Center for Independent Experts (CIE) Independent Peer Review Report on the Virtual STAR Panel Review of the 2021 Central Stock of Northern Anchovy Stock Assessment

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Executive Summary:

The review of the 2021 Central Subpopulation of Northern Anchovy (CSNA) draft stock assessment developed by the NMFS Southwest Fisheries Science Center (SWFSC) STAT team was conducted by the Stock Assessment and Review (STAR) Panel, virtually, from 7-10 December 2021. The main objectives of the Panel were to ensure that the stock assessment represents the best scientific information available and to facilitate the use of this information by the Council to adopt OFLs, ABCs, ACLs, harvest guidelines (HGs), and annual catch targets (ACTs). This included a detailed technical review of the stock assessment data inputs, analytical models, and to provide a completed STAR Panel report. The CSNA stock assessment was based on the Stock Synthesis Assessment tool Version 3.30.17 with a single index of abundance (ATM) and two fishing fleets. The aim was to estimate the 2020 Age 1+ biomass. The last stock assessment of this subpopulation was in 1995.

The assessment document and all background material necessary to conduct the Panel Review was made available to Panel members about two weeks in advance, allowing plenty of time to prepare for the meeting. In general, the Panel review adhered to the agenda provided prior to the meeting, although the Chair was flexible and allowed diversion into other subject areas when they were relevant to the discussion. Thirty-three Panel requests for additional information, sensitivity runs, and clarification of procedures were made to the STAT over the 4-day meeting. These requests were fulfilled promptly and to the satisfaction of the Panel. Only two requests could not be completed during the meeting due to the extensive effort or time required to undertake the analysis. Much of the success of the Panel Review can be attributed to the STAT who did an excellent job of summarizing the information and providing the available data to address the issues at hand. The Chair kept the group focused on the topic being addressed while at the same time allowing everyone, including observers, to express their views or contribute their expert opinion. A number of the attendee's also provided valuable input during the course of the meeting.

The initial base model provided in the draft assessment report estimated current 1+ biomass (2020) based on the data source (i.e., AT survey) the STAT considered most reliable. Consequently, the proposed assessment model started in 2015, the first year for which estimates of biomass for the CSNA were available from the AT survey. Earlier AT surveys (2006-2014) took place with similar areal coverage, but estimates of anchovy biomass were considered unreliable as these surveys focused on sardine abundance. The model was fit to AT biomass index and the age-composition data from the AT survey, as well as the age-composition data from two fisheries MexCal S1 and MexCal S2. The review and subsequent exploration of the assessment through sensitivity analyses concentrated on the need to address issues associated with the input data, the index of abundance, overall model parameterization and the time series.

Panel discussion focused on a number of issues including the specification of survey catchability (Q), which was set to 1 for the AT survey, consequently there was no correction for inshore abundance in the initial base case assessment. This was counter to previous direction given at various reviews of the AT survey. Selectivity-at-age. which varied considerably from one year to the next, was discussed in detail as well as whether the very high fishing mortality rates observed for

some fisheries and seasons were plausible given the estimated age-specific selectivity patterns. The ageing and specification of age-reading matrices was a major area of concern for the Panel as well as whether the results of 2015 AT survey (which appear to be lower than expected given the subsequent surveys) should be included in the assessment. The Panel made numerous requests of the STAT to address these issues/concerns.

The final base model differed from the base model in the draft assessment report in that it included the Summer 2021 AT survey preliminary biomass estimate, reducing the plus-group from 4+ to 3+, an updated age-reading error matrices (removal of suspected problematic reader), and modifying how time-varying selectivity was modelled. Adjustments were also made to the biomass estimates and survey Q to reflect biomass inshore of the area sampled by the AT survey.

The Panel concluded, based on the information provided and the available data, that a revised based model that addressed and number of concerns expressed during the meeting was more appropriate than the original proposed base model provided in the draft stock assessment document. Specific areas of concern were associated with stock structure, ageing errors, catchability, natural mortality and fishing mortality rates, selectivity, and discrete time period for key parameters, as well as the length of the assessment. However, the Panel concluded that the short-term model using the ATM as the sole index of abundance (including 2015 and 2021 preliminary data) was the better approach to provide the required estimate of age 1+ biomass for management of the CSNA resource. The terminal year (2021) age 1+ biomass was estimated to be 1,371,634t; 1,358,587t from the AT core area, and 13,047t from the nearshore.

The Panel's report, to some extent summarized in this report, represents the consensus view of the STAR Panel Review of the 2017-2018 Pacific Sardine Stock Assessment and I fully concur with its content, recommendations, and conclusions. Overall, there were no major areas of disagreement between the STAT and Panel, nor among members of the Panel.

1.0 Background.

1.1 Process Overview

The National Marine Fisheries Service (NMFS) is mandated by the Magnuson-Stevens Fishery Conservation and Management Act, Endangered Species Act, and Marine Mammal Protection Act to conserve, protect, and manage the nation's marine living resources based upon the best scientific information available (BSIA). To fulfil this mandate stock assessments are conducted at regular intervals to assess the abundance and trends of fish stocks and to provide the fundamental basis for evaluation of stock status and for management decisions regarding appropriate harvest levels. In most cases, assessments use statistical population models to integrate and simultaneously analyze survey, fishery, and biological data. Environmental and ecosystem information may also be integrated in stock assessments. In essence, statistical and mathematical calculations are used to evaluate quantitative predictions about the reactions of fish populations to alternative management actions (Hilborn and Walters, 1992). Stock assessments must also attempt to identify and quantify major uncertainties, balance realism and parsimony, and make best use of the available data. The STAR Panel process was designed to provide the peer review referenced in the 2006 Reauthorization of the Magnuson Stevens Fishery Conservation and Management Act (RMSA). National Standard 2 (NS2) provides guidance and standards to be followed when establishing a peer review process including guidance on the timing, scope of work, peer reviewer selection and process transparency. The STAR process follows these standards and is fully compliant with NS2. The STAR Panel review of the 2021 Central Sub-population of Northern Anchovy Stock Assessment was chaired by Dr Andre Punt.

Under this mandate the NMFS Office of Science and Technology coordinates and manages a contract for providing external expertise through the Center for Independent Experts (CIE) to conduct independent peer-reviews of NMFS scientific projects. The CIE reviewers are selected by the CIE Steering Committee and the CIE Coordination Team to conduct an independent peer review of the NMFS science in compliance with the predetermined Terms of Reference (TORs). In this case the "Terms of Reference for the groundfish and coastal pelagic species stock assessment review process for 2021-2022", provided as background material for the meeting, describes the objectives and the roles and responsibilities of the participants. Two CIE reviewers served on the six-person Stock Assessment and Review (STAR) Panel. The reviewers were chosen based on their expertise to provide an impartial, independent peer review without conflicts of interest, report on methods, outcomes and recommendations of the stock assessment review. The Statement of Work (SoW) described in Appendix 2 identifies the roles, responsibilities and reporting structure for the CIE reviewer.

It is important to note that the following report to the CIE reflects my independent opinions and views on the issues and questions identified for the Central Sub-population of Northern Anchovy stock assessment in the terms of reference, the statement of work, and the goals and objectives. The report is, however, generally consistent with the recommendations and conclusions of the other STAR Panel members and CIE reviewer expressed in the Star Panel Report prepared by the Panel Chair. Overall, there was consensus on the interpretation and conclusions for each of the TORs among the Panel members with no decision changing areas of disagreement.

1.2 General Background:

The Northern anchovy (Engraulis mordax) is a small pelagic species that ranges from northern British Columbia in Canada to the Gulf of California, Baja California Sur, Mexico. Evidence from meristic, morphometric and serological studies support the existence of three subpopulations along the west coast of North America; a northern subpopulation (NSNA) ranging from the Queen Charlotte Islands, British Columbia, to Cape Mendocino, California; a central subpopulation (CSNA) extending from approximately Point Reyes, California, to Punta Baja, Baja California; and a southern subpopulation (SSNA), ranging from Sebastian Vizcaino Bay to the Gulf of California. Movement between the three subpopulations is thought to be minimal, although some overlap in distribution does occur in both the north and south it appears to be limited. However, while the current literature suggests that the subpopulations is not genetically distinct and cannot be not divided into geographically structured independent subpopulations, it does not appear to form a single panmictic populations (Lecomte et al., 2004). Allozyme studies reveal shallow and transient genetic heterogeneity (Hedgecock et al., 1994), while mtDNA studies reveal diversity gradients. The central subpopulation of northern anchovy is typically found in waters from 12° to 22°C with spawning occurring between 12 and 17°C. Although spawning has been observed throughout the range and year, it tends to be concentrated in the Southern California Bight between January and April. June 1 is the assigned birthdate for northern anchovy. The inshore/offshore and north/south distribution of the CSNA appears to vary based on life stage and year. Young of year are typically found in nearshore waters, juveniles are both further offshore and nearshore, and adults observed mostly offshore (Parrish et al. 1985). In addition, the proportional movement (known to be variable) of this sub-population into Mexican waters changes with season and year.

The last stock assessment for CSNA was conducted in 1995 when the biomass was estimated to be 388,000 mt (Jacobson et al. 1995). Biomass peaked at over 1.54 million mt in 1974 but declined rapidly to 326,000 mt in 1978. From 1986-1994 biomass has declined slowly, to an average of 262,000 mt. Anchovy biomass remained low until 2015 when levels began to increase. The following review and assessment are focused on fishery and survey information available for the central subpopulation of northern anchovy (CSNA) up to and including 2021. The current 1+ biomass is in excess of 1.37kt.

1.3 Review Overview:

The STAR Panel Review of the 2021 Central Stock of Northern Anchovy Stock Assessment was convened virtually from December 7-10, 2021, to review a draft assessment prepared by the Stock Assessment Team (STAT). The structure, responsibilities, goals, objectives and reporting requirements were defined under the terms of reference (TOR) for the groundfish and coastal pelagic species stock assessment review process for 2021-22. This was the first stock assessment in 25 years for this species and a major step forward in the management of this resource. Essentially, the Panel reviewed an initial stock assessment for providing advice to management on stock status. and the STAT revised it accordingly based on the inputs from the Panel members and responses to requests for additional information or assessment sensitivity runs with new parameters (see Panel requests). A list of attendees and the agenda are provided in the Appendices. It should be noted that because the CIE reviewer report is a standalone document, several sections of this report contain text that has been extracted almost

verbatim from the STAR Panel report as the reviewer contributed to the document and feels it provides a good overview of the process and discussions.

Stock assessment team (STAT) members, Drs. Peter Kuriyama, Kevin Hill, and Steve Teo from the NOAA / SWFSC and Juan Zwolinski from the University of California Santa Cruz, presented a general overview of the assessment methodology, inputs and results for various aspects of the stock assessment. Peter Kuriyama outlined the draft assessment and then moved on to provided information on the fishing fleets, and the primary index of abundance from the Acoustic trawl Method survey (AT) as well as potential alternative indices. Juan Zwolinski provided a more in-depth overview of the Acoustic Trawl (AT) Method survey detailing the survey design, its coverage and the procedures for estimating biomass. He also described the survey-based method for apportioning the biomass into age classes which involved estimating numbers-at-age from the numbers-at-length using an age-length key (assumed to be an annual ALK's) from the AT survey. Emmanis Dorval and Brad Erisman summarized the inter-reader difference and how the age-reading error matrices and maturity ogives were estimated. Kirk Lynn (CDFW) summarized the results of recent aerial surveys for CSNA. John Field (SWFSC) presented the Rockfish Recruitment and Ecosystem Assessment Survey (RREAS).

Stock Synthesis Assessment Tool v3.30.17 was used to develop the proposed base model provided to the Panel in the Draft Stock Assessment Document. The aimed was to estimate current 1+ biomass (2020) using the data source (i.e., index of abundance) the STAT considered most reliable (i.e., the AT survey). Consequently, the assessment started in 2015, the first year for which estimates of biomass for the CSNA were available from the AT survey. Because of the management requirements and fishing year, there was a requirement to provide the age 1+ biomass as of June 1. Earlier AT surveys (2004-2014) took place with similar areal coverage, but the estimates of anchovy biomass were considered unreliable as these surveys focused on sardine abundance. In addition to fitting to AT biomass index and the age-composition data from the AT survey, the assessment also fitted to age-composition data from two fisheries MexCal S1 and MexCal S2. The assessment pre-specified weight-at-age rather than estimating it using a parametric growth curve and allowed for time-variation in selectivity. The review and subsequent exploration of the assessment through sensitivity analyses were motivated primarily by the need to address issues associated with the input data, the index of abundance, overall model parameterization and the time series.

