, records indicate that there were at least seven vessels active in the California live bait fishery.

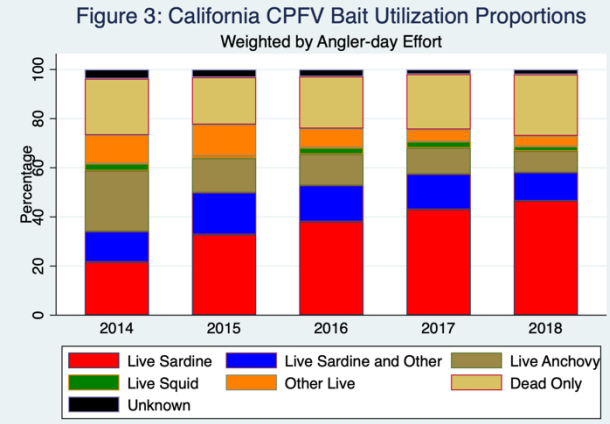
Data gaps exist in catch and economic data for live bait harvest and utilization. California live bait logs were voluntary for most years from 1939 to 2018, but with the implementation of mandatory catch reporting on fish tickets in 2019 these data gaps have been partially addressed and may provide an opportunity to further study the live bait fishery. However, while utilizing the historical data the estimation of landings levels may involve a great deal of uncertainty, the data may provide useful information such as the proportion of landings consisting of sardine. Additionally, data on the utilization of live bait by the CPFV industry does exist, as 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.

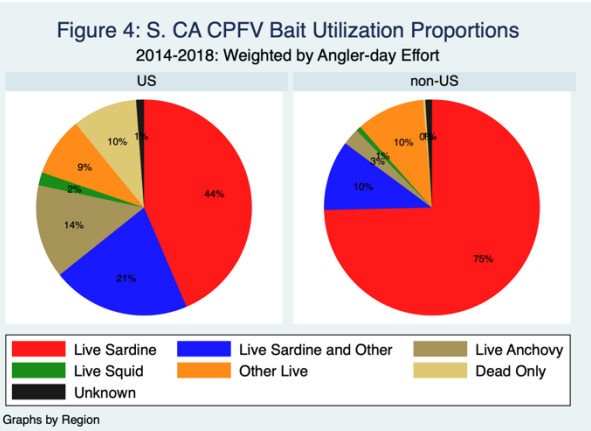
Landings data can be utilized to calculate the proportion of landings[1]. Over the 2005 to 2019 period, sardine accounted for 79 percent (Std. Dev. =.11) of reported landings weight for sardine and anchovy (See Figure 1). While the proportion of sardine catch in the live bait fishery has not been constant, the prevalence of sardine landings illustrates the importance of sardine to the live bait fishery.

[1]The annual proportion estimate is provided under the assumptions that landing weight measurements are independent of species within vessel – year, and that species mix is independent of vessel.









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 part of 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. The adoption of live bait-specific technology, such as live bait wells with water circulation technology aboard private vessels and CPFVs, and live bait specific recreational tackle has required financial investments and utilizes space on vessels that would be otherwise used for other purposes[2]. 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

[2] Many of the same investments can be seen in the private boat fleet.

annual revenues based on a 2013 survey of CPFV business expenses and revenues (Hilger & Lovell, 2017). Based on average CPFV ticket expenses / guide fees of $202.35 (2018$) for 559,680 passengers[3], and that roughly 75 percent of all CPFV effort utilized some form of live bait, CPFVs are conservatively estimated to have spent roughly $8.1 million on all bait expenses in 2018. For private boat-based recreational anglers, empirical data also illustrates the importance that recreational anglers place on bait. Based on an estimated 501,020 private boat fishing trips taken by adults, expenditures on unspecified bait totaled an estimated $11 million (2018$) by private boat recreational anglers in 2018 (Lovell et al., 2020).

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 U.S. and non-U.S. waters departing from California. These data indicate that from 2014 through 2018, 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) (Figure 2). Figure 3 illustrates annual live bait utilization by species for the period 2014 through 2018. Consistent with Figure 1, Figure 2 shows a relatively stable proportion of trips utilizing sardine live bait, with the exception of 2014 which marked both higher levels of relative anchovy live bait landings and overall live bait utilization on CPFV trips.

Recreational angling bait utilization patterns very geographically and by target species. Pacific sardine live bait utilization is more prevalent on trips departing from San Diego, Orange, and Los Angeles counties in Southern California. For these counties, the combined angler effort day bait utilization percentages were 44 percent, 64 percent, and 89 percent, respectively, for Pacific sardine as the sole live bait, Pacific sardine mixed with other species at live bait, and at least one species of live bait. For U.S. based trips from Southern California into non-U.S. waters, the angler effort day bait utilization percentages were 75 percent, 85 percent, and 99 percent, respectively, for Pacific sardine as the only live bait, Pacific sardine mixed with other live bait species, and at least one species of live bait (Figure 4). Outside of San Diego, Orange, and Los Angeles counties, live bait utilization is less prevalent, based on CPFV logbook records.

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.

Angler Economic Value

In 2018, California recreational angling effort was estimated at 644 thousand angler days on CPFVs in U.S. waters, 74 thousand angler days on CPFVs in non-U.S. waters, and 497 thousand angler days on private boats.

The act of participating in a day of recreational fishing is economically valued by anglers and can be measured as consumer surplus. Consumer surplus is defined as the difference between the price

[3] Note, this estimate excludes CPFV effort in non-US waters.

that consumers pay and the price they are willing to pay. In general, the presence of positive characteristics increases willingness to pay for a good or service; conversely, the presence of negative characteristics decreases willingness to pay. To the extent that reductions in the availability of Pacific sardine live bait or live bait in general decrease the amount that a consumer would be willing to pay for a trip, economic losses may be realized. These losses can be segmented into those losses to the consumer in terms of their economic welfare, and those that would accrue to businesses due to a reduction in the quantity of fishing trips demanded due to lower consumer valuations. A reduction in 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 suggests that angler valuations of both CPFV and private boat angling days would decline if use of Pacific sardine were constrained. It is unknown the degree that anglers would be able to substitute for Pacific sardine utilizing alternative baits and how much live bait restrictions would impact consumer welfare and the number of angler days.

