Pacific Sardine
Stock Assessment Review (STAR) Panel Meeting Report

Southwest Fisheries Science Center (SWFSC),
National Oceanic and Atmospheric Administration (NOAA)
La Jolla, California
February 21-23, 2024

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1) Overview
The Pacific sardine Stock Assessment and Review (STAR) Panel (Panel) met at the Southwest Fisheries Science Center (SWFSC), La Jolla, CA from February 21-23, 2024 to review a draft assessment by the Stock Assessment Team (STAT) for the US stock (i.e., northern subpopulation, NSP) of Pacific sardine (*Sardinops sagax*). Introductions were made (see list of attendees, Appendix 1), and the agenda was adopted. A draft assessment document and background materials were provided to the Panel in advance of the meeting on the Pacific Fishery Management Council (Council) website (www.pcouncil.org).

Dr. Peter Kuriyama outlined the data used in the stock assessment, the assessment methodology, and the results of the draft assessment. Dr. Matthew Craig described current information about the presence of Japanese sardine (*Sardinops melanostictus*) off the US West Coast based on samples from 2014 to 2023. Dr. Juan Zwolinski described the application of the acoustic-trawl (AT) survey-based method for estimating biomass and its associated age structure during 2022 and 2023 and provided an overview of the revised habitat model used to apportion observations into the subpopulations.

The proposed base model in the draft assessment provided to the Panel was based on the Stock Synthesis Assessment Tool V3.30.22. It differed from the model on which the 2020 assessment (Kuriyama *et al*., 2020) was based by:

a) updating the Stock Synthesis tool to v3.30.22 from v3.30.14;
b) including catches, catch age compositions, and a survey biomass index informed by the revised habitat model (Zwolinski and Demer, 2023) and updated to include data to 2023;
c) using a new age-reading error matrix for the AT survey age-composition data for 2021 and 2023;
d) revising the steepness parameter (*h*) to 0.65 from 0.3;
e) modeling natural mortality (*M*) using the Lorenzen function with the base *M* estimated using a prior based on the Hamel and Cope (2022) method with a prior mean of 0.675 yr^{-1};
f) estimating fishery weight-at-age using a random effects model; and
g) modeling time-varying selectivity for the Mexico-California (MexCal)S1 and MexCalS2 fisheries using the 2dAR formulation instead of blocks of years.

The 2022 AT survey, which included sampling for biological data by purse seine instead of trawl gear, was included as two separate indices (one based on the core area surveyed by the *Lasker* and the nearshore area surveyed by the *Lisa Marie*, and the other based on the offshore area surveyed by the *Lisa Marie*) due to staffing and mechanical issues related to the *Lasker*.

The review and subsequent discussions of the proposed base model were motivated by a need to justify the specifications related to the survey estimates included in the model, assumptions regarding survey catchability (Q) for the 2021 and 2022 AT surveys, the value for *h*, how to specify weight-at-age for the population, and the realism of the catch off Ensenada in January 2022, which was initially assigned to the NSP.

The final base model was similar to the proposed base model, except that the value of *h* was changed from 0.65 to 0.6 (supported the data), the survey data for 2022 were combined into a single estimate with Q = 1, and the high January 2022 catch off Ensenada was excluded.

The STAR Panel thanked the STAT for their hard work and willingness to respond to Panel requests, and the staff at the SWFSC La Jolla laboratory for their usual exceptional support and provisioning during the STAR Panel meeting.

2) Requests to the STAT

Day 1 requests made to the STAT during the meeting - Wednesday February 21, 2024

Request 1: Update Table 7.2, which lists the state-specific catches through time and re-run the assessment model using the updated catches.

Rationale: Although the minor discrepancies between the updated time series and what is available on the Pacific Fisheries Information Network (PacFIN) are not likely to be consequential, it is important to include an accurate catch record in the assessment. There are some instances where differences in catch are non-trivial.

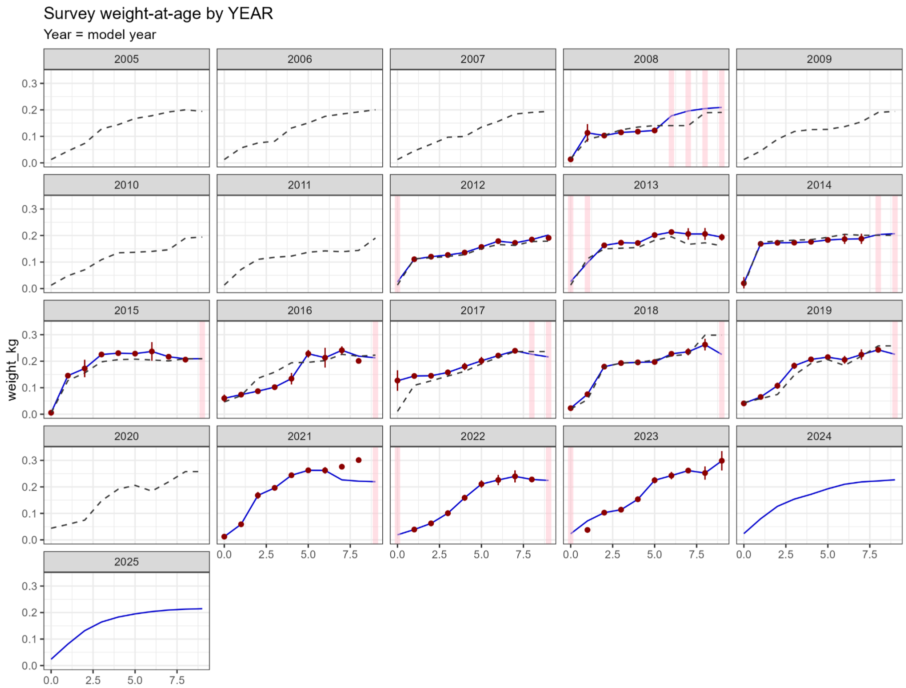
STAT Response: The following table lists the original state-specific catches in metric tons (mt) from Table 7.2, the updated values, and the differences between them. A total of 18 mt of sardine catch from at-sea whiting fleets is not included in the revision below. The Panel did not ask the STAT to re-weight the age-composition data based on revised catch stream.

Year-Semester	OR Table 7.2	OR PacFIN	Diff	Table 7.2 WA	WA PacFIN	Diff
2005-1	44316	44418	-102	6605	6395	210
2005-2	102	102	0	0	0	0
2006-1	35546	35565	-19	4099	4364	-265
2006-2	0	2102	-2102	0	0	0
2007-1	42052	40041	2011	4662	4662	0
2007-2	0	0	0	0	0	0
2008-1	22940	22949	-9	6435	6032	403
2008-2	0	0	0	0	0	0
2009-1	21482	21481	1	8025	8009	16
2009-2	437	437	0	511	0	511
2010-1	20415	20415	0	11870	12389	-519
2010-2	0	0	0	0	0	0
2011-1	11023	11023	0	8008	8009	-1
2011-2	2874	2874	0	2932	2981	-49
2012-1	39744	39792	-48	32510	32758	-248
2012-2	149	149	0	1421	1423	-2
2013-1	27599	26139	1460	29619	29064	555
2013-2	0	0	0	908	908	0
2014-1	7788	7788	0	7428	6876	552
2014-2	2131	2131	0	63	31	32
2015-1	0	0	0	66	66	0
2015-2	1	1	0	0	0	0
2016-1	3	3	0	170	85	85
2016-2	0	0	0	0	0	0
2017-1	1	1	0	0	0	0
2017-2	2	2	0	0	0	0
2018-1	6	7	-1	2	2	0
2018-2	2	4	-2	0	0	0
2019-1	8	9	-1	0	1	-1
2019-2	0	0	0	0	0	0
2020-1	0	0	0	0	0	0
2020-2	3	3	0	0	0	0
2021-1	9	9	0	3	3	0
2021-2	0	0	0	0	0	0
2022-1	7	7	0	2	2	0