It was noted that the Pacific Fishery Management Council (PFMC) had adopted a new management framework, which requires a "long-term" average estimate of 1+ biomass for the most recent ten years and an estimate of the exploitation rate on 1+ biomass corresponding to MSY (e.g., E_{MSY}). Conversely, the STAT developed its assessment with a focus on estimating the current 1+ biomass. Panel discussion included an evaluation of whether an assessment that involved a longer time period would be feasible and the STAT examined assessment model runs based on a longer time period with some of the alternative indices. However, in the end the STAT decided to base the assessment on the shorter time period and the Panel concurred.

Panel discussion also focused on a number of other issues including the specification of survey catchability (Q), which was set to 1 for the AT survey with no correction for inshore abundance in the draft assessment. This was counter to previous direction given at various reviews of the AT survey. Selectivity-at-age which varied considerably from one year to the next was discussed in detail as well as whether the very high fishing mortality rates observed for some fisheries and seasons were plausible given

the estimated age-specific selectivity patterns. The ageing and specification of age-reading matrices was a major area of concern for the Panel as well as whether the results of 2015 AT survey (which appear to be lower than expected given the subsequent surveys) should be included in the assessment. The Panel made numerous requests of the STAT to address these issues/concerns.

The final base model differed from the base model in the draft assessment report by including the Summer 2021 AT survey estimate of biomass, reducing the plus-group from 4+ to 3+, updating the age-reading error matrices (removing a suspected problematic reader), and modifying how time-varying selectivity is modelled. Adjustments were also made to the biomass estimates and survey Q to reflect anchovy biomass inshore of the area sampled by the AT survey. The effects of these adjustments were minor but reflect implementation of the recommendation of the 2018 AT Methodology Review that the corrections be made to AT estimates to reflect inshore areas (albeit giving extrapolation of AT densities more emphasis than use of aerial survey estimates of abundance, a decision questioned by aerial survey proponents including the CPSAS representative). This decision was noted by some as inconsistent with conclusions reached at the joint meeting on issues related to management of CSNA (November 2019) to use direct observations in preference to extrapolation.

The STAR Panel would like to thank the STAT, and particularly the STAT lead, for their hard work and willingness to respond to the many Panel requests. The Panel also recognized the tired less effort and contributions of the other scientists who contributed to the assessment through the provision of, for example, abundance indices, age-reading error matrices, age-composition data, and basic biological information. The Panel also appreciated the very collaborative nature of the team that led to the draft assessment and the final base model.

1.4 Goals and Objectives– Stock assessment review process

The goals and objectives of the groundfish and CPS STAR process are to: 1) ensure that stock assessments represent the best scientific information available and to facilitate the use of this information by the Council to adopt OFLs, ABCs, ACLs, harvest guidelines (HGs), and annual catch targets (ACTs); 2) meet the mandates of the Magnuson-Stevens Fisheries Conservation and Management Act (MSA) and other legal requirements; 3) follow a detailed calendar and fulfill explicit responsibilities for all participants to produce required reports and outcomes; 4) provide an independent review of stock assessments; 5) increase understanding and acceptance of stock assessments and peer reviews by all members of the Council family; 6) identify research needed to improve assessments, reviews, and fishery management in the future; and 7) use assessment and review resources effectively and efficiently

2.0 Description of the individual reviewers' role

The CIE reviewers served two roles on the STAR Panel Review of the 2021 Central Stock of Northern Anchovy Stock Assessment. The first is to participate as a full Panel member in the review of the practices and procedures involved in the proposed assessment methods/approaches, and the second to provide an independent review of the methodology and process.

To meet these requirements for the assessment of the 2021 Central Stock of Northern Anchovy the reviewer must have achieved recognition in several fisheries related fields. In this context I am considered an expert in the assessment of small pelagic fish stocks, fisheries acoustics as applied to assessment of small and large pelagics fishes, and their application to the management. Currently, I am the Chair of the ICCAT Standing Committee on Research and statistics (SCRS) responsible for the coordination of stock assessments and research for all mandated tuna and tuna like species in the Atlantic Ocean and the Mediterranean Sea. Before retiring I was a senior Research Scientist with the Canadian Department of Fisheries and Oceans responsible for the research and assessment of large and small pelagic fish species. In addition, I was the scientist responsible for the acoustic program in my region of Canada and I have spent more than 30 years as lead scientist for the small pelagic stock assessment program. I have a B.Sc. M.Sc., and PhD in fisheries related fields and have served on several international stock assessment review groups including STAR Panel reviews. Between 2010 and 2014 I was the Chair of the ICES North Sea Technical Review working group which provided quality control for all North Sea fish stocks assessed by ICES.

My primary role in this STAR Panel review was to participate in the 2021 Review as an informed expert and to contribute to the discussions and recommendations put forward by the STAT and the STAR Panel. Prior to the meeting, the draft stock assessment document was provided by the STAT team along with numerous background reports/documents on the fishery, methods, outputs and recommendations. The majority were read before the meeting so that well informed questions and discussions could be undertaken. Thereafter my focus shifted to the other areas of the review, participating in the discussions on the model-based assessment, major issues such as ageing, changes in mortality, selectivity, and finally, the conclusions/ recommendations of the STAR Panel, contributions to the Panel Report and the preparation of an independent reviewer's report.

3.0 Summary of Findings for each Term of Reference:

The summary presented below is a representation of the STAR review and is generally consistent with the observations and results found in the STAR Panel Review Report. However, in several sections the text has been enhance or is more inclusive to elaborate on specific issues. Prior to discussing the outcomes of the review associated with each TOR I would like to make a few general comments regarding the documentation and the presentations. The stock assessment team (STAT) provided an excellent overview of the methodology and approaches described in the assessment document (Kuriyama et al., 2021). The presentations by individual members of the team were informative and coherent. However, there were a number of cases where insufficient details were provided in the methods section of the draft assessment document for the Panel members to have a clear understanding about what or how something was done. This was promptly resolved by the STAT in providing additional information on an issue or concern when requested by the Panel (see Requests). The STAT was also very helpful in providing the

details or the source of the details to the Panel where clarification was requested. A number of concerns were identified by the Panel and are discussed below. (e.g., Ageing error, stock structure, selectivity and Q).

The STAT team initially presented a proposed base model to the STAR Panel for review (Draft assessment report) based on a single index of abundance (AT) and two fleets (MexCal S1 and MexCal S2). The initial base model assessment provided outputs for age 0+ and 1+ plus biomass, however after consideration of the Pacific Fishery Management Council's (PFMC) new management framework it focused on the 1+ biomass. Given the limited length of the AT survey time series with a focus on northern anchovy, the assessment started in 2015. Although only briefly discussed, the earlier AT survey data (2004-2014) were not used as the STAT felt it was not reasonably developed for the species being assessed.

Consideration was given to the feasibility of a longer timeframe for the assessment by the Panel when alternative indices were examined to accommodate the PFMC request, but in the end the assessment of the CSNA was limited to the period 2015-2021. It is important to note that Summer 2021 AT survey estimate of biomass (preliminary) was provided (not available for the draft base model) to the STAT during the meeting and used in some of the model runs. Caution is warranted before the final base model is endorsed by the SSC in that the survey biomass estimate will not be finalized until early 2022.

The role of the STAR Panel was to conduct a detailed technical evaluation of a full stock assessment to advance the best available scientific information to the Council. The specific responsibilities of the STAR panel were to:

1) Review draft stock assessment documents, data inputs, and analytical models, along with other pertinent information (e.g., previous assessments and STAR panel reports, when available);
2) Discuss the technical merits and deficiencies of the input data and analytical methods during the open review panel meeting, work with the STATs to correct deficiencies, and, when possible, suggest new tools or analyses to improve future assessments; and
3) Develop STAR panel reports for all reviewed species to document meeting discussion and recommendations.

The STAR Panel, including the CIE Reviewers, are responsible for determining if a stock assessment or technical analysis is sufficiently complete. It is their responsibility to identify assessments that cannot be reviewed or completed for any reason. The following provides a summary of the discussions, concerns, request for additional information including additional model runs, the conclusions reached on issues addressed and the research recommendations. Note that some sections have been directly extracted from STAR Panel Report while others have been condensed to reduce the redundancy.

3.1 Technical Merits and Deficiencies:

This is the first assessment of the CSNA in over 25 years. The STAT formulated the assessment giving considerable emphasis to the data source it considered most reliable. The resulting assessment led to biomass trajectories that mimic the biomass estimates from the AT survey well, with the exception of

the 2015 estimate. The 2015 AT survey estimate was lower than expected from the model but because there was no *a priori* reason (e.g., based on survey performance) to exclude the 2015 survey data from the assessment it was included. The fits to the age-composition data from the AT survey were quite poor even though age-reading error was taken into account. The assessment recognized that the fishery age-composition data were informative about the age-structure of removals but given changes in the timing and location of fishing over time may not be informative about recruitment strength. The assessment consequently allowed for time-varying selectivity by fishery. Weight-at-age was set to empirical values.

The STAT attempted to obtain a model that captured a longer set of years than 2015+. Models explored during the Panel included an index of young-of-year and catches prior to 2015 (along with a 2014 fishery age-composition). Indices were also available from California Cooperative Oceanographic and Fisheries Investigations survey (CalCOFI) eggs and larvae and age-1+ animals from the RREAS, but these were not included in any of the models presented to the Panel. The RREAS young-of-the-year (YoY) index was however considered in late sensitivity runs. The resulting "long" models were found to be very unstable (i.e., poorly fix or would not converge) and the point estimates of *M* were very low in some cases.

Three key parameters of the population dynamics model were poorly estimated by the available data (steepness, survey Q and natural mortality). The STAT decided to set survey Q to 1 for the core survey area and explored the implications of correcting the estimates of biomass for the coverage of the stock, (i.e., Mexican waters, and the proportion of the stock that is inshore of the core sampling area). The likelihood profiles for steepness and *M* were found to be quite flat, indicating that the available data provided little information on these parameters. Possibly related to the shortness of the time series.

For some models the parameterization lead to very high fishing mortalities for specific ages in 2015. The final base model has fewer high fishing mortalities than the model in the draft assessment, owing to the change in the way selectivity is modelled. The exploitation rate on age-1+ biomass is much lower than the fishing mortality rate on single age-classes, and this exploitation rate is higher than if the exploitation rate was based on age-0+ biomass as some of the catch is of age-0 animals.

The approaches used to modify survey Q are based on limited data and the uncertainty of extrapolations into the inshore area was not quantified. The effect of the latter is likely small for this assessment but could have been consequential had biomass not been so substantial in recent years.

3.2 Assessment Concerns and Uncertainties

3.2.1 Stock Structure, Distribution and Movement:

Northern anchovy are distributed along the west coast of North America from northern British Columbia, Canada to the Gulf of California, Baja California Sur, Mexico. Current perception is that there are 3 sub-populations (Northern, Central and Southern) which are separated in time and space however the boundaries of these subpopulations are somewhat uncertain and likely subject to interannual variation with potential overlap. The 2021 stock assessment and Star Panel review is focused on the Central Sub-population of Northern Anchovy (CSNA), consequently any overlap in

distribution or mixing can have consequences on the assessment at hand. The CSNA assessment assumes a discontinuous distribution of the northern and central sub-populations with a gap between them in the vicinity of Point Reyes to Cape Mendocino, California identified in DiNardo and Sweetnam (2018), which is not supported by previous studies (Vrooman and Smith 1979; Vrooman 1981). The boundaries of the northern and central sub-populations are potentially subject to seasonal shifts and previous studies have provided differing perspectives on the geographic distribution or the extent of geographic separation of sub-populations. The geographic distribution of sub-populations is an uncertainty relative to growth rate given patterns of latitudinal variation in weight-at-age, catchability considerations regarding the spatial extent of the AT survey and geographical expansion of survey estimates for each sub-population. Under the Fishery Management Plan (FMP) approximately only 70% of the Central subpopulation is thought to reside in US water (inshore and offshore) with the greatest portion in the offshore waters.