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. 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 U.S. and non-U.S. waters (Table 1). 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 and Lovell, 2018).

Table 1: 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 predicting the economic impact of regulations on live bait harvest include uncertainty as to the relationship between recreational bait utilization and catch rates and fishing behaviors, 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 (commonly referred to as 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 catch per unit effort (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.

Substitution and adaptation

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 such as in New Zealand (Burgess, 2020) and Australia (Getfishing.com.au, 2020). It is unclear to what degree these alternative methods may be successfully applied in California, and the economic impact of the transition.

The prohibition of Pacific sardine live bait harvest may lead to direct and indirect economic costs through decreasing the availability of live bait. The effects of reducing live bait availability on California recreational fisheries and related businesses may be negative, immediate, and potentially substantial depending on: the availability of substitute live bait species; the impact on target species specific catch rates of live bait species substitution; the degree to which anglers substitute away from current fishing practices to alternative fisheries and/or non-fishing activities; and the ability of firms to adapt to new fishing practices, technology, capital, and business and marketing practices.

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 West Coast Pacific sardine commercial primary directed fishery is an important fishery with historical cultural and community roots that has served as a major component of the West Coast commercial CPS fishery. Throughout the mid-1990s to early 2010s the West Coast CPS fishery landed Pacific sardine with ex-vessel revenue values in the millions of dollars, and between 2000 and 2014 upwards of roughly $10 million annually (Figures 5 and 6; Table 2).

In 2015 the primary directed fishery for Pacific sardine closed. 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 ex-vessel revenues totaling $80,603 (2018$). As a percentage of CPS totals, Pacific sardine landings accounted for roughly 0.6 percent of landings and 0.2 percent revenues in 2018: a change from the five-year 2010-2014 average of 33 percent for landings and 16 percent for revenues. Relative to the pre-closure 2010-2014 period, the Pacific sardine fishery has decreased by over 97 percent in terms of landings and revenues. Annual average landings for the 2010-2014 period were 60,485 mt with annual average revenues of $14.8 million; these decreased to an average of 1.3 mt with landing revenues of $371,524 for the 2015-2018 period (PFMC, 2019).[4]

Excluding the California live bait fishery, total CPS 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 CPS ex-vessel revenues totaled $41,980,524 in 2018, a 42 percent decrease from the 2017 exvessel revenues of $72,051,440. Relative to the 2010-2014 five-year average of 182,713 mt in landings and $94,106,376 in revenues, landings and revenues for the 2015-2018 period decreased 66 percent and 41 percent, respectively, to an annual average 62,162 mt and $47,504,878 respectively (PFMC, 2019).

[4] The 2015-2018 period figures include the period between January 1 and June 30th, prior to the closure of the Pacific sardine primary directed fishery.

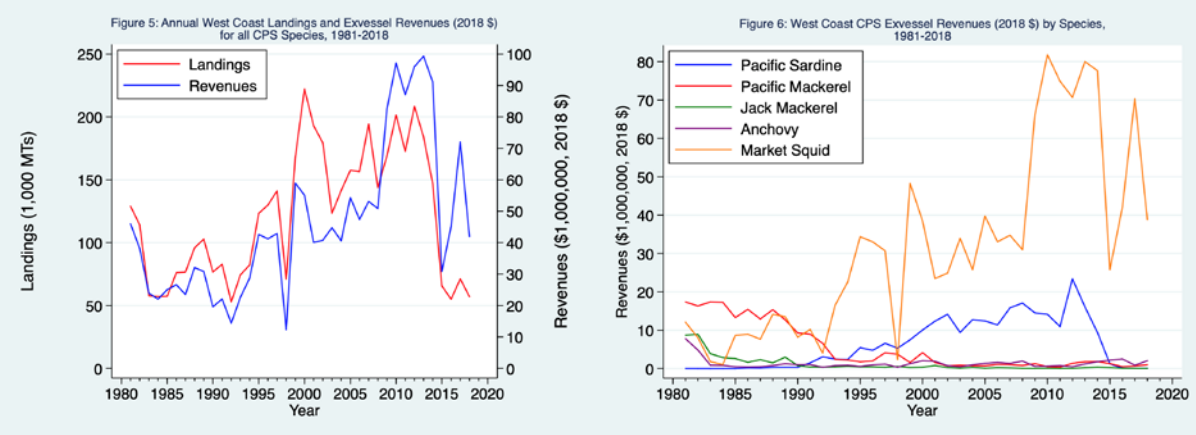


Table 2. West Coast CPS real[1] exvessel revenues (2018$), 2009-2018[2].

Year	Pacific Sardine Rev	Pacific Mackerel Rev[3]	Jack Mackerel Rev	Anchovy Rev	Squid Rev
2009	$14,527,322	$1,282,682	$22,355	$588,476 *	$66,102,454
2010	$14,133,334	$476,662 *	$71,983 *	$646,366	$81,754,947
2011	$10,954,443	$367,982 *	$21,075	$771,755 *	$74,913,427
2012	$23,383,210	$1,374,238	$43,071	$502,716	$70,695,834
2013	$16,089,470	$1,784,171 *	$227,241	$1,189,825 *	$80,012,672
2014	$9,445,584	$1,827,689	$379,614	$1,788,369	$77,676,198 *
2015	$1,232,313	$1,295,939	$264,700	$2,197,158 *	$25,799,388
2016	$109,970	$504,426	$65,094	$2,500,667	$42,017,892
2017	$63,208	$675,211	$58,578	$878,111	$70,376,336
2018	$80,603	$1,001,639	$29,087	$2,028,074 *	$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] 2017 & 2018 data are preliminary at time of data extraction.

[3] Pacific mackerel revenues also include revenues of unspecified mackerel.