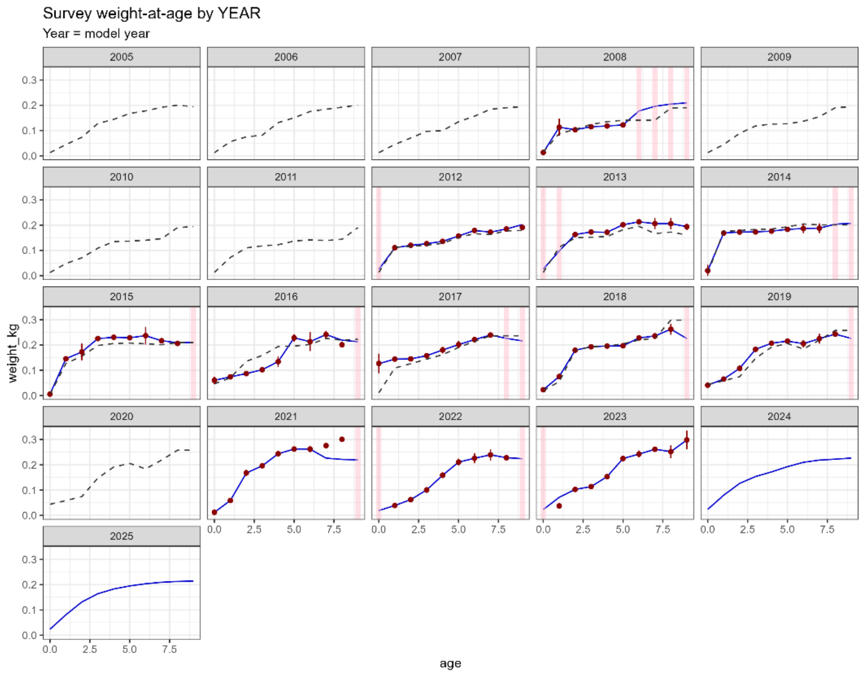
2022-2	0	0	0	0	0	0
2023-1	1	1	0	0	0	0

Request 2: Provide the justification for fixing *h* at 0.65. There is no disagreement regarding the steepness value used.
Rationale: The document is lacking adequate justification for fixing *h* = 0.65 in the proposed base model. This value has consequences for biomass estimates relative to the 50,000 mt Minimum Stock Size Threshold. There needs to be a data-supported value for *h* that maintains a risk-neutral approach.
STAT Response: Steepness was estimated at 0.304 and fixed at 0.3 in the 2020 assessment. These values are considered low based on the life history traits for sardine. The stock assessment team for Atlantic herring (*Clupea harengus*) are currently exploring steepness values that range from 0.6 to 0.9 as part of a management strategy evaluation (MSE) (G. Melvin, pers. comm.). In addition, values for *h* ranging from 0.669 to 0.903 are used for Pacific herring (*Clupea pallasii*) along British Columbia, Canada (DFO, 2021). Both of these examples provide support for the use of *h* set to 0.65 for this assessment. The STAT noted that their basis for setting *h* is to use (a rounded version of) the highest value that is included in a likelihood-profile-based 95% confidence interval for *h*. The likelihood profile based on the model from Request 1 supports *h* set to 0.7 (model revisions during the meeting later reduced it to 0.6).

Request 3: Display the means and associated estimates of uncertainty (e.g., 95% confidence intervals) for the weight-at-age data that were used to fit growth curves (weight as a function of age) for each fleet. For Figs. 10.2-10.4, use red/salmon for raw data, blue/green for model-based estimates, and grey for imputed values. Also include estimates of uncertainty for forecasted values and ensure that the values in Table 10.3 match those in Fig. 10.1.
Rationale: The Panel noted that model-based estimates of weight-at-age differed from the weights-at-age used in the 2020 assessment, but some of those weights-at-age were imputed. Also, some of the data on weight-at-age used to fit the model were based on small sample sizes, which may explain why the model is unable to match all of the observations.
STAT Response: The following plot represents an example of those produced by the STAT. Imputed values were removed. Instead, years with missing data are shown as pink bars. The weights-at-age in the 2024 model are shown in blue, and those from the 2020 model are displayed as dashed lines. Estimates of uncertainty for forecasts are considered as part of Request 10. The need to ensure matching values between Table 10.3 and Fig. 10.1 is listed in Appendix 2.



Request 4: Apply the model-based estimator to raw weight-at-age data from the survey rather than applying age-length keys.
Rationale: The model-based approach can provide estimates of weight-at-age for all years, which is important because survey-based weight-at-age estimates are assumed to be the population weights-at-age.
STAT Response: The STAT provided the requested figure. It suggested that the model-based approach leads to unrealistic values for weight-at-age. The weights-at-age in the 2020 assessment were based on applying age-length keys to length-frequency data. In contrast, the figure provided by the STAT was based only on aged individuals. However, the number of age samples is low relative to the number of length samples. There was no change to how weight-at-age is specified for the survey / population in the base model based on this request.



Request 5: Provide a figure that displays the spatial extent of the survey for years with greater biomass (e.g., 2005 and 2007).
Rationale: The spatial extent of the population likely varies with population size, but the STAT only provided plots for years with lower abundance.
STAT Response: The STAT presented the following figure (excerpt from Zwolinski *et al*., 2014), thus confirming this assumption.