Parrish et al (1985) points out that "there is a great deal of regional variation in age composition (number of fish in each age group) and size at age with older and larger fish found at offshore and northerly locations, probably due to northern and offshore migration of large fish, regional differences in growth rate, and water temperature." There is also the potential that as the biomass of the CSNA increases, which it is currently doing, the distribution may protract extending into the geographical regions of the other subpopulations or visa versa. Combine this with the known inshore/offshore and north/south seasonal movement of the species and there is uncertainty as what proportion of the CSNA that is actually being covered by the AT survey, how it varies from year to year and how to account for this variability in the assessment. The issues associated with distribution and movement were a major subject of discussion for the Panel and reflected in the requests to the STAT during the meeting. Further discussion on this issue will be addressed under the survey Q (Section 3.2.2). At the very least new research is required to document the intra and inter annual distribution of northern anchovy. Modern genetics methods may help to resolve some of uncertainty associated with the actual stock structure.

3.2.2 Catchability (Q)

During the course of the meeting the Panel had several detailed discussions on the AT survey catchability "Q" that resulted in requests for additional information and sensitivity runs. In the base model of the draft assessment the Q was assumed equal to 1, implying that all biomass was accounted for by surveying in the core area sampled by the NOAA Ship *Reuban Lasker* (*Lasker*). To some extent this is an unrealistic assumption when it is known that anchovies are observed outside the core area during the AT survey (aerial surveys, unmanned surface vehicle and small boat acoustic surveys); albeit a small portion of the total biomass (5% in 2019) but likely variable from year to year. To investigate this, alternative models accounting for biomass outside the core sampling area through concomitant nearshore sampling by the aerial survey, AT small boat sampling, or extrapolation from the offshore areas sampled by the *Lasker* to the shoreward areas were explored. Unfortunately, data were not available for all inshore survey types in all years for comparison. To accommodate this and to account for biomass outside the core area the STAT prioritized the method to be used, in the following order: direct observations by the AT small boat sampling, followed by extrapolations shoreward from offshore sampling by the *Lasker*, and lastly estimates from the aerial survey. The Panel did not have strong views on the prioritization; however, it was pointed out that this was contrary

to the guidance of the joint meeting of the members of the SSC, CPSMT, and CPSAS on issues related to management of CSNA nearshore estimation Panel, where it was recommended to use direct observations from the AT nearshore or aerial survey before invoking extrapolations given the potential for disparate densities of fish offshore.

The STAT noted the lack of complete coverage of the entire coastline of the other datasets as justification for prioritizing extrapolation, yet the aerial survey biomass in the summer of 2017 was nearly twice that of the extrapolated value despite having only sampled a fraction of the coastline. This led to concerns regarding the representativeness of the extrapolations from offshore to inshore (although the aerial estimate is fairly imprecise, lacks validation of large schools and a defined method to add the biomass to the AT survey). In this instance, use of the aerial survey instead of direct observations may have been preferable to assumptions regarding the abundance of fish offshore vs. inshore in extrapolations. While adjustment of Q to account for biomass inshore of the AT survey may not result in a substantial difference in the biomass estimates at present, since the stock is at relatively high abundance, a substantial proportion may be nearshore at low abundance, underscoring the importance of accounting for nearshore catchability.

As a CIE reviewer I am a little concerned that the entire assessment is dependent upon a single survey (index of abundance) and that the STAT is a little reluctant to explore other options. Reasons have been cited to eliminate all other potential indices of abundance rather than examining ways to integrate the results into the assessment. Further research in this area should be undertaken.

The interannual north/south distribution will also have an influence on the assumption of Q=1 and the assessment results. Previous information on the southern movement, plus the 2021 summer AT survey which sampled into Mexico, provided a mechanism to estimate the proportion of biomass in Mexican waters (outside the core AT survey area) and to inform catchability of previous surveys conducted only in U.S. waters. The adjustments to AT catchability for spring surveys and in other years of the assessment period assumed the total biomass has not change over time, an unlikely scenario. In this case Q will be potentially biased depending on the distribution of the biomass in the period in question compared to summer 2021.

Sensitivity analyses were conducted on catchability assumptions that ranged from ignoring the biomass inshore and assuming a Q = 1, to those alternatives using data from the aerial survey resulting in the lowest estimates of Q to bracket uncertainty, and resulted in a relatively narrow range of biomass estimates. This was consistent with expectations given that the stock is at high abundance level, and the majority of the biomass is distributed offshore. However, accounting for catchability inshore of the AT survey when the stock is at low abundance becomes more critical, as a higher proportion of the stock is expected to be distributed closer to shore and unavailable to the AT survey in the core area offshore as is the unknown proportion in Mexican waters.

Another potential source of uncertainty affecting Q, but not addressed by this review due to the lack of data, is vessel avoidance. Northern anchovy occur near the surface as inferred by the aerial survey detections, consequently there is potential for them to occur in the surface acoustic dead zone (up to 10 meters of more for the *Lasker*) or to avoid the research vessel due to a visual response. Remember the fish must pass beneath the transducer to be detected by the acoustic system. In the

future, additional research to account for the biomass between the surface and the transducer mounted at the bottom of the hull of the *Lasker*, potentially missed if the fish move laterally rather than dive under the vessel is required to provide a more complete understanding of the survey catchability in the core area.

3.2.3 Ageing:

The ageing of fish, either from otoliths or other means, has become an important aspect of stock assessments given the increased use of age-structured stock assessment models, such as those used to assess CPS biomass along the U.S. Pacific west coast. For Northern Anchovy the maximum age appears to drop from 8 to 4 years during unfavorable years, although in recent year fish older than 6 have been observed. Ageing errors can have a profound effect on biological parameters, like age-at-maturity, length-at-age, and weight-at-age, and fishery data such as catch-at-age and catch-per-unit effort indices. In addition, when used in an absolute sense, such as the AT survey where Q=1, to apportion the acoustic biomass into year-class biomass, there can be a misrepresentation of year-class strength depending upon how the age length key was developed, as well as concealment of important stock-recruit relationships and the effects of environmental factors. This is particularly true when the ageing results from multiple readers. The 2021 CSNA stock assessment model integrates sampling data collected from fishery port sampling by CDFW and the trawl surveys by SWFSC. Consequently, it is necessary to have comparable ageing methodologies between the two laboratories as institute dependent ageing results will be used to inform the California fishery samples and CPS trawl survey datasets. It is assumed that annual ALK's were developed and applied to the length data. If not, this is major issue that must be addressed.

Another important factor in determining age of a fish is the timing of the laying down of the opaque zone in the otolith used to determine the fish's birthdate in the calendar year. Any fish caught beyond this date will have a year added to the counted rings. For Northern anchovy it has been determined that based on the frequency of opaque vs translucent (T) edge types (Figure 3.3 – Schwartkopfetal et al., 2021) June 1 has been assumed as its birthdate. However. this is a subjective decision and July 1 could have been easily argued to be equally or more appropriate. Other researchers have used other birthdates for the species. Given the complex nature of anchovy spawning, its extended distribution, and its protracted spawning season further research into this issue should be undertake before the date is finalized.

Based on the information provided there is a serious ageing problem among readers. Age bias plots in Table 3.9 (Schwartzkopfetal et al., 2021) illustrates an unbiased distribution between readers for the CSNA collected from fishery port samples for 2015-2020. However, Figure 3.7 shows a strong systematic bias for CSNA collected samples from trawl surveys during the same period. This is a major issue with serious implications for age-based parameters and dependent upon what is actually used in the assessment. While not so critical in the assessment model when total biomass is used as an input because of the method used to estimate total biomass, it can be misleading when looking at the biomass of individual cohorts. For example, the AT survey estimates the number and biomass of fish by length then uses an age length key to convert the lengths to ages. Consequently, when the

between reader ageing is biased the distribution of age classes can vary depending on how age reader data are combined and the strength of the bias.

Ageing error for older individuals is expected especially for longer lived species, however here considerable error was observed in reads for age-1 fish, which was a source of greater concern. Implementation of an age-3+ age bin instead of age-4+ in the base model to address the high ageing error for the few age-4 fish available didn't resolve the high F values in the base model. Implementing the auto-regressive selectivity model resulted in improved fits to the composition data. While ageing bias is accounted for in the proposed base model, addressing ageing error in laboratory methods to increase consistency between readers in the future is essential to reducing the error among readers. That said, it should be acknowledged that some of the inconsistency in age reads may be due to the inability to standardize by being in the same room to calibrate reads among readers due to limitations on travel and laboratory access resulting from the COVID-19 pandemic.

For the stock assessment the problem was reduced by removing the so-called problematic reader and re-estimating the ageing errors. Standard deviations which were very high for the original dataset were substantially reduced however it would have been nice to see the revised bias plots to determine if there was still an issue with the actual ageing between readers. It is imperative that the ageing issues associated with ageing northern anchovy be resolved. This will require the development and adoption of standard methodologies and protocols for the readers to follow. Regular reader comparisons will be required to insure there is no drifting from standard practices by a reader or readers. Age validation studies are necessary and also provide a means for an objective basis for standardizing reads rather than basing reference reads on the most experienced reader, which can still be subject to potential error. Bomb radiocarbon methods may be useful in age validation, especially if otoliths are available from the 1960's and 1970's and the owner is willing to sacrifice one otolith.

Acknowledging the issues associated with ageing error identified above there may be an additional problem with the inclusion/exclusion of samples on the length/maturity at age. Biological samples were collected during the spring 2017 and 2021 surveys. The geographical coverage encompasses the range of potential spawning distribution with good sampling where NA occur. The concern rests in the removal of 2021 samples north of Point Conception to make it more representative of the peak spawning area and if this is an appropriate approach. In this case it really doesn't appear to make a significant difference in the age at 50% maturity (A50) with only 3mm difference between their inclusion and the exclusion. However, given that practices adopted here will affect future assessments, consideration should be given to the possibility of a distributional shift in spawning. If this occurs, and it will likely occur gradually due to climate change, then the exclusion of samples north of Conception Point could have an impact on the estimated age at 50% maturity and their inclusion necessary. One suggestion would be to weight the samples based on spawning biomass distribution, thereby allowing for the inclusion of all samples. If the biomass north of Point Conception is small then samples from this area will have little impact on the length at maturity, however, if biomass increases in the area the results could be significant and a mechanism will be available for the sample inclusion in estimating age-based parameters.

3.2.4 Length of the Assessment:

The last stock assessment of the CSNA was undertaken in 1995 utilizing several indices of abundance for a timeframe extending from 1963 to 1994. Between 1995 and 2015 the stock biomass remained at a relatively low level however in 2016 the stock began to increase rapidly to the levels being reported in the current assessment. About the same time the NMFS refocused its AT surveys to incorporate northern anchovy, indicating that before 2015 (2006-2014) the design may not represent the abundance and distribution of northern anchovy. As such, the STAT conducted and presented in the draft report a short-term model based on the period of greatest data availability for the AT survey (2015 to 2021), and indicated that the longer-term model was less stable. In fact, during the course of the meeting there was discussion about the possibility of removing 2015 given its apparent anomalous results (negatively biased). Fortunately, there was no strong or supporting evidence for removing the year from the analysis and it was retained for the final northern anchovy base model.

From a reviewer's perspective the truncated time series for this assessment is a bit worrisome, especially given that it relies on a single index of abundance. While the current assessment meets the general objectives and represents the best available biomass estimate for the data used, there are a number of options that the STAT could explore outside of the Panel review that could possibly extend the timeframe of the assessment and potentially reduce the assessment's sole dependency on the AT survey. Other data sources of biomass (e.g., CalCoFi, aerial surveys, and small boat AT surveys) should be examined to see if they can be integrated into the assessment. If there are issues with these on-going programs, perhaps they can be modified to accommodate the concerns. Several sensitivity analyses of the revised base model were undertaken using different model configurations to explore the inclusion of the RREAS -YOY index from 2004 to 2021to inform the model. However, in the end the short model was found to perform better. This issue is taken up again in the research recommendations.

Under the TOR's a ten-year time series of biomass estimates is requested to determine the average biomass component of the OFL estimate for management purposes. The biomass estimates resulting from the shorter-term revised base model, provides fewer years for estimating the average biomass (see Request 31) than required. For this assessment the surveys for short-term biomass are considered better informed given data availability, and more years of data can be added to update the OFL and ABC with a longer-term average biomass from a longer time series. The management quantities can be informed with the current short-term assessment model as well but with the option to revisited when additional data are available from 2015 to 2025, and assessment considerations are addressed. Final recommendations will come from the SSC on the data that the OFL should be based on and default harvest control rules for use in the interim.