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. West Coast market squid landings totaled 36,375 mt in 2018 with exvessel revenues totaling $38,841,122. The 2010-2014 five (5) year average was 111,731 mt in landings and $77,010,616 in revenues. As a percentage of CPS totals, market squid landings accounted for 82 percent and 93 percent of landings revenues for the 2010-2014 and 2015-2018 periods respectively (PFMC, 2019) showing an increase in the relative dependence on a single fishery.

Regional-level breakout of the CPS fishery

The West Coast commercial fishery can be described by multiple regional sectors: southern California, northern California, and the Pacific Northwest. Commercial fisheries are defined by ports as follows: southern California includes ports from San Diego in the south to Morro Bay in the north, northern California includes ports from Monterey in the south to Crescent City in the north, and Pacific Northwest includes ports from Oregon and Washington.

Pacific sardine targeted regulations would be expected to impact the fishery heterogeneously across regional sectors. Regional sectors for which Pacific sardine have historically made up a large portion of landings and revenues may be impacted by increased or continued regulations to a larger degree than those regional sectors that have historically been less dependent on Pacific sardine landings. However, it is noted that a large proportion of CPS landings and revenues are associated with export markets, and that the success of these markets and the supply chain which they are built on, in part, depends on market stability.

The southern California sector had CPS landings of 22,230 mt and revenues of $22,113,835 (2018$U.S.) in 2018. For the 2010-2014 period, landings and revenues were 105,930 mt and $62,406,396, respectively. This accounted for a 39 percent share in West Coast landings, and a 53 percent share of West Coast revenues; this marked a change from the 2010-2014 period landings shares of 39 percent and revenue shares of 53 percent.

For Pacific sardine, the southern California sector accounted for 77 percent West Coast landings and 88 percent West Coast revenues in 2018. This is in contrast to 24 percent of landings and 17 percent of revenues for the 2010-2014 period. The northern California sector had CPS landings of 31,255 mt and revenues of $16,734,379 (2018$U.S.) in 2018. 2017 landings and revenues were 13,967 mt and $10,391,048, respectively. This accounted for a 55 percent share in West Coast landings, and a 40 percent share of West Coast revenues; this marked a change from the 2010-2014 period landings shares of 19 percent and revenue shares of 22 percent.

For Pacific sardine, the northern California sector accounted for 20 percent of Pacific sardine West Coast landings and 8 percent of West Coast revenues in 2018. This is in contrast to 9 percent of landings and 8 percent of revenues for the 2010-2014 period.

The Pacific Northwest sector had CPS landings of 3,549 mt and revenues of $3,132,312 (2018$U.S.) in 2018. 2017 landings and revenues were 569 mt and $89,886, respectively. This accounted for a 6 percent share in West Coast landings, and a 7 percent share of West Coast

revenues; this marked a change from the 2010-2014 period landings shares of 23 percent and revenue shares of 12 percent.

For Pacific sardine, the Pacific Northwest sector accounted for 3 percent of Pacific sardine West Coast landings and 4 percent of West Coast revenues in 2018. This is in contrast to 67 percent of landings and 75 percent of revenues for the 2010-2014 period (PFMC, 2019).

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 landing Pacific sardine. These fisheries may make targeting decisions based on local species availability. Minor directed fisheries are limited to landing up to 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 minor directed fishing is no longer economically viable.

Commercial Groundfish Fishery

Pacific sardine is incidentally caught in several fisheries including the West Coast groundfish fishery. Average annual landing revenues in the groundfish fishery during the 2014 through 2019 period were roughly $99.9 million (2018$) (PFMC, 2019b).

Incidental landings of sardine have been documented in multiple groundfish sectors during the 2011 through 2019 period (see Table 3). Over that period, average annual sardine landings totals were 2.6 mt, with a minimum of 0.2 mt in 2011, and a maximum of 6.8 mt in 2019. In 2018 and 2019, the whiting sectors accounted for about 95 percent of incidental sardine landings, and non-whiting sectors accounting for roughly 5 percent. Note, total mortality has been zero for recreational fisheries and for individual fishing quota participants using fixed gears.

At the fish ticket level, sardine are reported in an average annual 0.4 percent of all groundfish tickets for the 2014 through 2019 period. The minimum annual percentage was 0.1 percent in 2015, and the maximum annual percentage was 0.8 percent in 2019.

From a revenue standpoint, the timing of the annual initial sardine landing in the groundfish fishery is of interest. For the 2014 through 2019 period, sardine was landed as early as February 21st in

2014 and as late as May 17th in 2016. An average of 13.4 percent of annual groundfish landing revenues occurred prior to the date of the first sardine landing that calendar year. The minimum pre-sardine groundfish revenue percentage was 4.4 percent in 2014, and the maximum was 20.6 percent in 2016.

At the haul level, Pacific sardine are reported in both whiting at-sea coastal processor and at-sea mothership hauls. For the 6-year period of 2014 through 2019, 3.5 percent and 4 percent of annual at-sea coastal processor and at-sea mothership hauls, respectively, contained Pacific sardine. The minimum annual percentages were 0.8 percent in 2014 and 0.6 percent in 2015 for at-sea catcher processors and at-sea mothership respectively; while the maximum annual percentages were 9.5 percent and 9.7 percent, respectively, in 2019.

While the economic value of the groundfish fishery extends beyond landing revenues, the magnitude of those revenues places the importance of the groundfish fishery in context. Recent levels of sardine incidental catch in the groundfish fishery should be considered in the evaluation of the ROA under consideration. Conditional on biomass levels, Alternative 1 and Alternative 3 have the potential to constrain current economic activities that land sardine; these activities include the live bait fishery, and commercial fishery such as groundfish and non-sardine CPS. It is noted that the groundfish fishery accounts for roughly 1 to 2 tenths of a percent (0.1 percent - 0.2 percent) of average recent total sardine landings.