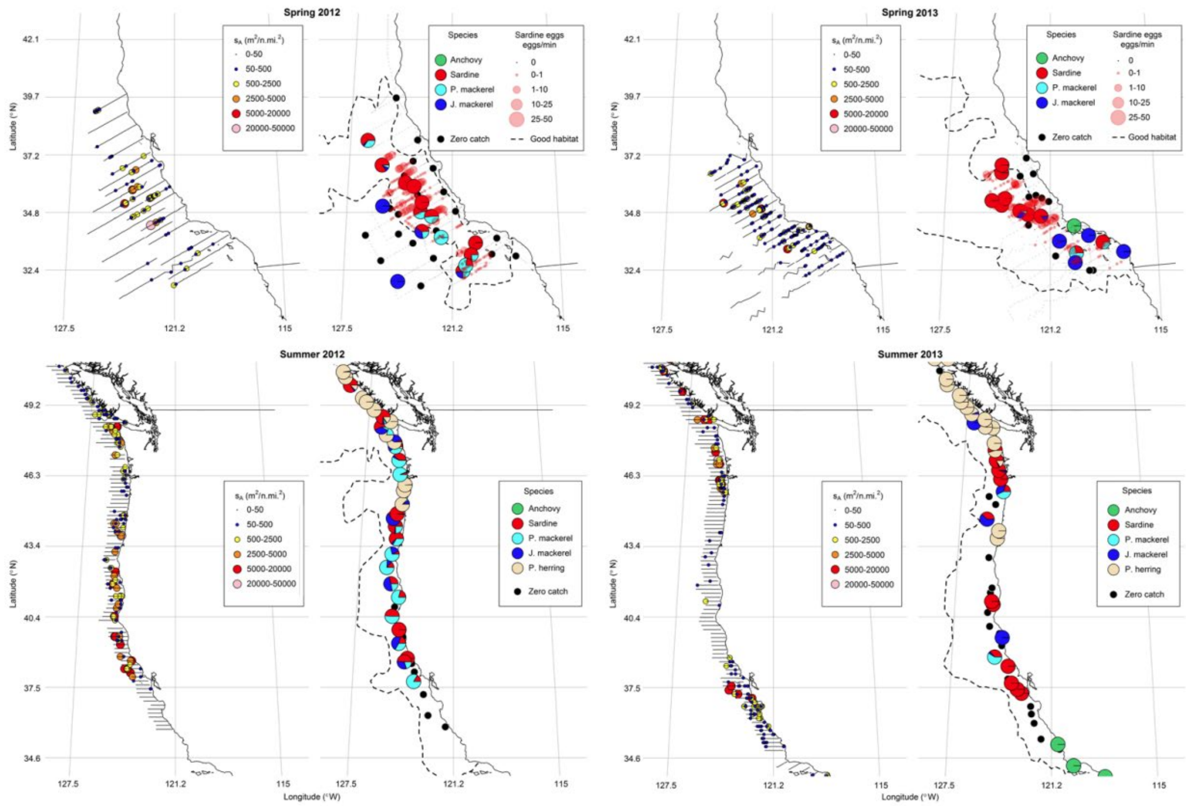


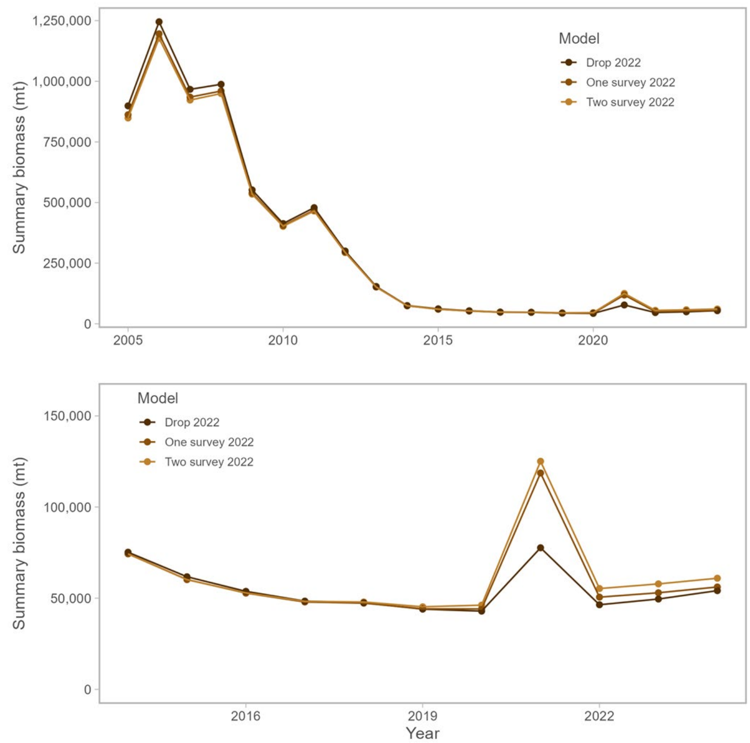
FIGURE 4. (left) Spring and summer 2012 and 2013 distributions of coastal pelagic fish species (CPS) daytime backscatter integrated from approximately 10 m to the depth of the thermocline and averaged over 2,000 m distance intervals. (right) Proportions of CPS in the trawl samples. Spring is the peak spawning period for Pacific sardine, and sardine egg counts measured using a continuous underway fish egg-sampler (CUFES) are a valuable resource to delineate sardine distribution. The isolines represent the boundaries of good habitat for sardine as defined by Zwolinski et al. (2011). Inshore, the habitat is bounded by freshly upwelled waters (temperature < 11°C and chlorophyll-*a* concentration > 3.2 mg m^{-3}) and offshore by oligotrophic oceanic waters (temperature > 15.5°C and chlorophyll-*a* concentration < 0.18 mg m^{-3}).

Request 6: Perform a sensitivity analysis in which the AT biomass estimate for 2022 is the total biomass estimate for the NSP and Q for the 2022 survey is set to 1. The survey age compositions for 2022 should equal the sum of the age compositions for *Lasker*+nearshore and for *Lisa Marie*.
Rationale: The Panel wished to understand if a simpler way of handling the 2022 survey data would lead to a different result.
STAT Response: The STAT presented results from combining the 2022 survey data and dropping the 2022 survey altogether. Combining the surveys resulted in slightly higher biomass after 2019. Dropping the 2022 survey had larger impacts. Combining the surveys simplifies model calculations and thus will be the approach used for the new base model. The STAT also corrected the CV for the 2023 survey estimate of biomass for this model run.

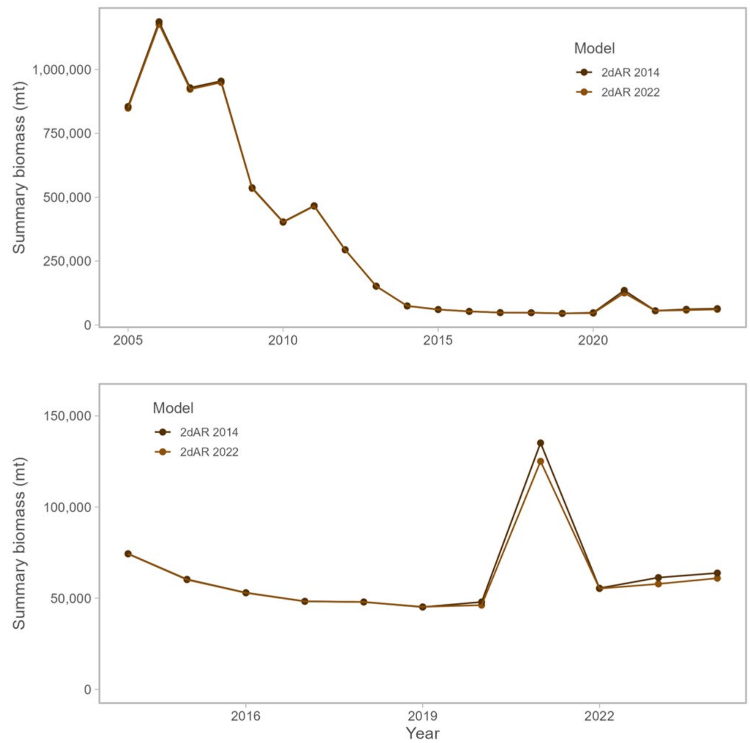
Area	Vessel	Stratum	Clusters	B	CV	sd	var
Core	Lasker	4	4	4,838	45	2177.1	4739764
Core	Lasker	5	5	5,956	36	2144.16	4597422
Core	Lisa Marie	6	13	42,946	32	13742.72	1.89E+08
Core		All	22	53,740	26	13972.4	1.95E+08
Nearshore	Lisa Marie	1	5	15,764	23	3625.72	13145846
Nearshore		2	2	0	61	0	0
Nearshore		3	3	1	51	0.51	0.2601
Nearshore		All	10	15,765	23	3625.95	13147513
		Total	**32**	**69,505**	**21**	**14596.05**	**2.13E+08**
				biomass	**totvar**	**sd**	**cv**
	Lasker + nearshore			**53740**	**198199539.5**	**14078.34**	**0.261971**

	Clusters	B	sumvar	sd	CV
Lasker + Nearshore	9	26,559	22483032	4741.628	0.178532
Stratum 4, 5,					
stratum 1, 2, 3					

	Clusters	B	sumvar	sd	CV
Lisa Marie	13	42,946			0.32
totbio		69,505			
LaskerQ		0.382116	-0.9620		
LisaMarieQ		0.617884	-0.4815		



Request 7: Conduct a sensitivity analysis that stops using 2dAR as time-varying selectivity in 2014 (i.e., use base selectivity from 2015 to 2023).
Rationale: 2014 is the last year with decent age-composition data.
STAT Response: There were small effects of altering time-varying selectivity on model results. Ending 2dAR selectivity in 2014 and using base selectivity from 2015 to 2023 will form part of the new base model.

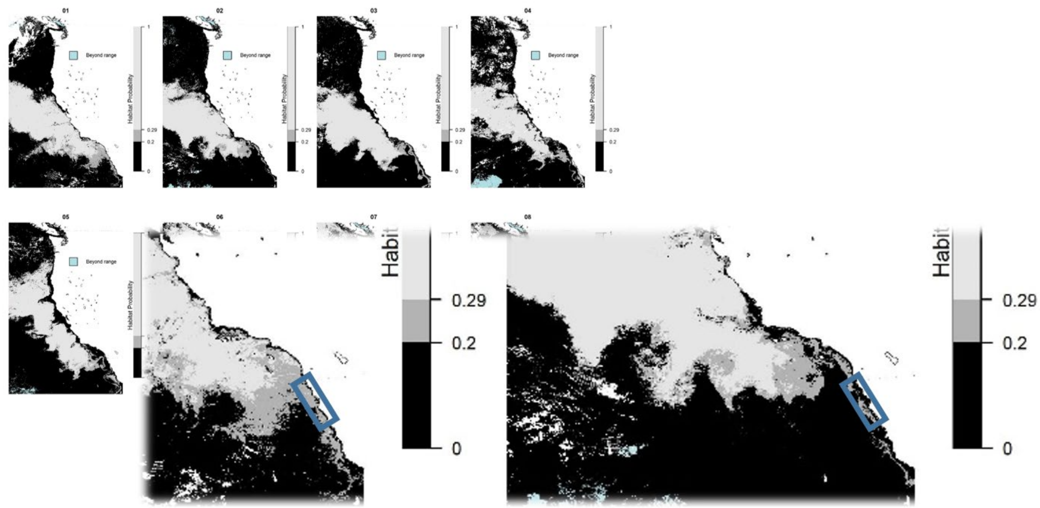


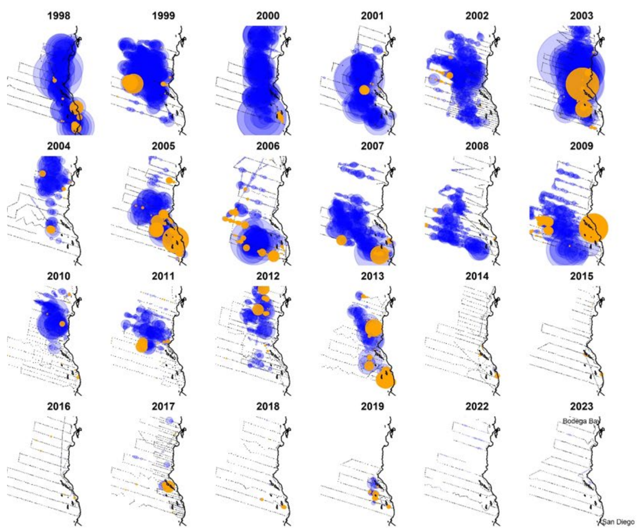
Request 8: Plot the geographic area used for the January 2022 catch estimate from Ensenada and color-code the covariates. Conduct a sensitivity analysis that removes the January 2022 catch estimate for Ensenada from the time series used in the assessment.