3.2.5 Uncertainty in the estimate of the E_{MSY}:

Selectivity, maturity, *h* and *M* have implications for the estimates of E_{MSY}. The current data are largely uninformative about *M* and *h* (Request 31), thus, the recommendation to estimate them within the model rather than fixed inputs. Differences in the maturity ogive derived from 2017 and 2019 data compared to 2017 data alone lead to additional uncertainty in the estimate of E_{MSY}. While it may not have bearing on the 1+ biomass, the maturity-at-age may be biased by the geographic distribution of

sampling, given the cline in the age-at-length observed in the spring 2021 survey data. The extent of any bias is difficult to determine, making this an outstanding uncertainty that should be examined further.

3.2.6 Natural mortality estimation and high fishing mortality rates

Natural mortality and fishing mortality are critical aspects of parameterization in the assessment model. The ability of the model to estimate *M* with precision is limited given the availability of data and the lack of a constant value in reality. The precision of the *M* estimates depends on the model, but a range from 0.2 to 0.8yr-1 seems reasonable given the confidence interval estimates. The long model did not not provide additional information on *M* relative to the short model, and would make the assumption of a time-invariant *M* even less tenable. No prior on *M* was implemented, and its basis is in question given the limited available data.

Natural mortality rates below 0.6 yr^{-1} were subject to scrutiny given studies conducted by MacCall (1973) that resulted in an estimate of *M* of 1.06 yr^{-1} for periods when predator populations were much lower than present. The value of *M* may depend on age and varies over the long term based on environmental conditions including predator abundance, but is currently assumed constant. Multi-species models could help examine the effects of predation by sealions and whales etc. on *M* over time, however this type of assessment model was not applied to the CSNA. Exploration of these and other variables correlated with a time-varying *M* may be an additional area of future research.

Structural assumptions of the model can change the estimate of *M* including the initial *F*, R_0, and offsets between sexes, which should be examined in future assessments. There are fewer extreme F values in the final base model than in the pre-STAR base model but the estimate of F for age 3+ in the final base model is still very high and reasons for this remain unclear.

3.2.6 Selectivity

The factors contributing to variability in selectivity of age-0 and age-1+ fish was the subject of Request 5. Variability in the timing of peak spawning and growth rates between years relative to the timing of the AT survey can affect the selectivity of the survey for age-0 fish necessitating time-varying selectivity. It was also pointed out that in some years the age 0 fish may be too small to be collected by the trawl gear and the lack of a fully developed swim bladder depending upon the survey timing. Time varying age-0 selectivity with a time block, was successfully implemented in Stock Synthesis. The 2016 and 2017 age-0 selectivities were consistently set as 1 among model options, but the estimated selectivity of 1 in 2015 may contribute to the apparent underestimates when the biomass estimates for the 2015 survey were back calculated from the 2016 results. Thus, a sensitivity analysis with an age-0 selectivity in 2015 fixed at 0.5 was conducted to evaluate uncertainty, though results were not wholly inconsistent, indicating that the biomass estimates were robust to the assumed value (Request 31).

Understanding the reasons for the time-varying selectivity is important given the high interannual variance in the fishery data and the reduction in information from the age composition

since true variability is subsumed by invoking variable selectivity. Discussions with CPSAS representative indicated that variability in fishery age data may be market-driven, since fish below a given size are not marketable. That said, the fisheries in the Los Angeles and Monterey areas were represented in the 2015-2018 fishery data, and most of the data are from Monterey during 2019-2021, potentially affecting selectivity over time. No age data from Mexico are included, and the selectivity from Monterey may not be representative of Los Angeles and Mexico. While length data are available, age data from Mexico are needed to inform age-specific selectivity in the entire fishery. Combining data from three fisheries with potentially different availability and selectivity, and representing them as a single fleet, may contribute to uncertainty in the assessment.

3.2.7 Discrete vs. continuous time periods for key parameters:

Another area of uncertainty is the concept of discrete vs continuous time periods for key model parameters. The model is based on discrete time, but the population dynamics are continuous (recruitment and growth). The timing of spawning and rates of growth relative to the discrete time break between the first and second semester of each year may contribute to the variability in selectivity of the survey and impact parameter estimates and estimates of exploitation rates.

3.3 Requests made to the STAT

This section of the report provides a condensed version of the requests made to the STAT during the meeting. It represents a considerable amount of additional work by the STAT and the Panel is grateful for their commitment to the process and their effort to provide the information in the shortest timeframe possible. The details of the request and the tables and figures associated with each request is provided in the star Panel report.

Request 1: Provide a figure or table displaying the timeline of important events both as modelled and how they occur in reality, including: model semesters, model years, calendar years, fishing seasons, spawning, aging up/birthdays, model censuses, and surveys.

Response/Comment: The table provided proved very useful in aligning the timing of various components of the assessment relative to the calendar year.

Request 2: As a sensitivity analysis, show the results of starting the plus group at age 3 rather than age 4.
Response/Comment: In the weight-at-age file, the weights-at-age for age 3 and age 4+ fish were combined as a weighted average based on the age 3 and age 4+ values in the age compositions for each fleet. The time series comparing age 0+ and age 1+ biomass, selectivity and fully-selected fishing mortality for the two models show very little difference between the base model and the age 3plus model run.

Request 3: Similar to Request 2 but retain a plus-group of 4+ in the population dynamics model and pool the age-composition data (not weight-at-age data) for ages 3 and 4+ to create a "data plus-group" of age 4+.
Response/Comment: Again, very little difference among model runs with the biomass overlapping and following similar trends and fleet F almost the same. Changing the plus-group age for the data but not the population dynamics model had little impact on the results of the assessment.

Request 4: Provide more details on the interpolation method used to reconstruct weight-at-age.
Response/Comment: The explanation provided by the STAT was very informative at explaining how the extrapolation was used compared with the assessment document. The Panel requested that the final assessment document include the description of how the interpolation was conducted.

Request 5: In the final assessment document, include discussion of the various factors beyond size-dependent vulnerability to gear that may influence the fitted selectivities (e.g., age-dependent movement, fishery targeting behavior, collapsing multiple fisheries into a single modelled fishery, ageing error, unaccounted for spatial structure in sizes, absorbing unmodeled process variation such as changes in *M*, etc.).
Response/Comment: This response was deferred until final assessment document See Request ??)

Request 6: Recalculate the age-reading error vectors (for the survey data) to reflect the removal of one reader's outputs from the data included in the assessment, re-run the assessment, and justify the assumption of no bias once that reader is removed.
Response/Comment: The STAT updated the age-reading matrices excluding the data for "reader 15", which led to much smaller (and more realistic) estimates of age-reading standard deviation. A model run based on the updated age-reading error matrices show little effect of changing the age-reading error matrices on the time-trajectory of 1+ biomass. Fits to survey and fishery age data were also similar. However, there were some slight differences between the base model and ageing error corrected run in 2019 and 2020 where most of the bias was observed.

Request 7: Plot mean age by trawl for the Spring 2021 AT survey. This is based on the fact that substantial biomass was observed in the north but spawning occurs in the south thereby confounding the calculation of age/length at maturity if the age/length compositions vary across space.
Response/Comment: From the figures, the information provided did not necessitate a change to the assessment model but that continued work on understanding maturity was important.

Request 8: Perform a sensitivity analysis to assess how much 1+ biomass changes if the maturation ogive is based on 2017 data alone or 2021 data alone.
Response/Comment: Although the maturity ogives for 2017 and 2021 differ from the base model, the biomass values differ very little among model runs. The Panel agreed that specifications for maturity had little impact on final model outputs used for management. However, the estimate of E_{MSY} will depend to some extent on the assumed maturation ogive. Short-term research recommendations should include the need to assess the sensitivity of EMSY to the assumed maturation ogive.

Request 9: As a sensitivity analysis, re-run the base model except with catchability Q=0.93 for summer AT surveys and 0.6 for spring AT surveys.

Response/Comment: Based on the 2021 spring and summer AT survey it was estimated that only a fraction (0.58) of the total biomass was in U.S. waters in the spring and 93% in the summer compared to a survey Q for 2016 of 0.6 for both surveys in the base model. As expected, the biomass increased slightly for the decreased Q, especially in the recent 2 years.

Request 10: Same as Request 9, but also include the preliminary results from the summer 2021 AT survey with Q=1.
Response/Comment: The base model forecasts age 0+ biomass for June 2021 to be 2.26 million mt and 1.59 million mt for age 1+. The preliminary biomass estimate from summer 2021 cruise was 2.357 million mt, CV=0.15 (and no age compositions yet). This model has an additional year in the model time period. This illustrates that the biomass between the spring and summer surveys were comparable when the summer, Mexico distribution is considered.

Request 11: Convert plots of F through time to exploitation rate for the extended RREAS (Rockfish Recruitment and Ecosystem Assessment Survey) model (last slide of Kuriyama's afternoon presentation), similar to Figures 34 versus 35 of the draft assessment document.
Response/Comment: The Panel noted that the exploitations rates were generally low (< 5% for most years and fleets) with the notable exception of 2015, which had similarly high exploitation rates in the base model and appears to be a year of rapid biomass increase that may not be well reflected by using June 1 biomass as the denominator in the exploitation rate calculation. This supports the request to re-examine the assigned birthdate for Northern anchovy.

Request 12: Provide r4SS outputs for the draft base model and for the extended RREAS model to investigate patterns in F, exploitation rate, selectivity, and how well the modelled recruitments fit the RREAS recruitment index.
Response/Comment: The reasoning behind this request was to better understand changes in fit due to the inclusion of the RREAS survey and the model timeline is extended. The plots were provided as requested and the Panel continued to use r4ss to examine model fits, outcomes and parameter values.

Request 13: As a sensitivity analysis, re-run the base model excluding the 2015 AT survey.
Response/Comment: It was suggested that the biomass estimate from the 2015 AT survey may be less reliable than the more recent surveys (2016-2021), consequently the Panel wanted to explore the results of leaving the 2015 survey data out of the model. The results of the run with no 2015 survey (index of age-composition) were qualitatively nearly identical to those for the original base model.

Request 14: Explain the parameterization of the selectivity function used (Pattern 17 in SS).
Response/Comment: The parameter values, which can be both positive and negative, in the parameter section of the SS report file do not directly represent selectivity-at-age. The 2012 selectivities are the average from 2015-2020 used for benchmark calculations. The Panel noted that the current parameterization implies that the ratio of selectivity for ages 0 and 1, and that between the selectivities for age 3 and 4+ are time-invariant, which led to a new request (Request 25) to examine a more flexible (but at the same time constrained) selectivity pattern.
Request 9a: Similar to Request 9, but use separate Qs for the spring versus summer surveys in 2016. This was done by treating the spring and summer surveys as separate fleets.

Response/Comment: The plots show the biomass values with the AT survey treated as two separate fleets, each with their own Q values when separate Q's are applied. As expected, the biomass increased with the different Q's.

Request 15 (STAT-initiated): Re-run the extended RREAS model with a fix to the timing assigned to the AT survey in the model, with and without the 2020 YOY index, and using a larger upper bound on M ($1.5yr^{-1}$).
Response/Comment: This was undertaken because the timing was incorrect in previous versions of the model with the RREAS index and the 2020 index was estimate from a very small spatial coverage. The Panel agreed that dropping the 2020 (as well as 2011, which also had low spatial coverage and was dropped from all runs under consideration) estimate from the index was appropriate.

Request 16: Provide information relevant to the reliability of estimates of weight-at-age for age 0 fish from the AT survey when applied to the modelled population as a whole.
Response/Comment: This request was based on the fact that age 0 fish make up a significant portion of the total biomass and considerable inter-annual variation has been observed in the survey weight at age 0. Unfortunately, this task was deemed too large to be completed during the meeting and will be addressed as a future research issue.

Request 17: Provide a run of the extended model including the RREAS survey but excluding the 2015 AT survey.
Response/Comment: Given the concerns regarding the reliability of the 2015 AT survey the request was made to remove this data point. The revised model showed that excluding the 2015 AT survey generally increased the total 1+ biomass (as expected). It was noted that the estimate of M hit its upper bound (initially set to 1.0 yr^{-1}), which led to request 26. In the re-run of this model that increased the M boundary to 1.5 yr^{-1}, M was estimated as 1.06 yr-1.