Alternative 2, zero catch of Pacific sardine is interpreted as a prohibition on catching Pacific sardine. A prohibition of Pacific sardine landings would have a negative impact on all fisheries landing Pacific sardine. While landings of Pacific sardine occur on a relatively small number of overall groundfish fish tickets (0.4 percent), they are observed on roughly 3 to 4 percent of whiting at-sea coastal processor and at-sea mothership hauls. Additionally, the first sardine landed in the groundfish fishery occurs, on average, relatively early in the season – after only 13.4 percent of average annual revenues are made. The overall expected economic impact from a prohibition of Pacific sardine landings in the groundfish fishery would in part depend on how the prohibition was carried out and the degree that the groundfish fishery was permitted to operate – prior to landing Pacific sardine. In closing, it is noted that based on recent historic timing of the first incidental landings of Pacific sardine, that the groundfish fishery would have shut down after landings contributing to 13.4 percent of annual revenues which average $94.9 million. Thus, roughly $82 million in annual groundfish landing revenues and the associated economic impacts could be at risk.

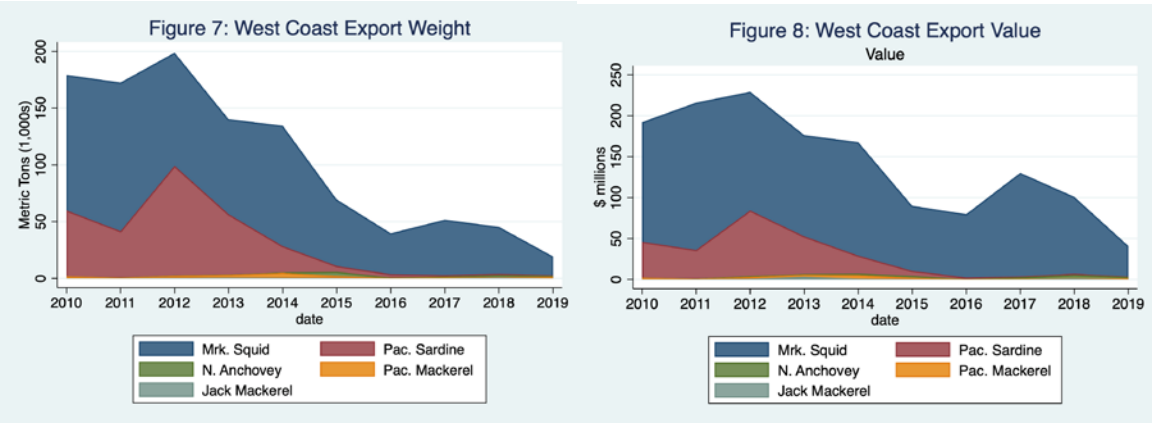
CPS Markets and International Trade

The export of U.S. products helps support U.S. fisheries and contributes to the nation's balance of payments. Historically, the export of CPS species accounted for roughly 10 percent of total U.S. fisheries exports from the West Coast (CA, OR, and AK). Since 2012, both export volume and export value of CPS products from the West Coast have been following a downward trend (Figures 7 and 8). 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.

Table 3. Sardine total mortality (landings and discard mortality) by groundfish sector and year.

Sector	2011	2012	2013	2014	2015	2016	2017	2018	2019
Whiting: Catcher-processor, Mothership, IFQ whiting	0.1	0.4	0.9	0.7	0.3	0.7	2.7	5.6	6.4
IFQ mid-water non-whiting	0.0	0.0	0.1	0.7	0.0	0.1	1.1	0.0	0.4
IFQ bottom trawl	0.1	0.7	2.1	0.1	0.1	0.0	0.1	0.0	0.0
Commercial non-trawl (LEFG OA)*	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total mortality	**0.2**	**1.1**	**3.2**	**1.5**	**0.4**	**0.8**	**3.9**	**5.6**	**6.8**

*Total mortality is zero for recreational fisheries and for IFQ participants using fixed gears.
Source: C.1.a, NWFSC Report 4:, 2020.



Forage and other non-fishery values

The value of Pacific sardine is not limited to commercial fishery landings or use as bait in both commercial and recreational fisheries. The scientific literature illustrates that Pacific sardine are understood to play an ecological role as forage and may even play a role in general ocean health (Bakun and Weeks, 2004).

In its role as forage, Pacific sardine has an economic value; this value is partially dependent on the value of the predators that forage on sardine and the predator's dependence on sardine as a source of forage. Pacific sardine plays a role as forage to multiple species including commercial fisheries target species, non-target species, marine mammals, and seabirds. These wide variety of species can be valued in the context of commercial fisheries, but also in the role that they play in the ecosystem (Chami et. al., 2019), wildlife viewing (Pendleton, 2004; Saaymam, 2014), and in their existence (Harvard Law Review, 2016). To the degree that a predator's diet is dependent on Pacific

sardine, the absence of sardine may cause a decline in the predator's population. The availability of sardine as forage is therefore valued to the extent of its role in supporting the predator population and the value of that population. In other words, in the absence of sardine, what costs would be incurred to support the predator population and what losses would be incurred if a substitute for sardine as forage was not found.

Pacific sardine and its predators may also serve ecological functions that have value. One valuation approach would be to determine the cost to fulfill those ecological functions that sardine (and/or its predators fulfill). Similar to the case of the value of Pacific sardine as forage, the degree that the ecological role played by Pacific sardine has substitutes plays in the valuation of Pacific sardine.

While it is clear that forage fish, including Pacific sardine, do play a role in the transfer of energy from lower to higher levels of the food web, it is uncertain to what extent this role is played by individual species or the degree that the role can be filled by substitute species during periods of both initial species population decline and long term reduced populations. Therefore, while it is clear that Pacific sardine do have value in the provision of forage, and possibly in the provision of direct non-forage ecosystem services, the magnitude of that valuation is beyond the scope of this report.

Discussion of the Range of Alternatives

This section provides information on the potential impacts of each of the alternatives. Levels of economic activity are reported before and after the closure of the primary directed Pacific sardine fishery in 2015, to serve as benchmarks on the projected impacts of the alternatives. This section focuses on the median percentile biological model run estimates of Pacific sardine biomass and U.S. landings utilizing a fixed Mexican catch rate (2005-2018 scenario) from Hill et al. (2020). Multiple distributional factors may influence the assessment of each alternative; in particular an analysis of the relationship between uncertainty of the rebuilding tool estimates and length of forecast (years out) is encouraged; The term "impacts" is used generically in this discussion, as opposed to the specific term "economic impacts" often used in reference to the results of regional economic input-output models that describe the effects of a policy action on the number of jobs, dollar values of sales, or economic output.