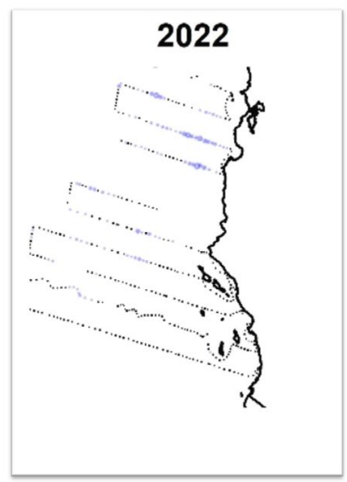
Rationale: This sensitivity analysis will elucidate potential impacts of the anomalous January 2022 catch estimate on model results.

STAT Response: Habitat maps for 2022 are shown below. There were higher sea surface temperatures recorded during winter 2022 (K. Hill, pers. comm.). Although potential sardine habitat was detected in January 2022, ancillary information showing that the northern stock has been practically absent from its southernmost distribution in the recent past, particularly in 2022 and 2023, provides support to removing the Ensenada catches. The sensitivity analysis of removing Ensenada catches in January 2022 is considered as part of Request 11.

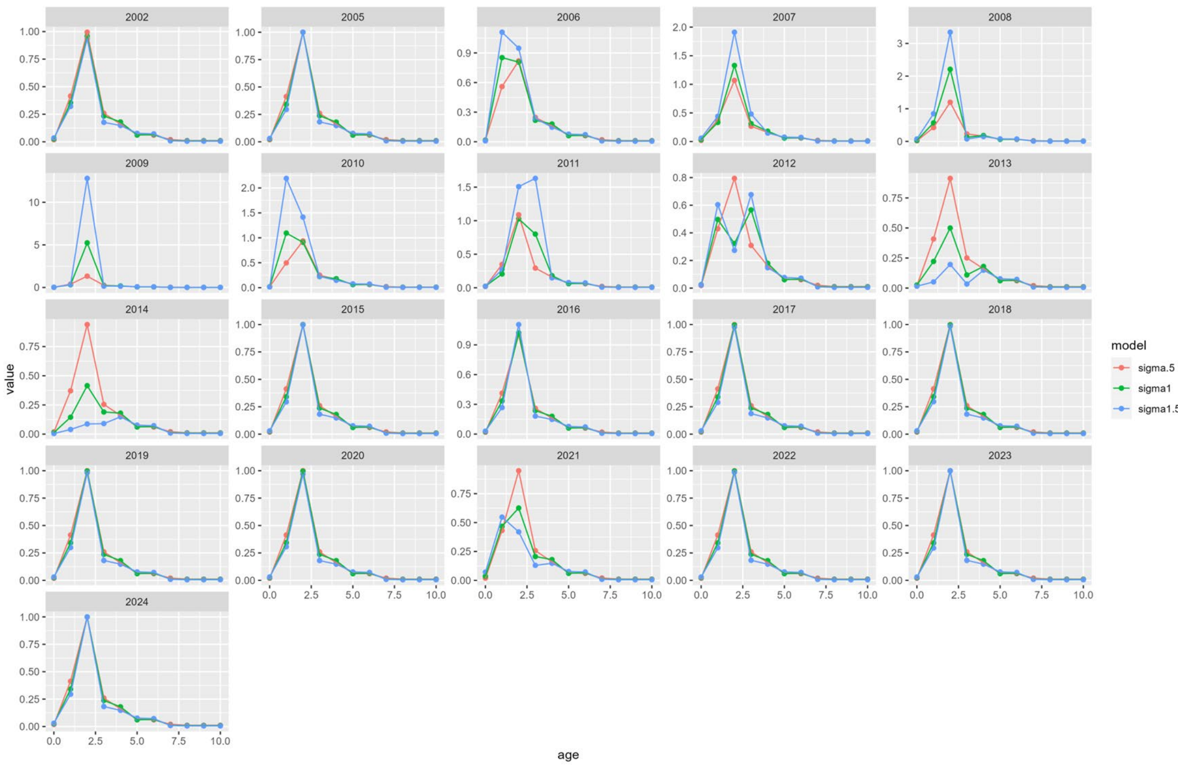
2022 Sardine Habitat







Request 9: Include a visual representation of model fits to age compositions, and selectivities for different levels of 2dAR sigma (based on the updated model).
Rationale: The Panel wished to understand how the value of sigma impacted the fit to the fishery and survey age composition data.
STAT Response: Below are examples of fits to age compositions at different levels of sigma (left = 0.5; center = 1.0; right = 1.5). Increasing sigma improved the fit to the fishery age compositions only marginally and did not noticeably improve the fits to the survey age compositions. The base model after the day 1 requests differed from the base model in the draft assessment report by setting *h* set to 0.7, using updated Pacific Northwest (PNW) catches, stopping 2dAR selectivity in 2014, summing the two 2022 survey estimates, and correcting the CV for the 2023 estimate of biomass. Following the day 2 requests (e.g., dropping Ensenada catch from January 2022), *h* was updated to 0.6.


2002
2005
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2013
2014
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2016
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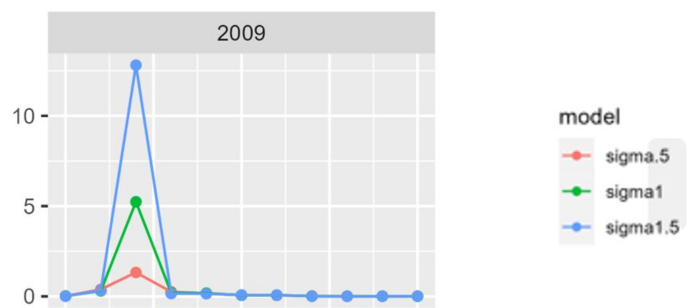
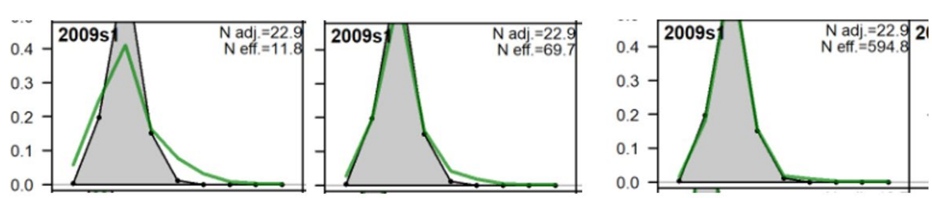
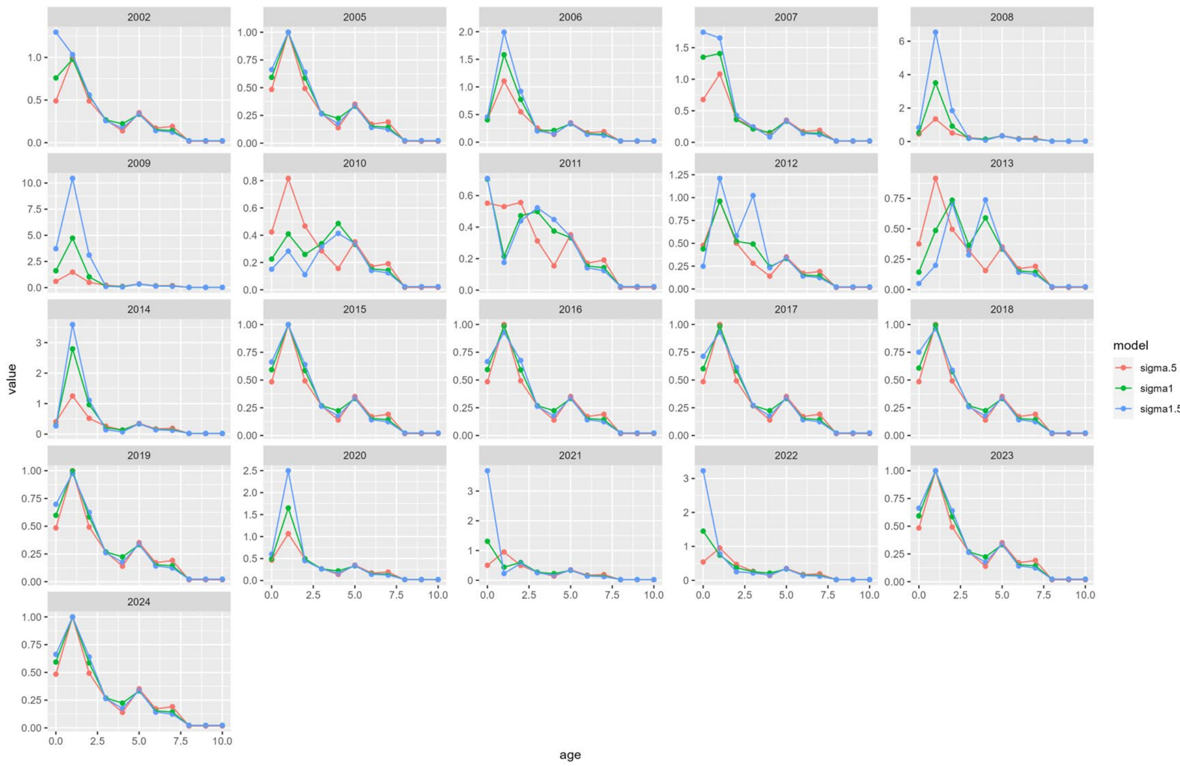
2020
2021
2022
2023
2024
value
age
model
sigma.5
sigma1
sigma1.5