Request 18: Provide a table of temporal overlap in aerial surveys and the corresponding biological sampling.
Response/Comment: The concern was that if sufficient time has elapsed between the aerial survey observations and the biological sampling that the sampling may not be representative of the fish observed by the plane. The table provided summarizes aerial survey (including # of anchovy observations) and sampling dates by source. The results suggest that the elapsed time between the survey and sampling in general was not that great, although for some aerial observations (7 of 17) there was no biological data available between 2016 and 2021.

Request 19: Provide a table of the spatial and temporal overlap of the AT survey and the inshore (aerial and/or small vessel acoustic) surveys each year 2015-2019.
Response/Comment: As requested a table was provided (2017-2021) that shows the daily aerial survey flights for seasons that were coordinated with the AT surveys. This information was used to explore the potential biomass missed by the AT survey. The difference in days between the aerial survey and other surveys (generally less than a few days), and the aerial biomass are presented.

Request 20: Conduct a sensitivity analysis using alternative values for the AT survey catchability Q informed by the estimates of the proportion of biomass observed by the aerial survey inshore of the AT survey.
Response/Comment: CSNA are commonly observed in the inshore water where the larger research cannot go, thus these fish are not included the survey estimates and their omission needs to be evaluated. Given the current high abundance and the fact that the majority of the biomass is typically found in the offshore water, the total abundance based on the proportion of fish inshore from the aerial is only marginally higher than the base model. However, in years of low total biomass their contribution could be significant.

Request 21: Conduct a sensitivity analysis using alternative values for the AT survey catchability Q informed by the estimates of the proportion of biomass observed by small vessel acoustic surveys inshore of the AT survey.
Response/Comment: In this request the intent was to use the small vessel acoustic survey data to inform catchability accounting for the proportion of the abundance unaccounted for in the area shoreward of the AT survey by survey. A table was provided showing the fraction of the biomass estimated nearshore, and used to inform Q. In the sensitivity analysis the biomass trajectory essentially overlayed each other with no detectable change in Age 1+ biomass.

Request 22: Conduct a sensitivity analysis using alternative values for the AT survey catchability Q informed by estimates of the proportion of biomass inshore of the AT survey based on the average of the aerial and nearshore acoustic surveys.
Response/Comment: As in Request 21, a Table was presented on the proportions used to inform Q and the sensitivity analysis run. Note there were only two cruises with overlap in both small vessel and aerial nearshore observations (Summer 2019 and Spring 2021). Given the large biomass in the area covered by the AT surveys compared with the inshore estimates, the 1+ biomasses from 2015 to 2020 were indistinguishable.

Request 23: Conduct a sensitivity analysis using alternative values for the AT survey catchability Q informed by the proportion of habitat south of the AT survey (i.e., Request 9) and inshore of the AT survey as estimated by the inshore surveys (using the average of the aerial and nearshore acoustic surveys, or otherwise as deemed appropriate).
Response/Comment: This request could not be completed during the review meeting

Request 24: Perform a run of the base model that does not estimate initial F.
Response/Comment: As part of the assessment model evaluation, it was hypothesized that initial F and the R_0 offset parameters were to some extent redundant, and the initial F estimate from the base model seemed suspect. This analysis indicated that the fit to the model (as indicated by the change in negative log-likelihood) got appreciably poorer (7 log-likelihood units) when the initial F was fixed, supporting continued estimation of all three parameters (R_0, R_0 offset, and initial F).

Request 25: Perform a run of the extended RREAS model that does not estimate initial F but does estimate offset in R_0.
Response/Comment: The model resulted in high fishing mortality rates, odd selectivities that change substantially among years, a similar fit to indices, and a very low M ($\sim.25 yr^{-1}$). This provided further

support to the contention that all three parameters determining the initial size should be estimated. The STAT and Panel agreed.

Request 25a: Explore selectivity parameterizations where the ratio of selectivity for age 0 vs age 1 is not fixed (consider the 2dAR option, which combines flexibility with a penalty for too much deviation). Consider combining this change to the model specifications with changing the data plus group to ages 3+.
Response/Comment: Fixing the ratio between selectivity for age 0 and age 1 for all years did not seem reasonable and could lead to model instability. The STAT and Panel concluded that the analysis suggests a penalized selectivity pattern leads to more realistic selectivity pattern results, but with little impact on the overall results (similar biomass trajectories and similar), and possibly slightly improved, fits to data.

Request 26: Raise the upper bound on *M* for future model runs. An upper bound of at least 1.5 yr-1 seems plausible for northern anchovy.
Response/Comment: Anchovy likely have high natural mortality with past estimates of *M* exceeding 1.0 yr-1. The revised model run estimated *M* as $1.06yr^{-1}$ and was otherwise similar to the previous run. *M* did not seem to approach the initial $1.0yr^{-1}$ boundary in all base model runs (Also see Request 17).

Request 27: The final assessment document should explain and justify years/seasons for which surveys were available but not used (e.g., early AT surveys, any individual years excluded from the AT survey or the RREAS survey if it is included in the final model).
Response/Comment: This information was inferred during the meeting to a limited extent and will be included in the final report.

Request 28: Provide a vector of average weight by year for young of year (YOY) anchovy in the RREAS survey.
Response/Comment: This request was made because the weight in the AT survey may not match that in the RREAS survey given the difference in timing. The weights for the RREAS survey were provided by John Field (SWFSC) and have been included in the model runs of Request 29.

Request 29: Run a set of models as described below, implementing the "agreed changes" listed below in all runs. For each row/model number, both a short and a long variant are requested. Model length "S" means a model starting in 2015 and using the AT survey but not the RREAS survey. Model length "L" means a model starting in 2004 and using both the AT survey and the RREAS survey.

- Plus-group 3+
- Catch series: extend the model so that the first projection year is part of the historical period
- Estimate R_0, R_0 offset and initial F
- Split AT formulation (will be inconsequential if Q is the same for all AT surveys)
- Include new age-reading error matrices
- Long model
    - RREAS: Exclude 2011 & 2020; include 2021
    - start in 2004.
    - Correct timing of survey

- Use John's weight-at-age

With steepness fixed at 0.6, it is difficult to decide which parameters to estimate. Looking at the likelihoods would support estimating initF and R1 or estimating R1 and not initF. However, these models with low likelihood also have *M* estimates that don't line up with previous studies

	Model length	Selex*	Q (summ/spr)	Q (nearshore adjustment?)	2015 AT survey
Model 1	S/L	Option 17	1/1	N	Y
Model 2	S/L	2dAR (σ=1)	1/1	N	Y
Model 3	S/L	2dAR (σ=1)	0.93/0.57	All corrected (average for common yrs)	Y
Model 4	S/L	2dAR (σ=0.5)	1/1	N	Y
Model 5	S/L	2dAR (σ=2)	1/1	N	Y
Model 6	S/L	2dAR (σ=1)	1/1	N	N

*For all instances of selectivity 2dAR, implement time blocking of age-0 selectivity.

Response/Comment: In summary, the STAT and Panel agreed that for the "short" model formulations, model 1 could be ruled out from further consideration because the 2dAR selectivity models performed in ways that were superior (equal or better fit and plausibility of parameter estimates) to the Option 17 selectivity and was better supported on grounds of theory and parsimony, model 4 could be ruled out due to a poor fit to the age data, and model 5 could be ruled out due to poor likelihood and convergence issues. The STAT and Panel further agreed that for the "long" model formulations, models 1, 4, and 5 could be ruled out for the same reasons and also because the model 5 Hessian did not converge. Further discussion also led to proposal of a tentative new base model, to be further analyzed as described in Request 30.

The negative log-likelihoods [NLLs] should not be compared between the long and short models because they differ substantially in the amount of data included, and NLLs should not be compared directly between model 6 and the other models without considering that model 6 is fit to fewer data - one less survey index and one fewer year of age data from the survey, which would be expected to improve [reduce the NLL] total likelihoods as well as likelihoods for the survey and age composition components.
Note that no "short" model run was undertaken with the AT and the RREAS. This was likely an oversight given all the combinations being investigated.

Request 30: Propose and run a tentative base model (structure as described in the Rationale below) and report:

- Likelihood profile across *M* with steepness fixed at 0.6
- Age 1+ biomass trajectories across *M* with steepness fixed at 0.6
- Likelihood profile (and corresponding *M* estimates) across steepness
- Age 1+ biomass trajectories across steepness
- Extensive jittering/convergence checks before final submission

Additional sensitivity analyses were requested to show the effects of not including inshore biomass estimates, a run in which the highest possible (out of aerial surveys, small vessel surveys, or extrapolations) inshore estimates were used each survey, the lowest possible inshore adjustments were used each survey, exploring the effects of Francis weighting for all fleets at once, and fixing age 0 selectivity for the 2015 AT survey at 0.5.

Rationale: The outputs and diagnostics requested are standard ways of evaluating a proposed base model, and sensitivity to Francis weighting is routinely evaluated. The remaining sensitivity runs reflect concerns about the treatment of nearshore biomass and the uncertainty surrounding the 2015 AT survey and a perception that the high age-0 selectivity estimated for that survey may not be correct. The proposed base model was structured as follows:

- Use the shorter model time period, excluding the RREAS survey because of model instability in the longer formulation, and because estimation of *M* was especially challenging for the long model.
- Keep 2015 AT data because after extensive discussion, it was decided that the data for this survey should not be discarded simply because 2015 seemed biologically anomalous since there was nothing unusual about the execution of the 2015 AT survey compared to later years, and it is expected that some data points will have large residuals such that large residuals alone are not sufficient reason to exclude.
- Use 2dAR selectivity with σ=1 for the two fisheries, with 2d selectivity estimation starting in the second year of available age composition data (the first age composition defines the reference curve), because the 2dAR selectivity with σ=1 led to the best performance (Request 29).
- Add ageing bias for reader 14, based on the outcomes of Requests 6 and 29
- Add nearshore AT biomass (preferably from small vessel surveys, otherwise from extrapolation) to AT core index where available and do not adjust Q to account for inshore coverage when these additions are made. When AT nearshore estimates are not available, apply Q ratio calculations based on aerial surveys as in Request 20.
- Adjust AT Q in all years to account for geographic coverage (spring Q=0.58, summer Q=0.93) based on the estimated proportion of biomass in Mexico as described in Request 9 (spring Q is 0.58 rather than 0.6 due to performing the final calculation to a higher precision).

Response/Comments: The age 1+ biomass trajectories for the model period of 2015-2021 are provided in Star Panel Report. The models include the base model ("newbase"; pink), a model that ignores nearshore biomass estimates ("ignore_near"; light blue), a model with Franics reweighted age composition for all fleets ("Francis"; yellow), a model that assumed the highest nearshore biomass values ("high_near"; green) and a model that assumed the lowest nearshore biomass values ("low_near"; purple). Overall, the biomass trajectories are very similar for the period 2015-2021. In the Likelihood profiles for M by component there are conflicting profiles for *M* for the spring vs summer AT surveys. Not many sources favour high *M* from a likelihood perspective and the profiles

for the index is quite flat. There is also little information on steepness beyond ruling out very low values. As steepness goes up, *M* goes down; but $M<0.65$ yr^{-1} over range explored. Although jittering will be completed after the Panel, 50 jitter runs with 5% jitter, resulted in no jitter runs with lower likelihood than base model (NLL=54.445). 62% of runs had the same NLL, 36% had an NLL of 54.454 and 2% with 55.522.

Request 31: Calculate E_{MSY} for the base model, and as sensitivities calculate E_{MSY} using maturity ogives based on just 2017 or just 2021 data.
Response/Comment. E_{MSY} from the base model is needed to inform management and may be sensitive to maturation schedules. Maturity ogives were estimated from only two years' worth of data with some differences between the two years. This will take place after the Panel is complete because Stock Synthesis does not report MSY divided 1+ biomass.

Request 32: Calculate a 10-year mean of age-1+ biomass using all available years from the base assessment model and each of three options for setting 1+ biomass for years before 2015: (a) zero, the estimate of 1+ biomass for 2015, and 1.5x the estimate of 1+ biomass for 2015.
Response/Comment: The management framework adopted for CSNA requires a 10-year mean biomass to inform specification of the OFL and ABC default, but the base model does not estimate biomasses for a full 10 years. The options above were presented to illustrate that because the biomass is so high in the7 years modeled compared with the previous 3 years that it really doesn't make much of a difference in the 10-year average. The three mean biomasses are: 567,554t, 574,997t, and 578,719t respectively.