Pacific sardine Associated Fisheries

This discussion separates Pacific sardine associated fisheries into two groups: (1) directed commercial fisheries that target Pacific sardine; (2) input fisheries, which catch Pacific sardine for use as an input to another fishery (e.g. the live-bait fishery) or as incidental catch in another commercial fishery. This distinction clarifies how Pacific sardine landed in these respective fisheries may be valued, and stratifies fishery operations under different management regimes.

For major directed fisheries, the commonly available metric of landings revenue is used as a measure of economic value (note that the Pacific sardine primary directed fishery has been closed since 2015). However, the landings revenue metric does not capture the value to West Coast fisheries of Pacific sardines utilized as an input to other fisheries as discussed above. In the case of the live-bait fishery, Pacific sardine is landed for use as bait by the recreational fishing sector - which then adds value to the resource. For the recreational fishery, it has been argued that substitution to alternative bait would be disruptive to angler practices, success, and the economic

viability of the industry. Valuing sardine to the recreational fishery will require additional information on its value as an input to a recreational fishing trip. In the case of incidentally caught Pacific sardine, while incidental landings may have no positive market value to the vessels that land them, incidental landings can be considered a production externality. A production externality is defined as a side effect, which is typically unintended, from an industrial operation. While externalities are typically unsolicited, they can have economic, social, or environmental side effects. In the current matter, incidental landings of Pacific sardine are a production externality to both the directed CPS fishery and the directed groundfish fishery.

Impacts

Impacts of an alternative are defined here as the changes from status quo general fishery conditions and management that occur as a result of implementing a new policy (an action alternative). In this discussion, Alternative 1 is defined as the status quo management of Pacific sardine.

Note that when the level of permitted fishing activity is changed, fishing activity and the economic measures of that activity may not change proportionally because of differences in how businesses and individuals may shift effort and resources between fisheries, non-fishery business, and other pursuits. Empirical research indicates that substitution between fisheries may be minimal and there can be short and long term amplifications that result in impacts more than proportional to the reduction in fisheries[5], and that upon recovery economic benefits may not return to the initial communities if entrants come from different communities.

Analysis

While a quantitative present value analysis is beyond the scope of this report, this section lays out some of the groundwork for such an analysis and highlights both the potential assumptions and challenges of such an analysis. It is our intent that laying out the groundwork will highlight issues that should be considered in evaluating the competing ROAs. We develop a generalized analysis framework for the present value of future economic values associated with the biomass and catch estimates corresponding with three alternatives under consideration by the Coastal Pelagic Species Management Team (CPSMT). The primary required input data and assumptions are as follows:

- The projected distribution of estimated Pacific sardine biomass and catch from the Rebuilder Tool analysis. Biomass and catch median estimates are currently available from the Rebuilder Tool Report (August, 2020);
- 2009-2014 benchmark landing revenue statistics from Pacific sardine associated fisheries: directed and input;
- 2015-2018 benchmark landing revenue statistics from Pacific sardine associated fisheries: input;
- Discount rate for the evaluation of future benefit streams. See 0MB Circular No. A-94, "Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs," October 29, 1992. and https://www.whitehouse.gov/wp-content/uploads/2019/12/M-20-07.pdf;
- Pacific sardine incidental catch landings for the CPS fishery by sub-sector;

[5] Richerson, K., and Holland, D. S. 2017. Quantifying and predicting responses to a US West Coast salmon fishery closure. – ICES Journal of Marine Science, doi:10.1093/icesjms/fsx093.

- Pacific sardine incidental catch landings for Groundfish fishery by sub-sector;
- Information on the utilization of Pacific sardine live bait within the recreational fisheries.

Challenges of analysis:
Challenges of analysis include:

- Uncertainty in fishery conditions for Pacific sardine and multiple other co-occurring stocks. The CPSMT concluded that while the Rebuilder model results (Hill et al. 2020) are useful, they are not able to definitively provide accurate and precise estimates of the time frame, nor biomass estimates for future years for any of the alternatives under consideration and the same is true for projected catches for the alternative that allow catch during the rebuilding time frame. Evaluation of the alternatives should weigh the near term through long term costs and benefits of each alternative while taking uncertainty into consideration;
- Uncertainty in economic impact of reduction in input fisheries. Pacific sardine are incidentally landed as part of the production process for commercial fisheries, including non-Pacific sardine CPS and groundfish. Pacific sardine are landed both as the primary target and incidentally by the live-bait fishery which supplies private anglers and the CPFV industry with live-bait;
- Lack of common accepted measure of value for comparisons between the commercial and recreational fisheries sectors;
- Incorporation of allocation assumptions. Rebuilder Tool analysis results show a positive probability that Alternatives 1 and 3 result in catch estimates that fall below the recent benchmark utilization. Catch levels below the current utilization benchmark would constrain fisheries and would trigger the need to determine how to allocate permitted catch between competing uses. The relative economic impact between the range of alternatives under consideration depends on the outcome of the expected allocation process;
- Estimating the degree to which constraints of Pacific sardine landings will impact fisheries that incidentally land Pacific sardine, and recreational fisheries that have historically utilized Pacific sardine live-bait.