2009
model
sigma.5
sigma1
sigma1.5


2009s1
N adj.=22.9
N eff.=11.8
2009s1
N adj.=22.9
N eff.=69.7
2009s1
N adj.=22.9
N eff.=594.8

- 0.5
- 1
- 1.5



Day 2 requests made to the STAT during the meeting - Thursday February 22, 2024

Request 10: Include estimates of uncertainty for forecasted values of weight-at-age and ensure that the values in Table 10.3 match those in Figures 10.1-10.4.

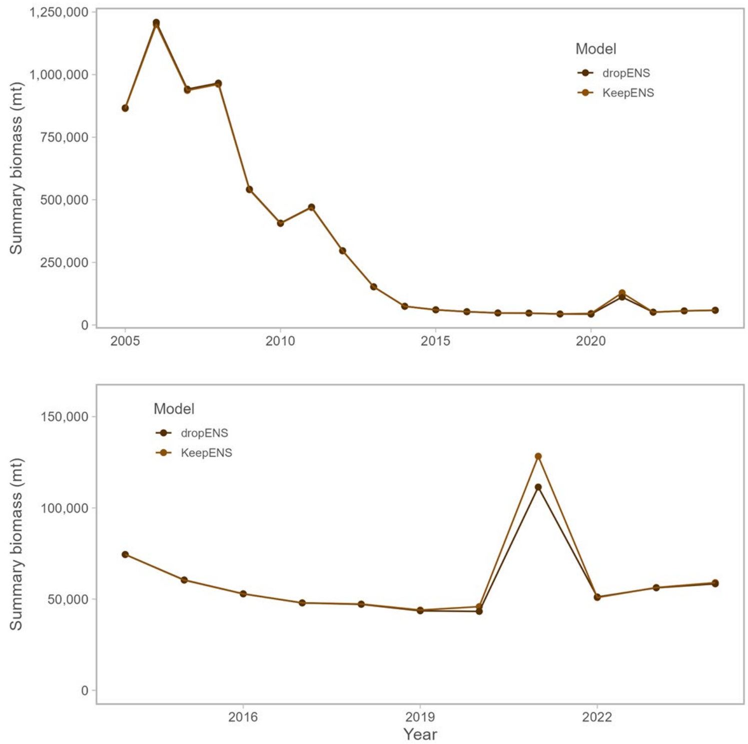
Rationale: This was included as part of Request 4 but was not completed.

STAT Response: The STAT presented revised weight-at-age plots with confidence intervals for both hindcasts and forecasts. Confidence intervals require additional consideration given little to no variability in some years and unrealistically high estimates in other years. It seems as though the issue originates from the model configuration. This is not expected to have a substantial impact on the assessment results given that the point estimates (and not estimates of uncertainty) are used in the model. All tables and figures in Appendix B of the assessment report will need to be revised in the final version.

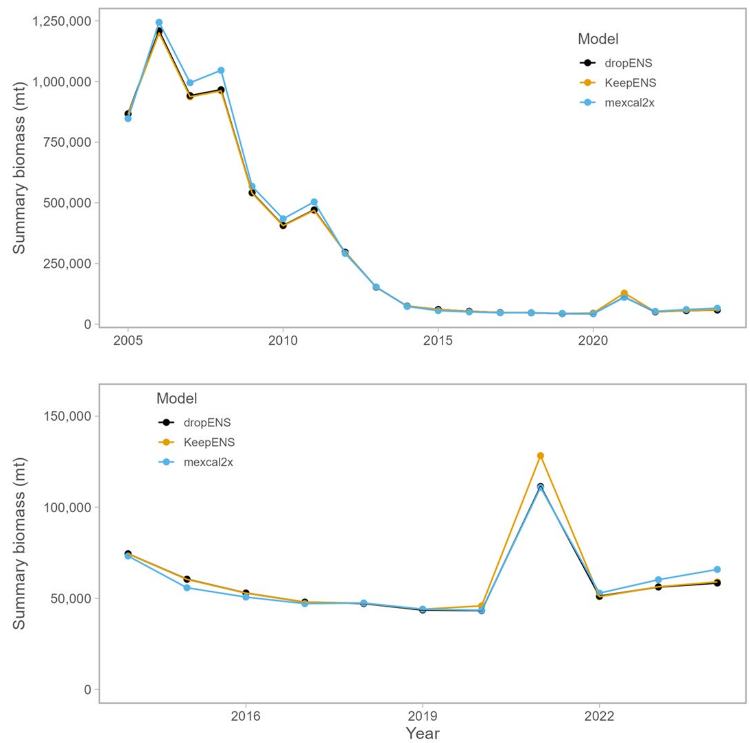
Request 11: Conduct a sensitivity analysis that removes the January 2022 catch for Ensenada from the time series.

Rationale: This sensitivity analysis will elucidate potential impacts of the anomalous January 2022 catch on model results.

STAT Response: The STAT dropped the catch data for January 2022 from the catch series used in the assessment because there is little support for the assumption that this catch should be attributed to the NSP. Although sardines are abundant along the Southern California Bight and off northern Baja year-round, those fish are exclusively nearshore and do not spawn in traditional NSP habitat. The original catch value was 11,172 mt and the STAT proposed replacing it with a value of 193 mt. The effect of excluding this catch on the trajectory of 1+ biomass was minor. This change was incorporated into the new base model.



Request 12: Using the new base model, double the MexCal catches in both seasons.
Rationale: To understand the impacts of potential unaccounted removals due to illegal, unreported, and unregulated fishing (IUU) (Cisneros-Montemayor *et al*., 2013) and increased uncertainty in Mexico catches. This sensitivity test is more extreme than simply doubling the catches off Ensenada.
STAT Response: Doubling the MexCal catches had minor impacts on age 1+ biomass.