4.0 Research Recommendations:

The following provides a list of specific research recommendation resulting from the STAR Panel review of the 2021 stock assessment of the CSNA. The recommendations have been broken down into broad categories and ranked according to three levels of priority high = "H", medium = "M", low = "L".

4.1 Natural Mortality:

- (M) Estimate a time-varying natural mortality rate given changes in predator numbers relative to prey abundance over time. The STAT indicated that there is a proposal within SWFSC to investigate this issue.
- (M) Assess whether predator abundance, absolute or relative, and their anchovy consumption can provide a lower bound for anchovy biomass and/or inform *M*.
- (H) Develop a prior for *M*.

4.2 Ageing:

Assessing age presented a challenge for the assessment given the diversity of sources of data and methods.

- (H) Obtain length/age composition for the Mexican anchovy catch and include it in future assessment.
- (H) Improve the accuracy of ageing determination and increase age validation efforts.
- (H) Continue efforts to standardize the ageing process among laboratories, including Mexican laboratories.

4.3 Stock structure:

- (M) Consider genetic and non-genetic methods to determine stock structure.

4.4 Modeling:

- (M) Develop ways to better account for the continuous nature of spawning and growth versus the discrete time steps used in current modelling.
- (H) Examine the sensitivity of estimates of E_{MSY} to assumptions regarding *M*, maturity, and growth.
- (L) The current available input data for the model covers a period in which the CSNA stock is increasing. However, CSNA is characterized by rapid increases and declines. Examine the performance, stability or accuracy of the assessment framework under different circumstances such as different trends in CSNA recruitment and biomass. Explore whether other data sources, longer than the AT surveys (for example, CalCOFI egg and larval data, RREAS) might inform on YOY and/or age-1+ biomass.
- (M) Conduct research to understand the reasons behind the (interannual) variability in selectivity, including variability in market demand.

4.5 Data - *Aerial Surveys and Small Vessel Inshore Acoustic Surveys*

- (M) Uncertainty prevails in how to use/include the aerial surveys and/or small vessel inshore acoustic surveys as the coverage changes, and the aerial and the acoustic-trawl surveys have not always overlapped in the past. Continue to conduct research to estimate corrections to AT survey Q or adjustments to the AT survey estimates of abundance to account for the components of the stock south and inshore of the core sampling area.
- (M) Aerial survey biomass estimates have only been validated for a limited number of anchovy schools, and only for small schools (typically 100 mt or less) because of challenges in vessel capture of larger schools for sampling, but larger schools contribute most of the estimated inshore biomass in high biomass years. Use of packing densities, aerial photos of school area combined with vessel estimates of school depth is one approach to validating large school estimates from spotter pilots. Validation of biomass estimates for larger schools remains an ongoing challenge but important to increasing confidence in use of aerial survey estimates in high biomass years.
- (M) Compare the proportion of volume of waters shoreward of the AT sampled by the aerial survey vs. the inshore acoustics to better understand how much shoreward habitat each covers. While the nearshore AT penetrates deeper into the water column than the 10 meters typically observed by the aerial survey, the narrow swath of water sampled by the limited cone width AT

in shallow waters and water not observed between the transducer at the keel and the waterline limit the volume of habitat sampled in the nearshore. Using track lines and the geometry of the coverage of each survey, the total volume of surveyed waters shoreward of the AT survey can be estimated and compared to account for differences in spatial coverage in considering which survey is preferable. This becomes important given the patchy distribution of the species and a minimum target of 30% from basic sampling design considerations, which have implications for the precision of the estimates.

- (M) Age-0 fish make a large contribution to total biomass and there was considerable annual variation in the estimated weight for fish of age-0 from the surveys. Provide information relevant to the reliability of estimates of weight-at-age for age-0 fish from the AT survey when applied to the modeled population as a whole.

4.6 Improvements to Stock Synthesis

- (H) Add an option to output estimates of uncertainty in age-1+ biomass

5.0 Areas of Disagreement

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

6.0 Issues raised by the CPSMT and CPSAS Representatives

This topic is included in the CIE report for completeness and is unmodified from the text provided by the Panel at the time of writing this report. The reviewer would like to point out that the CPSMT generally touched upon many of the topics and concerns expressed by the Panel. However, their concern of not adopting a base model that provides the requirement of management (10 yr average biomass) may be problematic is a concern. One topic that was not discussed by the panel was combining distinct fishing fleets that were widely geographically separated and their differing targeting strategies, timing, and degree of effort fishing for this stock of anchovy in Monterey, southern California, and Mexico. The reviewer agrees that the effect of this approach should be investigated further at a future assessment.

The CPSAS representative put the assessment in the context of landings and management actions over the past several decades. They point out that fishery sampling stopped in the 1980s and did not resume until 2014, and stressed the need to maintain a time series of fishery sampling even if the fishery declines or is closed. They also raise a number of points related to the input data, model parameterization and indices of abundance, all of which were discussed by the Panel. They did however note that the STAR Panel did not examine what happens to the assessment if the short-term model includes other indices, i.e., RREAS, instead of just the AT survey; and recommend that future assessments consider and incorporate multiple indices, including RREAS, CalCOFI and nearshore aerial surveys. This is consistent with the recommendations of this report.

6.1 CPSMT issues:

The CPSMT representative greatly appreciates the substantial efforts by the STAT and the constructive STAR Panel discussion and requests. Both the STAT and others from the SWFSC who did the aging and maturity work were very responsive to the numerous requests made by the STAR Panel.

The original base model used for the assessment initially provided to the STAR panel only encompassed AT survey data from 2015 forward as an index of abundance. Other data sources with longer time series were considered but not utilized. The CPSMT representative raised the issue early on that the stated goal in the draft assessment reviewed by the STAR panel (lines 552-526), "to estimate terminal year stock biomass, and for a short-lived species like CSNA, a model with a longer time frame would likely not enhance achievement of this goal", should be reconsidered. The management of CSNA is based on the long-term MSY rather than setting harvest specifications based on the terminal year biomass estimate (e.g., Pacific sardine). A management framework for CSNA was recently adopted by the Council and added to the revised COP 9 Schedule 3 after extensive review and revision dating back to 2018. That management framework calls for a 10-year biomass estimate for the stock and E_{MSY} value from an assessment. From a management perspective it would be ideal for the assessment to provide those two key parameter values needed to implement the adopted framework for CSNA if possible. Using another index of abundance such as the RREAS, which was examined during the STAR panel, may have provided those values for management since it provides a longer time series using standardized sampling that includes the Southern California Bight going back to 2004. However, the STAT preferred to utilize only the AT survey index of abundance in the final base model. The model proposed by the STAT for this assessment does not strictly meet the Terms of Reference which states, "Stock assessments are conducted to assess the abundance and trends of fish stocks and provide the fundamental basis for management decisions regarding appropriate harvest levels." Thus, the Council and its advisory bodies will need to consider the results from sensitivities done in the last request when making management decisions for this stock and setting any new harvest specifications when it meets to consider this assessment in June 2022. These sensitivities should provide the additional information needed for management purposes, but they will need to be examined by the full SSC in June for that determination. Depending on the management outcomes related to this assessment in June, the CPSMT may need to consider if it should recommend another assessment of this stock occur as soon as enough AT survey data are available to directly provide the key parameter values when it provides the Council with its Stock Assessment Prioritization report at the November 2022 meeting.

The STAR Panel discussed the technical merits and/or deficiencies of the assessment in section 3 and the unresolved problems and major uncertainties for this assessment in section 4. The CPSMT representative generally agrees with the STAR Panel on these issues. A couple of key points along these lines are noted here. The estimated value for natural mortality M seems quite problematic in this assessment as it is particularly low given previous work on this issue. The issues raised by the STAR Panel related to the uncertainty in being able to accurately estimate E_{MSY} is also concerning from a management perspective. While it is certainly easier to model the stock in discrete time periods, the

biology of anchovy does not fit that method very well given that CSNA can spawn throughout the year. The combining of the three very distinct fishing fleets widely geographically separated and their differing targeting strategies, timing, and degree of effort fishing for this stock of anchovy in Monterey, southern California, and Mexico also seems problematic. Also, the work on how best to adjust AT survey results to deal with the nearshore correction factor is still a work in progress for stock assessments of CPS. This assessment used methods for nearshore correction that were prioritized by the STAT which followed some of the recommendations made by the SSC in 2019. The CPSMT representative notes that the methods utilized in this assessment differ from those used in the 2020 benchmark assessment for sardine and that there may be benefits in developing consistent methods.

In the end the STAT proposed a base model that they are comfortable defending as representing the best information scientifically available for this stock. The CPSMT representative thanks the STAT for the hard work on modeling this stock and believes that the Council will be provided with an assessment in June that will be useful for management.

6.2 CPSAS issues

The CPSAS representative notes that this STAR Panel review is the first attempt to assess the CSNA in more than 25 years. However, it is important to understand this in context. Following sharply declining landings beginning in the early 1980s, CSNA (i.e., California's anchovy fishery) was categorized as a "monitored" stock in 2000, when the Northern Anchovy FMP was expanded to include all coastal pelagic species (CPS). One purpose of the monitored designation was to focus time and resources on fisheries requiring active management. The monitored category established a precautionary default management policy, reducing the OFL by 75% and setting an Annual Catch Limit (ACL) of 25,000 mt., with annual review and potential management action if landings approached the limit. In fact, California's anchovy fishery has landed less than 10,000 mt annually, on average, for the past three-plus decades, except for 2015, when a perfect storm of conditions – including a dearth of squid to catch and an abundance of anchovy near port in Monterey – increased landings to about 17,100 mt (17,264.4 mt statewide). This temporary spike triggered concern and urgent requests from some for active management, albeit 2016 landings declined to about 7,000 mt (only around 2,300 mt in Monterey). and have remained low in recent years.

A first impression of this STAR Panel meeting is amazement at the extraordinary amount of time and effort invested by the STAT and Panel to undertake this assessment, in light of the small size of the fishery, although the anchovy fishery is very important to California's wetfish industry, especially in Monterey. The CPSAS representative appreciates acknowledgement during the meeting, "We knew going in this assessment would be challenging." We also express thanks to the STAT, and particularly the STAT lead, for their hard work and willingness to respond to the many Panel requests. And we recognize the extensive work and contributions of the other scientists who contributed to this assessment.

Our second impression is concern over the dearth of biological data needed to develop a model that can accurately inform the anchovy management framework recently adopted by the PFMC,

including a 10-year average biomass estimate, natural mortality (M) and E_{MSY}. Essentially, fishery sampling stopped after landings declined in the 1980s and did not resume until 2014, making it virtually impossible to construct a model appropriately reflecting long-term biomass trends. This anchovy assessment is a painful example of why it is critically important to maintain a time series of fishery sampling even if the fishery declines (or is closed, as is the current case with Pacific sardine.)

We appreciate the STAT's and STAR Panel's efforts to develop the best assessment they could notwithstanding serious data constraints, but our concerns remain nonetheless. Following is a summary list of troublesome issues:

- The draft assessment report began by describing the hypothetical stock structure of CSNA, but misrepresented genetic studies (including Vrooman et al., 1981). In reality, the status of genetic and/or fishery stocks of northern anchovy in the Northeastern Pacific is currently unknown. This has particular relevant for the Central Coast area.
- The model is based solely on AT surveys from 2015-2021 that reflect wide variability in annual estimates. The 2018 AT Methods Review recommended the use of AT survey data as a relative index, and not appropriate for anchovy absent nearshore correction, preferably a nearshore AT survey. Q needs to be established.
- We agree with the recommendation to develop a model that includes nearshore correction for Q. That may be inconsequential now at a record-high biomass level (based on CalCOFI egg/larval surveys), but nearshore correction will be essential when the biomass naturally declines and the population moves inshore.
- The final base model is insensitive to the natural mortality rate, and the original model was incapable of estimating M>1yr $^{-1}$. The small differences in biomass based on fixed natural mortality rates from M = 0.3 to 0.9 yr $^{-1}$ suggest that some model input is interfering with natural mortality. The consistent pattern with biomass being higher with larger M until 2018 and switching to biomass being lower with larger M after 2018 is highly unusual. The model's insensitivity to the natural mortality rate needs further evaluation.
- When E_{MSY} is estimated for management, analysts will need to consider uncertainty around M, steepness, varying weight at age etc.
- Age validation has not yet been completed for northern anchovy. There was extensive discussion during the meeting regarding uncertainty in ageing, including ageing errors, weight at age estimates, and the age/length key in AT surveys.
- Although the 2015 AT survey was acknowledged to be underestimated, it was included in the model with a Q of 1 despite apparent problems. The extended run including the RREAS, with the 2015 AT survey omitted, increased the 2015 biomass by about an order of magnitude, and it increased the 2020 biomass by about 200,000 mt.
- The STAR Panel did not examine what happens to the assessment if the short-term model includes other indices, i.e., RREAS, instead of just the AT survey. We recommend that future assessments consider and incorporate multiple indices, including RREAS, CalCOFI and nearshore aerial surveys.