Benchmarks

This discussion provides benchmark landing revenue statistics for the fishery's past performance under general fishery and management conditions. Baseline estimates, a projection of these benchmark statistics into the future, are not utilized as they would add additional uncertainty to the exercise. These difficulties are exemplified by the current need for this rebuilding plan; despite basing management on the best available biological models and setting regulations that adhere to the fishery management plan (FMP), the Northern Pacific sardine (Pacific sardine) stock has declined to a level resulting in an overfished designation. Furthermore, quantifying the change in the baseline from historic conditions is not practical because of the numerous factors that interact to determine future fishing conditions and landings, including the trends of multiple CPS other than Pacific sardine, other West Coast commercial fisheries which incidentally land Pacific sardine, recreational fisheries that utilize Pacific sardine as live-bait, and a Council process which balances various biological, economic, and social factors in determining fishing opportunities. Therefore, this discussion provides a set of quantitative historic benchmarks for context. It is noted that utilization of a set of quantitative benchmarks in this report does not

conflate historical benchmarks for future baseline forecasts; rather historical benchmarks are utilized to provide quantitative information that can be interpreted qualitatively.

CPS landing revenue data for California, Oregon, and Washington ports during 2009 to 2018 are used as the benchmark. This time period is further stratified into two sub-periods 2009 to 2014 and 2015-2018. The first of these sub-periods, 2009 to 2014, represents the most recent period where the primary directed fishery of Pacific sardine was permitted. The second of these sub-periods, 2015-2018[6], represents the current period for which commercial directed harvest of Pacific sardine has been suspended. Differential analysis of the two sub-periods will consider the differences in the fisheries during the two distinct regulatory periods. The earlier period, 2009-2014, is presented to characterize the fishery under open conditions. The later period, 2015-2018, is commonly held to be more similar to conditions under current consideration and is projected to be representative of possible outcomes under the current status quo control rule. Three Pacific sardine rebuilding plans are under consideration; each rebuilding plan will utilize both the 2009-2014 and 2015-2018 periods as for the economic analysis. These two periods span recent history and provide a range of conditions that could be reasonably expected in future years, although due to ocean, climate, and other conditions, the actual distribution may differ.

For non-CPS fisheries, the most readily available revenue data is referenced.

Benchmark periods and average landing revenues:
2009-2014: Active primary directed fishery, active input fishery
CPS fishery revenue for Pacific sardine: $14,755,561 (2018$)
CPS fishery revenue for non-Pacific sardine species[7]: $ 77,420,300 (2018$)

2015-2018: Closed primary directed fishery, active input fishery (e.g. live bait, incidental catch)
Pacific sardine landing revenues: $371,524 (2018$)
Non-sardine landing revenues: $47,133,356 (2018$)

2012-2016: Groundfish fishery revenues
Pacific Whiting total average annual revenues: $52,827,642 (2018$)
Shoreside IFQ Trawl (Non-whiting): 26,423,549 (2018$)

2018 Recreational bait expenditures
2018 Private boat bait expenditures (all bait expenses): $11,077,000 (2018$)
2018 CPFV bait expenditures (live bait expenses): $8,100,000 (2018$)

Data sources: PFMC (2019); PFMC (2019b); Lovell et al. (2020); and Hilger & Lovell (2018).

Fishery status
Consideration of the ROA under consideration for rebuilding of Pacific sardine can be undertaken at several levels of complexity, for this discussion the following approach is followed. Pacific sardine fishery can be assigned a hypothetical generalized status for discussion purposes by the

[6] Note, the directed fishery was open from January 1 through June 30th, 2015.
[7] Pacific sardine present in catch of non-sardine CPS.

biomass and catch estimates produced by the Rebuilder Tool analysis. While it is noted that the below discussion tries to stay consistent with the assumptions modeled in the Rebuilder Tool analysis, an expectation was made for the utilization of catch[8]. For this discussion, fishery status is categorized into the following four states: closed, constrained input, input, and open. Each of the four status states are defined below:

Closed: Landings of Pacific sardine are prohibited. Prohibition of Pacific sardine is assumed to be assigned by management action. Closed status is the initial state under Alternative 2. The fishery may transition to open status by reaching a biomass level greater than 150,000 mt.

Constrained Input: Input fisheries allowed, but at a level of catch below the 2015-2019 benchmark average of 1,965 mt (Hill et. al, 2020). Catch levels below the benchmark are projected to raise allocation issues between fisheries (live bait, non-sardine CPS, and groundfish). In the short run, specific fisheries that are allocated Pacific sardine below their specific benchmark will either cease or continue at a reduced level when their specific input levels are restricted. In the long-run firms may alter production technologies to return to benchmark levels of economic output even with reduced Pacific sardine inputs. Primary directed fisheries are closed.

Input: Input fisheries occur unconstrained relative to 2015-2019 benchmark; primary directed fisheries are closed. The fishery is defined as being in input status if estimated catch is above or equal to 1,965 mt and estimated biomass is below or equal to 150,000 mt.

Open: Both primary directed fisheries and input fisheries are in operation and operate unconstrained relative to the 2009-2014 benchmark. Fisheries are defined as being in open status if estimated biomass is greater than 150,000 mt.

Range of Alternatives (ROA) Discussion

The following analysis is based on Pacific sardine biomass and catch estimates from the Rebuilder Tool. The discussion is focused on the median estimate. These median values are based on a wide range of simulated catch and biomass. Given that knowledge and the limitations of the assumptions in the rebuilding model, the CPSMT concluded that while the model is useful, it certainly is not able to definitively provide probabilities for recovery in any given time frame, nor accurate and precise biomass estimates for future years for any of the alternatives under consideration. Nevertheless, the CPSMT notes that despite its limitations, the modeling platform and its results do provide useful guidance and insights that are considered in these analyses of alternatives.

Alternative 1 maintains the status quo and continues current harvest control rules (HCRs) that are in place for the northern subpopulation of Pacific sardine. For Alternative 1, one may best consider the fishery in two time periods. In the first period the fishery is in input status with catch above the 1,965 mt benchmark; allowing the Pacific sardine input associated fisheries to operate unconstrained at benchmark levels. In the second period the fishery is in constrained input status,

[8] Based on current utilization of Pacific sardine landings and the definition of the Input fishery status below, no landings above the benchmark in the input fishery status were valued on the margin. It is recognized that this diverges from the specification of the rebuilding analysis.

defined by catch below the 1,965 mt benchmark; allowing the Pacific sardine input fishery to operate but at lower levels of economic activity. Under reduced landing levels, Pacific sardine inputs to associated fisheries are reduced and in the short run economic output will decrease. Both the degree of the reduction in economic output and the length of the time horizon to a long-term adjustment are conditional on numerous factors. While in input constrained status, projected catch falls to a minimum of 43 percent of the 1,965 mt benchmark in 2050. Under reduced landing levels, Pacific sardine inputs to associated fisheries are reduced and in the short run economic output will decrease. Both the degree of the reduction in economic output and the length of the time horizon to a long-term adjustment are conditional on numerous factors.