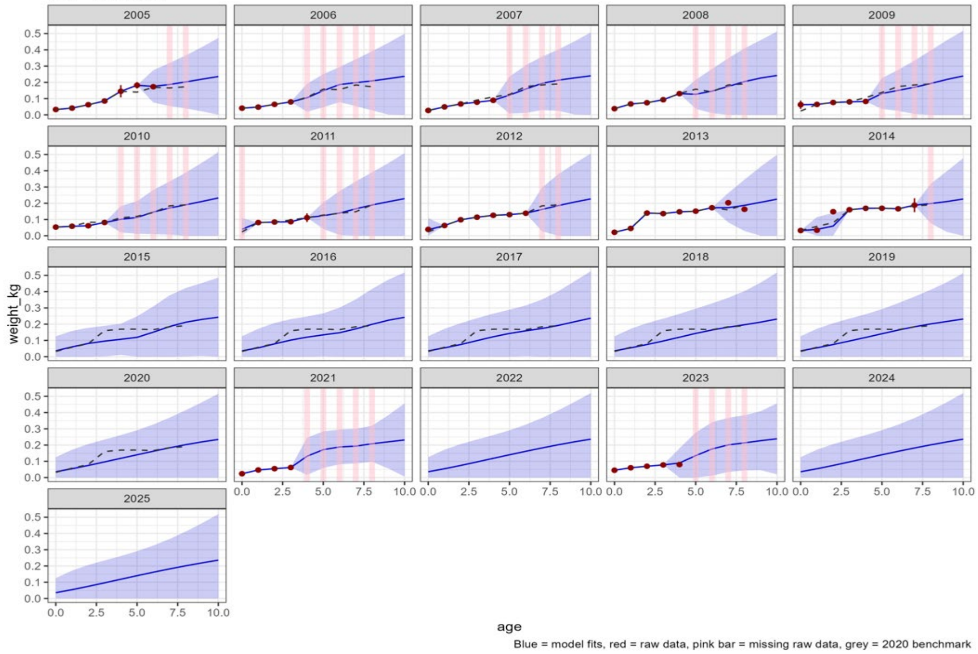


Request 13: Filter the fishery weight-at-age data for PNW by season.
Rationale: The plots for the 2020 model currently show two PNW data points for each year.
STAT Response: This plotting error was corrected (see STAT response for Request 14).

Request 14: More generally, the STAT should revisit the code used to plot fishery weight-at-age by season. If issues cannot be resolved, the STAT should present an alternative way forward (e.g., use similar methods to those used for the 2020 assessment).
Rationale: The 2024 model-based estimates appear to be poorly aligned with the data. There are also some highly unlikely estimates using the 2020 model (e.g., a decrease in mean weight at age-6 compared to age-5 in 2014).
STAT Response: Coding errors in generating plots were found and figures updated.

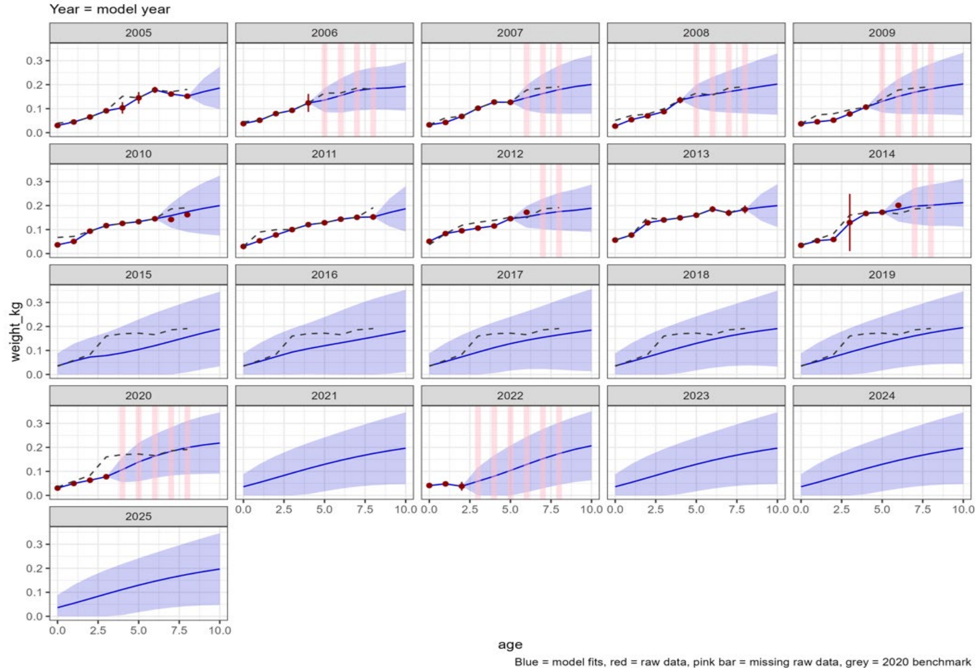
1: MexCal S1 weight-at-age by YEAR

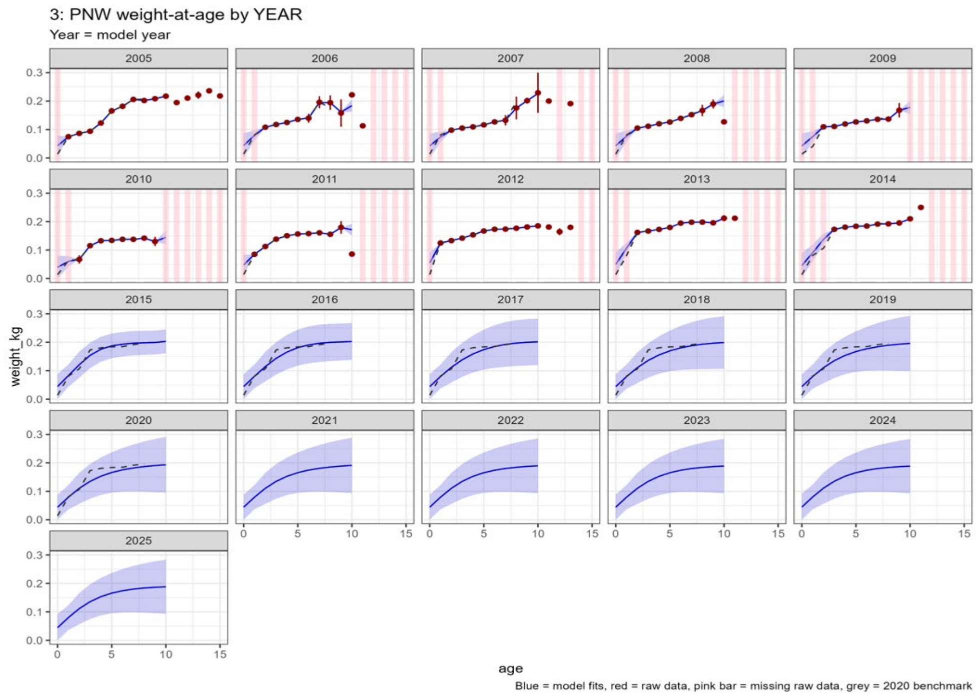
Year = model year



2: MexCal S2 weight-at-age by YEAR

Year = model year





Request 15: Include weight-at-age estimates for years with exempted fishing permits (EFPs) in the plots.
Rationale: Weight-at-age estimates from the EFP (2015 to 2023) were missing from the plots shown to the Panel.
STAT Response: The requested data are included in the STAT response to Request 14.

Day 3 requests made to the STAT during the meeting - Friday February 23, 2024
There were no requests on Day 3.

3) Technical Merits and/or Deficiencies of the Assessment
The final base model incorporates the following specifications:

- Time period from 2005-2023, with projections to 2025.
- Sexes combined and maximum modeled age of 10 years.
- Natural mortality estimated using a diffuse prior with median M=0.675 yr^{-1} and standard deviation 0.31 and a Lorenzen function of age.
- AT survey catchability (survey Q) set to 1 for 2005-2014 and 2022-2023, 0.589 for the 2021 spring survey, and 0.733 for 2015-2019 and the 2021 summer survey. The lower survey Qs for 2015-2021 are to account for fish surveyed nearshore of the core AT sampling grid.
- Estimates of maturity converted from length-based to age-based using a pooled spring survey age-length key.
- Empirical weight-at-age for the fishery based on a random effects model and the survey using observations and imputation.
- Selectivity
  - Fishery selectivity:
    - MexCal fleets: age-based, time-varying, and modeled using a non-

parametric base form with random (and independent) annual and age-based deviates for 2005-2014.

    - PNW fleet: age-based and logistic with time-varying age-at-50%-selection for 2006-2014.

  - AT survey selectivity: age-based, assumed asymptotic, and time-invariant with selectivity for age 0 estimated.