We understand that AT surveys including a nearshore small boat component, and nearshore aerial surveys with enhanced sampling, are improving data collection capabilities. These surveys, along with continued biological sampling, offer hope that over the next several years the data

deficiencies present in this assessment will also be improved. We recommend that the future management and assessment framework provides sufficient flexibility to account for deficiencies present in this assessment. This includes use of additional indices beyond acoustic surveys if they can inform biological parameters needed for management decisions that might be required before the next benchmark assessment.

7.0 Conclusions and General Recommendations

The primary objective of the STAR Panel was to review the 2021 draft Central sub-population of Northern Anchovy stock assessment prepared by the STAT using the best available information/data. The initial stock assessment and proposed based model was explored in the context of providing advice on stock status to managers. The Panel reviewed multiple options, described above and concluded that, given the current management approach requires an estimate of age-1 biomass on June 1, the revised base case model using the ATM (2015-2021) was the best approach at present for conducting this assessment notwithstanding the concerns listed above. The resulting assessment leads to biomass trajectories that mimic the biomass estimates from the AT survey reasonably well, with the exception of the 2015 estimate. The 2015 AT survey estimate is lower than expected from the model but there was no *a priori* reason (e.g., based on survey performance) to exclude the 2015 survey data from the assessment. The results from the assessment are susceptible to changes in how selectivity is modelled, the value for steepness and ageing error, but there were several concerns with the final base model that could not be resolved during the Panel meeting. Assuming uniform selectivity leads to lower estimates of current 1+ biomass, but this assumption reflects the expectation that all fish in the survey area are vulnerable to detection during an acoustic survey.

The Panel acknowledged the shortness of the ATM time series in the assessment and suggested exploration of a longer timeframe utilizing additional time series data through sensitivity analyses. The STAT attempted to obtain a model that captured a longer set of years than 2015+. Models explored during the Panel included an index of young-of-year and catches prior to 2015 (along with a 2014 fishery age-composition). Indices were also available from California Cooperative Oceanographic and Fisheries Investigations survey (CalCOFI) eggs and larvae and age-1+ animals from the RREAS, but were not included in any of the models considered during the Panel. The examined “long” models were found to be very unstable and the point estimates of M were very low in some cases. Note that a short term run with both the ATM and the RREAS YOY (2015+) time series, which may have diminished the stock assessment reliance on a single index of abundance, was not undertaken. It was suggested/recommended that future assessments consider and incorporate multiple indices, including RREAS, CalCOFI and nearshore aerial surveys.

Three key parameters of the population dynamics model were poorly estimated by the available data (steepness, survey Q and natural mortality). For this assessment the STAT decided to set survey Q = 1 for the core survey area and explored the implications of correcting the estimates of biomass for the latitudinal and inshore/offshore coverage of the stock, i.e., Mexican waters, and the proportion of the stock that is inshore of the core sampling area. The likelihood profiles for steepness and M were quite flat, indicating that the available data provided little information on these parameters. The

approaches used to add inshore biomass or modify survey Q are based on limited data and the uncertainty of extrapolations into the inshore area is not quantified. The effect of the latter is likely small for this assessment but could have been consequential had biomass not been substantial in recent years. Further research is required on stock structure, temporal and spatial distribution, and movement of the northern anchovy especially for CSNA.

Another concern of the Panel was that many of the model formulations explored lead to very high fishing mortalities for some ages in 2015. The final base model has fewer high fishing mortalities than the model in the draft assessment, owing to the change in the way selectivity is modelled, the outputs are a bit unrealistic. The exploitation rate on age-1+ biomass is much lower than the fishing mortality rate on single age-classes, and this exploitation rate is higher than if the exploitation rate was based on age-0+ biomass as some of the catch is of age-0 animals.

The final base model recommended by the Panel which incorporates adjustments of unobserved fish in the inshore and Mexican waters, has the following specifications:

- Sexes were combined; age-0 to age-3+.
- Two fisheries (MexCal S1 and MexCal S2), which combine the fisheries off Mexico and California and allow for seasonal selectivity patterns (the penalty on the deviations in selectivity about expected recruitment is based on a variance of 1).
- Beverton-Holt stock-recruitment relationship with steepness set to 0.6 and R to 1.
- Initial fished equilibrium with a "SR regime" parameter and an "initial F" parameter. M and virgin recruitment estimated.
- Recruitment deviations estimated for 2015 to 2020 and initial age-structure (age-1 to
- age-3+).
- Biomass estimates for the AT survey that reflect corrections for inshore biomass or survey Q for unsurveyed areas (See Table below). Note, that when available, observations from AT nearshore from small vessels or model extrapolation from unmanned surface vehicles were added to the AT survey observation from the core area.
- For spring 2016 (model year), the Q value was adjusted based on the temporally aligned aerial observation.
- Age-composition for the AT survey weighted by the number of positive clusters (calculated during AT survey data processing), with selectivity assumed to be uniform (fully-selected) above age-1 and estimated annually for age-0.

- The age data are weighted with effective sample sizes set to 1 per cluster.
- Empirical weight-at-age (fisheries and the AT survey).

The CSNA final base model 1+ biomass estimates are shown in the table below.

	AT Values Model year	AT Core	AT Nearshore	AT total
S1 (summer)	2015	10,528	7,180	17,708

	2016	150,907	274	151,181			
	2017	153,460	45,446	198,906			
	2018	723,826	4,110	727,936			
	2019	769,154	41,480	810,634			
					Aerial	Q ratio	Q adj (0.5798)
S2 (spring)	2016	173,973	--	--	294	0.9983	0.5780
	2021	1,358,587	13,047	1,371,634			

On another matter related to the STAR report editing process. For this review a cloud site was established where material/documents, including the draft STAR report, were posted. A few days after the completion of the meeting the draft report was closed and suggested edits were directed to the Panel chair for collation as well as being copied to Panel members. From a reviewer's perspective it was a challenge to keep track of which version was the latest. Perhaps another approach could be developed for future reviews.

CIE Report Appendix 1: Bibliography of materials provided for the review

Primary Document:

Kuriyama, P.T., Zwolinski J.P., Teo, S.L.H. and K.T. Hill. Assessment of the Northern anchovy (Engrualis mordax) central subpopulation in 2021 for U.S. management in 2021-2022.

Other documents prepared for this review:

Lynn, K., Dorval, E., Porzio, D., Nguyen, T. and D. Myers. Nearshore Aerial Survey Biomass for the 2021 Northern Anchovy Stock Assessment.
Schwartzkopf, B.D., Dorval, E., James, K.C., Walker, J.M., Snodgrass, O.E., Porzio, D.L. and B.E. Erisman. A summary report of life history information on the central subpopulation of Northern Anchovy (Engraulis mordax) for the 2021 stock assessment.

Background documents:

Hedgecock, D. 1994. Temporal and spatial genetic structure of marine animal populations in the California current. Reports of California Cooperative Oceanic Fisheries Investigations (CalCOFI), 35, 73–81.

Hilborn, R. and C. Walters, 1992. Quantitative fisheries stock assessment: choice, dynamics & uncertainty. Chapman & Hall, New York. DOI / ISBN.
Jacobson, L.D., Lo, N.C.H., Herrick, S.F. and T. Bishop. 1995. Spawning biomass of the northern anchovy in 1995 and status of the coastal pelagic fishery during 1994. SWFSC Administrative Report LJ-95-11.

Lecomte, F., W. S. Grant, J. J. Dodson, R. Rodriguez-Sanchez, and B. W. Bowen. 2004. Living with uncertainty: genetic imprints of climate shifts in East Pacific anchovy (Engraulis mordax) and sardine (Sardinops sagax). Molecular Ecology (2004) 13, 2169–2182.

PFMC. 2011. Acoustic-Trawl Survey Method for Coastal Pelagic Species Report of Methodology Review Panel Meeting.

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Parrish, R.H., Mallicoate, D.L., and Mais, K.F. 1985. Regional variations in the growth and
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Stierhoff, K.L., Zwolinski, J.P., Palance, D.G., Renfree, J.S., Mau, S.A., Murfin, D.W., Sessions, T.S. and D.A. Demer. 2019. Report on the 2018 California Current Ecosystem (CCE) Survey (1807RL), 26 June to 23 September 2018, conducted aboard NOAA Ship Reuben Lasker. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SWFSC-609.

Stierhoff, K.L., Zwolinski, J.P. and D.A. Demer. 2020. Distribution, biomass, and demography of coastal pelagic fishes in the California Current Ecosystem during summer 2019 based on acoustic-

trawl sampling. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SWFSC-626.

Stierhoff, K.L., Zwolinski, J.P. and D.A. Demer. 2021a. Distribution, biomass, and demography of coastal pelagic fishes in the California Current Ecosystem during summer 2015 based on acoustic-trawl sampling. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SWFSC-648.

Stierhoff, K.L., Zwolinski, J.P. and D.A. Demer. 2021b. Distribution, biomass, and demography of coastal pelagic fishes in the California Current Ecosystem during summer 2016 based on acoustic-trawl sampling. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SWFSC-649.

Zwolinski J.P., Stierhoff, K.L. and D.A. Demer. 2019. Distribution biomass, and demography of coastal pelagic fishes in the California Current Ecosystem during summer 2017 based on acoustic-trawl sampling. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SWFSC-610.

Other Documents:

PFMC. 2020. Terms of Reference for the Groundfish and Coastal Pelagic Species Stock Assessment Review Process for 2021-2022. https://www.pcouncil.org/documents/2021/01/terms-of-reference-for-the-coastal-pelagic-species-stock-assessment-review-process-for-2021-2022-december-2020.pdf/

CIE Report Appendix 2: Performance Work Statement

Performance Work Statement

National Oceanic and Atmospheric Administration (NOAA)
National Marine Fisheries Service (NMFS)
Center for Independent Experts (CIE) Program
External Independent Peer Review

Virtual STAR Panel Review of the 2021 Central Stock of Northern Anchovy Stock Assessment

December 7-10, 2021

Background

The National Marine Fisheries Service (NMFS) is mandated by the Magnuson-Stevens Fishery Conservation and Management Act, Endangered Species Act, and Marine Mammal Protection Act to conserve, protect, and manage our nation's marine living resources based upon the best scientific information available (BSIA). NMFS science products, including scientific advice, are often controversial and may require timely scientific peer reviews that are strictly independent of all outside influences. A formal external process for independent expert reviews of the agency's scientific products and programs ensures their credibility. Therefore, external scientific peer reviews have been and continue to be essential to strengthening scientific quality assurance for fishery conservation and management actions.

Scientific peer review is defined as the organized review process where one or more qualified experts review scientific information to ensure quality and credibility. These expert(s) must conduct their peer review impartially, objectively, and without conflicts of interest. Each reviewer must also be independent from the development of the science, without influence from any position that the agency or constituent groups may have. Furthermore, the Office of Management and Budget (OMB), authorized by the Information Quality Act, requires all federal agencies to conduct peer reviews of highly influential and controversial science before dissemination, and that peer reviewers must be deemed qualified based on the OMB Peer Review Bulletin standards.

(http://www.cio.noaa.gov/services_programs/pdfs/OMB_Peer_Review_Bulletin_m05-03.pdf).

Further information on the CIE program may be obtained from www.ciereviews.org.