Based on median catch estimates, the period from 2019 to 2036 is projected to be characterized as in input status; the period from 2037 to 2050 is projected to be characterized as in input constrained status (See Table 12 in Hill et. al, 2020). Based on the median Pacific sardine biomass projections the probability that Pacific sardine recovers does not reach a level above 40 percent during the period of analysis (2019 to 2050) (See Table 6 in Hill et. al, 2020).

Alternative 2 would prohibit the landing of Pacific sardine through the adoption of a zero-harvest approach within the U.S. management jurisdiction during the rebuilding period. For Alternative 2 one may best consider the fishery in two time periods. In the first period the fishery is in closed status; no live bait, no incidental harvest in CPS or non-CPS fisheries, and no minor directed harvest would be allowed. In the second period, the fishery has met rebuilding biomass targets and is above CUTOFF, the fishery is in open status.

It is assumed that a zero catch Pacific sardine fishery would result in the closure of the fisheries that target or incidentally land Pacific sardine, such as major components, if not all, of the live-bait fishery, CPS fisheries, and groundfish fisheries. The prohibition on landings of Pacific sardine would be expected to have wide ranging negative economic consequences across the West Coast fisheries, support businesses, communities, and households. Upon being declared rebuilt, it is unknown what the timeline and the extent that West Coast fisheries would recover after a cessation of activities for roughly 16 years. A 16-year cessation would impact vessel capital markets, fisheries labor markets, fishery knowledge, distribution channels, and both domestic and foreign markets. While a prohibition on catch of Pacific sardine would directly impact the CPS, groundfish, and live bait fisheries, it would also be expected to indirectly impact all West Coast fisheries and would have ripple effects on the entire U.S. fisheries sector with impacts on international trade and domestic food supply.

Based on median catch estimates, the period from 2019 to 2036 is projected to be characterized as in closed status; the period from 2037 to 2050 is projected to be characterized as in open status (See Tables 8 and 12 in Hill et. al. (2020).

Alternative 3 is defined by a reduced U.S. catch rate of 5 percent. For Alternative 3 one may best consider the fishery in three time periods. In the first period the fishery is in input status with catch above the 1,965 mt benchmark; allowing the Pacific sardine input associated fisheries to operate unconstrained at benchmark levels. In the second period the fishery is in constrained input status, defined by catch below the 1,965 mt benchmark, allowing the Pacific sardine input fishery to operate at lower levels of economic activity. In the third, the fishery has met rebuilding biomass targets, however projected catch remains below the 1,965 mt benchmark; the fishery remains in

constrained input status. Under reduced landing levels, Pacific sardine inputs to associated fisheries are reduced and in the short run economic output will decrease. Both the degree of the reduction in economic output and the length of the time horizon to a long-term adjustment are conditional on numerous factors. While in input constrained status, projected catch falls to a minimum of 88 percent of the 1,965 mt benchmark in 2047. Under reduced landing levels, Pacific sardine inputs to associated fisheries are reduced and in the short run economic output will decrease. Both the degree of the reduction in economic output and the length of the time horizon to a long-term adjustment are conditional on numerous factors.

Based on median catch estimates, the period from 2019 to 2042 is projected to be characterized as in input status; the period from 2043 to 2046 is projected to be characterized as in input constrained status; the period from 2047 to 2050 is projected to be characterized as in input constrained status and rebuilt (See Tables 6, 8, and 12 in Hill et. al. (2020).

Discussion

Each alternative within the ROA under consideration is associated with a stream of future economic benefits. The present value concept can be utilized to add context and illustrate the differences in economic values of the ROA. The Present value (PV) of the fishery is the current value of the estimated future stream of values from the fishery. Future values are discounted at the discount rate; the higher the discount rate, the lower the present value of the future cash flows. Discounting reflects the preferences for value streams today relative to the future. Zero discounting, a discount rate of zero, assumes that an activity today is valued equally to the same activity in the future. Discount rates are tied to financial markets, and current discount rates are historically low. Therefore, current future streams of economic benefits are not greatly discounted relative to current benefit streams – relative to periods characterized by high discount rates.

As defined as status quo management, Alternative 1 would not change harvest policy for Pacific sardine; therefore, by definition there would initially be no direct or indirect economic impact from the rebuilding plan based on the median model run. However, the rebuilding tool model reports a greater than 50 percent probability of a period of constrained catch to occur starting in 2036. Based on model catch expectations, the benchmark level of economic activity will not be feasible at projected median catch levels; e.g. in 2050 median projected U.S. catch 839 mt under Alternative 1 is 43 percent of the input status period benchmark of 1,965 mt[9].

Relative to Alternative 1, status quo, Alternative 2, zero landings, would have a negative economic impact in the near term based on the median model run. Barring major advancements in bycatch avoidance technology and behavior, the adoption of Alternative 2 would in effect prohibit, or at a minimum severely constrain, the execution of the live-bait fishery, and fisheries that incidentally land Pacific sardine. The full magnitude of the impact of a prohibition on Pacific sardine would depend on the regulatory approach taken to the prohibition (i.e., would fisheries with a positive projected level of Pacific sardine incidental catch be permitted to operate prior to reaching a limit of 1 Pacific sardine, or would fisheries be preemptively closed). Additional factors to consider would be the feasibility to define fisheries that would have zero-level of projected sardine catch.

[9] Under Alternative 1, US catch is 55.2 percent of total catch.