- Virgin recruitment (R_0) estimated, underlying recruitment variability (σ_R) set to 1.2, and h set to 0.6 (assigned based on other small pelagic assessments where steepness was estimated and the upper limit of the likelihood profile-based confidence interval for h using the data for the NSP).
- Initial equilibrium ("SR regime" parameter) estimated.
- Recruitment deviations estimated from 2005-2023.
- Catch for 2024 based on the fishing mortality estimates for 2023.

The model fits the fishery age compositions well for most years owing to the use of flexible selectivity patterns. The fit to the age compositions for the survey is poorer due to the general lack of temporal information in the age data for cohorts, i.e., it is difficult to follow strong cohorts through the time series of age compositions. The fits to the AT survey index are good, with no need to estimate an additional variance parameter.

Although the catch time-series for the PNW fishery was updated during the Panel meeting, the age compositions for the PNW fishery were not reweighted. This was considered appropriate given the fact that the last age composition for this fishery was for 2014.

Some key parameters are assumed to be known exactly (e.g., h and σ_R). As for the previous assessment, the high value for natural mortality in the base model (mean = 0.545 yr^{-1}, SD = 0.038) resulted in a relatively large proportion of the age 1+ biomass in 2024 consisting of "generated" fish.

4) Areas of Disagreement

There were no major areas of disagreement between the STAT and Panel, nor among members of the Panel.

5) Unresolved Problems and Major Uncertainties

The primary data sources used to estimate total biomass and relative recruitment strength are the AT biomass indices and the AT age compositions. Age-specific selectivity patterns for the fisheries are flexible and time-varying, with the aim of being able to correctly remove the historical catches by age. The inability to fit the survey age-composition data is not due to conflict with the fishery age-composition data because making fishery selectivity even more flexible did not improve the fits to the AT survey age-composition data (see response to Request 9). The sampling for biological data has improved considerably over time due to increasing sample sizes from the AT survey and the availability of biological samples from EFP catches. It may be necessary to increase sample sizes further given the reliance of the assessment on age data. Work needs to be undertaken (see high priority research below) to check whether the sample sizes for age composition are sufficient to reliably estimate the age composition of the component of the population available to the survey.

The assessment is based on fishery age-composition data from the US only. The effect of this is minor given that the revised habitat model reduced the proportion of the total catch assumed to be NSP taken off Mexico. However, the assessment model still assumes that the US and Mexican catch age compositions are the same.

The Panel was presented with preliminary information on the presence of Japanese sardine off the US West Coast. This information is insufficient to quantitatively assess the proportion of the catch or survey biomass that consists of Japanese sardine in recent years, and Appendix C to the assessment report is at best illustrative. The results of the assessment would, however, be sensitive to some of the historical catches and AT survey biomass being attributed to Japanese sardine.

The catch data are also uncertain given that the habitat model was used to identify locations and times for which the stock represents the NSP. The habitat model will lead to errors in allocation of catch to a given stock (even if it is correct "on average"), which led to the STAT reviewing the catch for Ensenada during January 2022 that was allocated to the NSP based on a direct application of the habitat model.

The assessment is based on pre-specifying survey Q. The value assumed for many years of survey data is 1. The AT survey has been reviewed by the PFMC SSC and the assumption that Q=1 for some surveys forms the basis for several previous assessments. although the value of Q in the Q likelihood profile with the maximum likelihood was 1.5. There are many sources of uncertainty related to the AT survey, and fixing Q=1 leads to an underestimate of variance (as does pre-specifying parameters such as *h* and the weight-at-age). Previous reviews of the AT survey have identified factors that could lead to variability in survey Q (PFMC, 2011, 2018) including (but not limited to):

- differences in relative catchability of species by acoustics and trawl net;
- species-specific effects of behavior, trawl catchability, and selectivity on relative and absolute population sizes;
- CPS in the surface layer not observed by acoustics;
- CPS avoidance of and escape from the trawl net;
- uncertainty in target strength; and
- uncertainty and bias in ageing methods.

The Panel reiterates the importance of implementing previous research recommendations related to the AT survey to improve the confidence in the AT survey estimates.

The assessment of Pacific sardine (as well as those of other CPS such as Pacific mackerel [*Scomber japonicus*] and the central subpopulation of northern anchovy [*Engraulis mordax*]) is based almost entirely on the information from the AT survey (index and age-composition data) because the AT survey is considered the most reliable method available for indexing Pacific sardine. The Panel notes the difficulties in obtaining estimates of biomass (and associated age-compositions) in 2022 and 2023, and highlights the importance of the AT survey and attempting to ensure that it is implemented as planned. It also notes that if problems running the AT survey continue, future STATs may need to reconsider the use of alternative surveys such as the Rockfish Recruitment and Ecosystem Assessment Survey (RREAS).

Several of the key parameters of the model could not be estimated given the short time series of data used in the assessment.

6) Issues raised by the CPSMT and CPSAS representatives during the meeting

a) CPSMT issues

The CPSMT (MT) representative greatly appreciates the substantial efforts by the stock assessment team and the constructive Panel discussion and offers the following comments.

The MT representative agrees with the stock assessment review panel on the identified research recommendations that could help inform future stock assessments. One research recommendation to highlight is developing a sampling design for Japanese sardine so that future surveys can apportion biomass to the two species accurately. The MT representative is looking forward to seeing more research on this relatively new finding to acquire more complete information of this species. As noted during the review, there should also be a continued effort to develop other indices of abundance in case one data source is unavailable in a specific year. Regular analyses of species composition comparisons between data collected using NOAA white ship trawl gear and industry vessel purse seine gear are recommended so that survey data stay consistent.

During the Panel discussion, it was noted that since the Pacific sardine fishery has been closed, there has been little fishery-dependent sample data in the assessment. California Wetfish Producers Association (CWPA) has been conducting an EFP to simulate a directed commercial sardine fishery. The biological and age data from the EFP were sampled by California Department of Fish and Wildlife staff and were included in the assessment. Other sectors of the Pacific sardine fishery are still open, such as the live bait fishery, and there is currently work being done by CWPA to collect data from this fishery. The stock assessment team should work with these and other fishery-dependent data and consider incorporating them in the assessment model.

The MT representative recognizes the importance of collaboration between NOAA, the West Coast Pelagic Conservation Group, and the CWPA use of industry vessels (*Lisa Marie* and *Long Beach Carnage*) to support collection of acoustic and biological data and would like to see this maintained for future surveys.

b) CPSAS issues

The CPSAS would like to thank the STAR Panel for their complex review of the Pacific sardine stock assessment. We especially would like to thank them for incorporating some of our suggestions into the model while considering others.

The CPSAS is concerned about several aspects of the STAR Panel review. While stock structure is not under review at this meeting, it is one of our major concerns. The assumption of two stocks makes it difficult for assessment now that the sea surface temperature index is combined with the lower-level production index. We believe that only one stock structure should be included in future STAR reviews - the entire Pacific sardine population including Mexico and Canada.

With regards to the acknowledgement of Japanese sardines on the West Coast, the CPSAS is concerned about how they will be considered in future assessments. Sufficient genetic work needs to be completed to determine their distribution and contribution to the West Coast stock of sardine.

Should they be ignored or subtracted from the stock assessment? Also, do Pacific sardines occur in Japan and what entity or entities manages Japanese sardines?

The CPSAS believes that the data from the CDFW aerial surveys and *Long Beach Carnage* surveys should not be excluded from the stock assessment because the assessment considers them to be from the southern stock. With a one stock model the issue of temperature and productivity could be eliminated and their data included.

The CPSAS would like to see a better analysis of how sardines are aged by weight. Anything short of actually reading the otoliths introduces error. Ageing past 1-year old introduces bias since the fish don't all grow at the same rate. Using weight to determine age introduces another bias, the condition factor of the fish.

While the habitat model does a good job of describing the habitat of 1+ sardines it is not as descriptive of 0 and age 1 fish, which tend to occur closer to shore. Perhaps some of the independent sardine surveys can contribute to a nearshore estimate.

Finally, the surveys conducted by the *Lasker* and *Lisa Marie* should be compared to determine if there are differences in biology and estimates.