It is expected that there would be ripple effects associated with a prohibition of landing Pacific sardine that would extend beyond fisheries that land, including incidentally, Pacific sardine. A prohibition would lead to a disruption in the following sectors: labor, fuel, vessel capital, processing, import/export trade, wholesale markets, etc. Disruptions in several of these sectors may impact other fisheries and other areas of the economy. For example, loss in demand for inputs such as fuel and ice from fisheries that land, including incidentally, Pacific sardine, would result in a contraction of the demand schedule for these inputs. This would result in the reduction of the means of production dedicated to fisheries associated with Pacific sardine, and a possible expansion in the means of production which could be utilized in other parts of the economy.

Alternative 2 is projected to result in an open status fishery in 2036, having both rebuilt and having biomass above CUTOFF. Open status would allow the primary directed fishery to resume.

In the initial years of the model projection, the economic impact of Alternative 2 relative to Alternative 1 would be negative. However in later years, the relative impact would depend on multiple factors including the degree that West Coast CPS, groundfish, and recreational fisheries would be able to recover after a period of roughly 16 years of a Pacific sardine prohibition under Alternate 2, and the degree that these same fisheries are able to operate under constrained Pacific sardine catch estimates that fall to roughly 43 percent of the current benchmark, Alternative 1. Additionally, under the present value framework, the alternative associated with a higher present value may be dependent on the discount rate used to discount larger value streams in the future (Alternative 2) relative to value streams in the present (Alternative 1).

Alternatives 1 and 3, Status Quo and U.S. 5 percent of total 1+biomass, are projected to maintain the current input fishery for a number of years prior to being constrained by catch levels below the 2015-2018 benchmark. In comparison, Alternative 1 initially allows higher levels of Pacific sardine catch to the input fisheries, but estimated catch levels fall below the 2015-2019 1,965 mt benchmark leading to a constrained fishery earlier (in 2037 versus 2043), while Alternative 3 is associated with lower levels of projected catch initially and maintains estimated catch above the 1,965 mt benchmark for a longer period of time. Upon classification as input constrained, median projected catch under Alternative 1 falls to 43 percent of the benchmark, whereas under Alternative 3 it falls to 88 percent of benchmark. Under the assumption that for the input fishery increases in catch above the benchmark have a low marginal value, it is argued that the annual value of the associated fisheries is roughly on the same order of magnitude between Alternatives 1 and 3. If the limits are not constraining for either Alternative 1 or 3, then there may be no meaningful difference between these alternatives for years where catch is above the benchmark. However, catch allotments under Alternative 1 would provide a larger buffer.

In this case, the projected present value of the stream of value associated with Alternative 1 and 3 is driven by the number of years that the fishery operates in input status before being constrained, the degree that the associated fisheries will be constrained, and the discount rate. By both measures, the fisheries under Alternative 3 are projected to have a higher value than under Alternative 1. First, under Alternative 3, it is projected that the fishery operates in unconstrained input status for 6 years longer; second, under Alternative 3, the associated fisheries face a reduction in catch to 88 percent of benchmark versus to 43 percent of benchmark. Lastly, under Alternative 3, Pacific sardine is projected to rebuild at a 50 percent probability by 2047, whereas under Alternative 1 the

Pacific sardine is not projected to rebuild at a 50 percent probability by the end of the reporting period in 2050.

The tradeoffs between Alternative 2 and Alternative 3 are similar to that between Alternative 1 and 2. However as discussed above, relative to Alternative 1, Alternative 3 is projected to remain in input status for a longer period of time, projected to be constrained to a lesser degree when constrained, and projected to rebuild with a probability greater than 50 percent. However, as above, from an economic perspective, the determination of the preferred alternative will be conditioned by several factors including: (1) the discount rate, (2) the economic value of catch above the benchmark requirements of the input fisheries, and (3) the economic value of catch below the benchmark in a constrained input fishery.

It is again noted that the CPSMT does not see evidence to support that the timelines and target spawning biomass provided by the modeling results should be viewed in absolute terms given its limitations and its sensitivity to catch relative to environmental factors. Consistent with this view, the CPSMT cautions that the economic marginal benefit of reducing catch in early periods in order to increase catch in later periods may be overstated. If this is true, it therefore follows that adherence to the rebuilding tools results would lead to an overly restrictive management at the cost to fishery related business and the communities which they support.

Minor directed and tribal fisheries

Minor directed and tribal fisheries land a small quantity of Pacific sardine on a periodic basis, either as targeted or incidental catch. Regulatory policies that limit the sardine landings within these fisheries are expected to have negative social and economic effects on the communities involved in these fisheries. The proportionality of these effects may differ from those impacting larger commercial fisheries due to the differences in the characteristics of minor directed and tribal fisheries relative to other fisheries reported on in this document.

Summary of economic impacts

Summary of economic impacts of the Pacific sardine ROAs under median biomass and landings estimates.

	Alt 1 – Status Quo	Alt 2 – Landings Prohibition	Alt 3 – U.S. 5 percent of total 1+biomass
Rebuilding Time Based on at least a 50 percent Rebuilding Probability	Not achieved	2036	2047
Economic Impacts	2020-2036: None (no change from baseline). 2037-2050: Projected catch level falls below benchmark utilization. Projected catch level at roughly 43 percent of benchmark. Reduction in economic activity in CPS, Groundfish, and live bait fisheries projected.	2020-2035: Complete loss of Pacific sardine related economic activity. Expected ripple effects through all West Coast fisheries, and likely U.S. fisheries. 2036-2050: Resumption of economic benefits from the primary directed Pacific sardine fishery, and associated fisheries including CPS, Groundfish, and live bait upon reopening. Risk of fishery not recovering to benchmark levels across multiple sectors due to breadth and length of closure.	2020-2042 Minimal. Projected catch at or above baseline (with exception of 2020 with projected catch at 97 percent of baseline). 2043-2050: Projected catch level falls below benchmark utilization. Projected catch level at roughly 88 percent of benchmark. Reduction in economic activity in CPS, Groundfish, and live bait fisheries projected. Fishery is projected to be declared rebuilt, although directed fishery is projected to remain closed

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