Research Recommendations:
High priority

1. Efforts to improve the AT survey should continue. This includes comparing species compositions between trawl and purse seine gears and between the *Lisa Marie* and NOAA white ships.
2. Stock structure investigations remain a high priority. Many studies are listed as being in progress in the recent Stock Structure Report (Yau, 2023). Completion of this work is considered a high priority, with considerable potential impacts for management.
3. Mexican scientists should be involved in CPS assessments. This is particularly important given the perceived changes to the distribution of the northern subpopulation.
4. The habitat model plays a critical role in the identification of the distribution of northern and southern subpopulations of sardine. Modifications to the original model (Zwolinski *et al.,* 2011) with new information has resulted in major changes in the potential distribution of each sardine stock in southern California and northern Baja California and how the stocks are dispersed throughout the species geographic range. While the habitat model will be applied for each assessment and it is important to update the parameters of model on a regular basis, it is not necessary to update the parameters annually. An appropriate frequency for updating the parameters of the habitat model should be determined.
5. It is important that CUFES (continuous underwater fish egg sampler) data as supplied from quarterly CalCOFI surveys continues to be available as it is essential to the ability to update the habitat model.
6. Japanese and Pacific sardines are virtually indistinguishable visually, and identification relies on genetic methodologies. The confirmation of Japanese sardines on the west coast of North America has potentially major consequences for apportioning the species and assessing their relative contributions to coastal pelagic biomass. Genetic studies of opportunistic sardine samples suggest that 42% and 28% of the fish examined in 2022 and 2023 respectively were Japanese sardines. If these preliminary results are correct, Japanese

sardine could represent a significant proportion of the assumed Pacific sardine biomass. The SWFSC Genetics and Life History Groups should work with the STAT to develop a study design to address this issue, acknowledging that many samples covering the entire stock range are needed.
7. Difficulties in tracking cohorts in the survey information (base run) requires further investigation. This includes evaluation of within reader bias, and how it impacts the assessment. Larger samples may be required to generate reliable age-length keys. Length-based alternatives could be explored.
8. A steepness prior based on the data on stock-recruitment relationships included in the RAM Legacy Stock Assessment Database (http://ramlegacy.org/) should be developed.

Medium priority

1. Changes in interannual coverage, timing, and north-south direction of surveys need to be more completely documented to allow assessment of the implications on important survey results such as biomass indices and size-at-age.
2. The confidence intervals for the survey mean weights-at-age are large, perhaps too large. How the variance is calculated in the model should be reviewed and corrected if necessary.

Low Priority

1. The assessment relies on the current AT survey time series. Having an alternative index would provide a second source of information to complete the assessment.
2. The STAT should develop a method that avoids negative or no growth scenarios when computing mean weights-at-age for the fishery.

Other

1. The STAT is encouraged to document the contributions made by industry and partner agencies to the stock assessment, including biological sampling. Furthermore, it was identified that further opportunities exist for sampling fisheries that still operate even though the directed fishery is closed (e.g., the live bait fishery). There may also be opportunities to obtain age-composition data from non-directed fisheries such as that for Pacific hake (*Merluccius productus*).
2. The catch data for the PNW fishery were updated twice during the Panel meeting and required model reruns for each update. There is a need to ensure that the catches included in the models reflect the most accurate estimates. The Terms of Reference for stock assessments should be updated to include clear guidelines for how the STAT interact with state data stewards to obtain catches prior to STAR Panel meetings.
3. The process for deciding when not to use the results of the habitat model (as was the case for the January 2022 catch off Ensenada) should be formally documented and included in the Accepted Practices document for CPS assessments.

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Appendix 1: Attendance List

Name	**Affiliation**
Stock Assessment Review Panel	
André Punt	SSC/University of Washington, Chair
Gary Melvin	CIE
John Neilson	CIE
Theresa Tsou	SSC/WDFW
Cheryl Barnes	SSC/OSU-ODFW
Advisors	
Steve Crooke	CPSAS
Trung Nguyen	CPSMT/CDFW
Stock Assessment Team	
Peter Kuriyama	SWFSC
Juan Zwolinski	SWFSC
Kevin Hill	SWFSC
Caitlin Allen Akselrud	SWFSC
Other attendees (in person or online)	
Alex Jensen	SWFSC
Kirk Lynn	CPSMT/CDFW
Kerry Griffin	PFMC
Lanora Vasquez	SWFSC
Josh Lindsay	NMFS WCR
Kelsey James	SWFSC
Brittany Schwartzkopf	SWFSC
Charlie Hinchliffe	SWFSC/UCSC
Owyn Snodgrass	SWFSC
Briana Brady	CDFW
Brad Erisman	SWFSC
Matthew Craig	SWFSC
Katie Davis	NMFS WCR
Nick Jurlin	CPSAS
Josiah Renfree	SWFSC
Steve Teo	SWFSC
James Hilger	SWFSC
Caeli Griffin	Scripps Institution of Oceanography
Richard Parrish	
Kristen Hinton	
Emmanis Dorval	SWFSC
Phil Dionne	WDFW
Huihua Lee	SWFSC
Alan Byrne	SSC/IDFG

CDFW = California Department of Fish and Wildlife
CIE = Center of Independent Experts
CPSAS = Coastal Pelagic Species Advisory Subpanel
CPSMT = Coastal Pelagic Species Management Team
IDFG = Idaho Fish and Game
NMFS WCR = National Marine Fisheries Service West Coast Region
ODFW = Oregon Department of Fish and Wildlife
OSU = Oregon State University
PFMC = Pacific Fishery Management Council
SSC = Scientific and Statistical Committee
SWFSC = Southwest Fisheries Science Center
UCSC = University of California Santa Cruz
WDFW = Washington Department of Fish and Wildlife

Appendix 2: Editorial changes to the draft assessment report

1. Include information about collaborations with industry and agencies in the assessment report (e.g., the California Wetfish Processors Association's involvement with abundance surveys, Saltonstall-Kennedy grants with Juan Zwolinski). There have been notable contributions (logistical and financial) related to data collection, and these should be acknowledged alongside relevant text or in the acknowledgements section of the report.
2. Modify the language on page 18 (Lines 593-595 of the draft report) to correct the statement about the limited capacity of purse seines to capture sardines because the net used is the same as that used by the *Lisa Marie*. A more appropriate reason for not including those data in the assessment needs to be provided.
3. Expand on the justification for fixing steepness at 0.65 (or 0.6 in the final model).
4. Add a caption to Figure 8.17.
5. Expand Section 2.5 to better describe the rationale for not including the RREAS survey data or the daily egg production method for estimating spawning biomass in the assessment. Although these decisions were made for previous assessments, it would be helpful to provide the rationale in the current assessment.
6. Line 242. The reference to PFMC (2017) should be to PFMC (2020).
7. Line 398. Correct the text as the instruction was a minimum of 3-5 sets, if possible.
8. Line 997. The reference to July 2023 should be to July 2024.
9. Line 779: "fixed at 0.65" should be "fixed at 0.30".
10. Line 1289: "h = 0.3" should be "h = 0.6".
11. Expand the maturity section of the assessment report.
12. More clearly document the methods used to impute survey and/or population values.
13. Add a column to Table 7.6 that lists the coefficient of variation (CV) estimates that were used in the assessment.
14. Include the time-invariant length-weight relationship in the assessment document and identify where it is used. The length-weight key used for survey data is not provided in the draft report.
15. Provide information about the model changes between steps G to H in Table 7.10. Descriptions of the changes that resulted in a reduction of 71 parameters and more than a two-fold increase in likelihood are missing.
16. Include text about recent genetics findings that illustrate the incidence of Japanese sardine in US waters. Note that future survey efforts will need to account for Japanese sardine catches and biomass estimates.
17. Text should be added about the habitat model and how it was used to classify Mexican catches and identify NSP habitat for the survey.
18. Line 312: How were the monthly landings, usually in mt, converted to the number of fish?
19. Line 490: Provide information on the "time-invariant length-to-weight relationship" for survey data. Is this the same as used in Hill et al. (2016), referenced in line 470?
20. Line 766: Should this be 0 to 8+ or 0 to 10+?
21. Consider restructuring Table 7.6 or add another appendix so that survey components are more clearly laid out.
22. Ensure that the values in Table 10.3 match those in Fig. 10.1.
23. Add a description of why the 2021 biomass "bump" occurs.

24. Color the recruitment estimates that are "taken off the stock-recruitment curve" in time-series plots of recruitment and recruitment deviations.
25. Replace "unmanned surface vehicle" (USV) with "uncrewed surface vessel" (*sensu* NOAA here) throughout the text.