Scope

The CIE reviewers will serve on a Stock Assessment Review (STAR) Panel and will be expected to participate in the review of Central Stock of Northern Anchovy (CSNA) stock assessment. The Central Stock of Northern Anchovy has not been assessed recently since commercial landings have been low since a reduction fishery in the 1980's and 1990's was shut down. The CSNA stock is currently monitored by SWFSC scientists, and the Pacific Fishery Management Council (PFMC). The stock assessment data and model will be formally reviewed by the STAR Panel with a coastal pelagic species subcommittee of the SSC. The resulting biomass estimate will be used to compare the efficacy of the current harvest guideline and other potential management recommendations.

This independent peer review is required by the PFMC review process. The STAR Panel will review draft stock assessment documents and any other pertinent information for CSNA, work with the stock assessment teams to make necessary revisions, and produce a STAR Panel report for use by the PFMC and other interested persons for developing management recommendations for the fishery. The PFMC's Terms of Reference (ToRs) for the STAR Panel review are attached in **Appendix 2**. The tentative agenda of the Panel review meeting is attached in **Appendix 3**. Finally, a Panel summary report template is attached as **Appendix 4**.

Requirements

Two CIE reviewers shall participate during a virtual panel review meeting in La Jolla, California during December 7-10, 2021, and shall conduct an impartial and independent peer review accordance with the Performance Work Statement (PWS) and ToRs herein. The CIE reviewers shall have the expertise as listed in the following descending order of importance:

- The CIE reviewer shall have expertise in the design and execution of fishery-independent surveys for use in stock assessments, preferably with coastal pelagic fishes.
- The CIE reviewer shall have expertise in the application of fish stock assessment methods, particularly, length/age-structured modeling approaches, e.g., 'forward-simulation' models (such as Stock Synthesis, SS) and it is desirable to have familiarity in 'backward-simulation' models (such as Virtual Population Analysis, VPA).
- The CIE reviewer shall have expertise in the life history strategies and population dynamics of coastal pelagic fishes.
- It is desirable for the CIE reviewer to be familiar with the design and application of fisheries underwater acoustic technology to estimate fish abundance for stock assessment.
- It is desirable for the CIE reviewer to be familiar with the design and application of aerial surveys to estimate fish abundance for stock assessment.

The CIE reviewer's duties shall not exceed a maximum of 14 days to complete all work tasks of the peer review process.

Tasks for reviewers

Prior to the Peer Review: Upon completion of the CIE reviewer selection by the CIE Steering Committee, the CIE shall provide the CIE reviewer information (full name, title, affiliation, country, address, email) to the NMFS Contracting Officer Representative (COR). The COR then forwards this information to the NMFS Project Contact no later than the date specified in the Schedule of Milestones and Deliverables. The CIE is responsible for providing the PWS and ToRs to the CIE reviewer. The NMFS Project Contact is responsible for providing the CIE reviewer with the background documents, reports, and other information concerning pertinent meeting arrangements. The NMFS Project Contact is also responsible for providing the Chair a copy of the PWS in advance of the panel review meeting. Any changes to the PWS or ToRs must be made through the COR prior to the commencement of the peer review.

Pre-review Background Documents: Two weeks before the peer review, the NMFS Project Contact will send (by electronic mail or make available at an FTP site) to the CIE reviewers the necessary background information and reports for the peer review. In the case where the documents need to be mailed, the NMFS Project Contact will consult with the CIE Lead Coordinator on where to send documents. CIE reviewers are responsible only for the pre-review documents that are delivered to the reviewer in accordance to the PWS scheduled deadlines specified herein. The CIE reviewer shall read all documents in preparation for the peer review.

Documents to be provided to the CIE reviewers prior to the STAR Panel meeting include:

- Stock assessment documents;
- STAR Panel- and SSC-related documents pertaining to reviews of past assessments;
- CIE-related summary reports pertaining to past assessments; and
- Miscellaneous documents, such as ToRs, logistical considerations.

Test: Additionally, two weeks prior to the peer review, the CIE reviewers will participate in a test to confirm that they have the necessary technical specifications provided in advance of the panel review meeting.

Virtual Panel Review Meeting: The CIE reviewers shall conduct the independent peer review in accordance with the PWS and ToRs, and shall not serve in any other role unless specified herein. **Modifications to the PWS and ToRs cannot be made during the peer review, and any PWS or ToRs modifications prior to the peer review shall be approved by the COR and CIE Lead Coordinator.** Each CIE reviewer shall actively participate in a professional and respectful manner as a member of the review panel's virtual meeting, and their peer review tasks shall be focused on the ToRs as specified herein. The NMFS Project Contact is responsible for any facility arrangements (e.g., video or teleconference arrangements). The NMFS Project Contact is responsible for ensuring that the Chair understands the contractual role of the CIE reviewers as specified herein. The CIE Lead Coordinator can contact the Project Contact to confirm any peer review arrangements.

Contract Deliverables – Independent CIE Peer Review Reports: The CIE reviewer shall complete an independent peer review report in accordance with the PWS. Each CIE reviewer shall complete the independent peer review according to required format and content as described in **Appendix 1**. The CIE reviewer shall complete the independent peer review addressing each ToR as described in **Appendix 2**.

- Attend and participate in the virtual panel review meeting
    - The meeting will consist of presentations by NOAA and other scientists, stock assessment authors and others to facilitate the review, to provide any additional information required by the reviewers, and to answer any questions from reviewers
- After the virtual review meeting, reviewers shall conduct an independent peer review in accordance with the requirements specified in this PWS, OMB guidelines, and TORs, in adherence with the required formatting and content guidelines; reviewers are not required to reach a consensus
- Each reviewer may assist the Chair of the meeting with contributions to the summary report.
- Deliver their reports to the Government according to the specified milestone dates

Foreign National Security Clearance
When reviewers participate during a panel review meeting at a government facility, the NMFS Project Contact is responsible for obtaining the Foreign National Security Clearance approval for reviewers who are non-US citizens. Since the meeting will be virtual due to the COVID-19 pandemic, there will be no Foreign National Security Clearance required.

Place of Performance:
The CIE reviewers shall conduct an independent peer review during the panel review meeting scheduled for the dates of December 7-10, 2021. Due to current uncertainties in the state of the COVID-19 pandemic at this time, this meeting will be conducted as a virtual meeting.

Period of Performance
The period of performance shall be from the time of award through January 2022. Each reviewer's duties shall not exceed 14 days to complete all required tasks.

Schedule of Milestones and Deliverables: The contractor shall complete the tasks and deliverables in accordance with the following schedule.

Schedule	Deliverables and Milestones
Within two weeks of the award	CIE sends reviewers contact information to the COR, who then sends this to the NMFS Project Contact
Approximately two weeks later	NMFS Project Contact sends the CIE Reviewers the pre-review documents
December 7-10, 2021	The reviewers participate and conduct an independent peer review during the panel review meeting
Approximately two weeks later	Contractor receives draft reports
Within two weeks of receiving draft reports	Contractor submits final CIE independent peer review reports to the COR

Applicable Performance Standards
The acceptance of the contract deliverables shall be based on three performance standards:
(1) The reports shall be completed in accordance with the required formatting and content (2) The reports shall address each TOR as specified (3) The reports shall be delivered as specified in the schedule of milestones and deliverables.

Travel
No travel expenses shall be incurred since the meeting will be held virtually.

Restricted or Limited Use of Data
The contractors may be required to sign and adhere to a non-disclosure agreement.

NMFS Project Contacts
NMFS Southwest Fisheries Science Center (SWFSC)

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Appendix 1: Peer Review Report Requirements

1. The report must be prefaced with an Executive Summary providing a concise summary of the findings and recommendations, and specify whether or not the science reviewed is the best scientific information available.

2. The report must contain a background section, description of the individual reviewers' roles in the review activities, summary of findings for each ToR in which the weaknesses and strengths are described, and conclusions and recommendations in accordance with the TORs.

   a. Reviewers must describe in their own words the review activities completed during the panel review meeting, including a brief summary of findings, of the science, conclusions, and recommendations.

   b. Reviewers should discuss their independent views on each TOR even if these were consistent with those of other panelists, but especially where there were divergent views.

   c. Reviewers should elaborate on any points raised in the summary report that they believe might require further clarification.

   d. Reviewers shall provide a critique of the NMFS review process, including suggestions for improvements of both process and products.

   e. The report shall be a stand-alone document for others to understand the weaknesses and strengths of the science reviewed, regardless of whether or not they read the summary report. The report shall represent the peer review of each TOR, and shall not simply repeat the contents of the summary report.

3. The report shall include the following appendices:

   Appendix 1: Bibliography of materials provided for review
   Appendix 2: A copy of this Performance Work Statement
   Appendix 3: Panel membership or other pertinent information from the panel review meeting.

Appendix 2: Terms of Reference for the Peer Review of the Central Stock of Northern Anchovy stock assessment

The CIE reviewers are one of the four or five equal members of the STAR panel. The principal responsibilities of the STAR Panel are to review stock assessment data inputs, analytical models, and to provide complete STAR Panel reports.

Along with the entire STAR Panel, the CIE Reviewer's duties include:

1. Reviewing draft stock assessment and other pertinent information (e.g., previous assessments and STAR Panel reports);
2. Working with STAT Teams to ensure assessments are reviewed as needed;
3. Documenting meeting discussions;
4. Reviewing summaries of stock status (prepared by STAT Teams) for inclusion in the Stock Assessment and Fishery Evaluation (SAFE) document;
5. Recommending alternative methods and/or modifications of proposed methods, as appropriate during the STAR Panel meeting, and;
6. The STAR Panel's terms of reference concern technical aspects of stock assessment work. The STAR Panel should strive for a risk neutral approach in its reports and deliberations.

The STAR Panel, including the CIE Reviewers, are responsible for determining if a stock assessment or technical analysis is sufficiently complete. It is their responsibility to identify assessments that cannot be reviewed or completed for any reason.

The review solely concerns technical aspects of stock assessment. It is therefore important that the Panel strive for a risk neutral perspective in its reports and deliberations. Assessment results based on model scenarios that have a flawed technical basis, or are questionable on other grounds, should be identified by the Panel and excluded from the set upon which management advice is to be developed. The STAR Panel should comment on the degree to which the accepted model scenarios describe and quantify the major sources of uncertainty Confidence intervals of indices and model outputs, as well as other measures of uncertainty that could affect management decisions, should be provided in completed stock assessments and the reports prepared by STAR Panels.

Recommendations and requests to the STAT Team for additional or revised analyses must be clear, explicit, and in writing. A written summary of discussion on significant technical points and lists of all STAR Panel recommendations and requests to the STAT Team are required in the STAR Panel's report. This should be completed (at least in draft form) prior to the end of the meeting. It is the chair and Panel's responsibility to carry out any follow-up review of work that is required.

Appendix 3: DRAFT AGENDA: 202 CSNA STAR PANEL

	Tuesday, 7 December	
08h30	Call to Order and Administrative Matters, Introductions	Punt
	WebEX troubleshooting	TBD
	Work plan and Terms of Reference	Griffin
	Report Outline and Appointment of Rapporteurs	Punt
09h00	CSNA survey-based assessment presentation	Kuriyama/Hill
10h00	Break	
10h30	CSNA model-based assessment presentation	Kuriyama/Hill
11h30	Acoustic trawl survey	Zwolinski, ATM group
12h00	Lunch	
13h00	Acoustic Trawl Survey, continued	Zwolinski, ATM group
14h00	CalCOFI Survey, Rockfish Recruitment Ecosystem Assessment Survey	Kuriyama/Hill
15h00	Break	
15h30	Aerial Survey, other surveys	TBD
16h00	Panel discussion and analysis requests	Panel
16h30	Public comments and general issues	
17h00	Adjourn	

Wednesday, 8 December		
08h30	Assessment Team Responses	Kuriyama/Hill
10h30	Break	
11h00.	Discussion and STAR Panel requests	Panel
12h30	Lunch	
13h30	Report drafting	Panel
15h00	Break	
15h30	Assessment Team Responses	Kuriyama/Hill
16h00	Discussion and STAR Panel requests	
16h30	Public comments and general issues	
17h00	Adjourn	

Thursday, 9 December		
08h30.	Assessment Team Responses	Kuriyama/Hill
10h30	Break	
11h00.	Discussion and STAR Panel requests	Panel
12h30	Lunch	
13h30	Report drafting	Panel
15h00	Break	
15h30	Assessment Team Responses	Kuriyama/Hill
16h30	Discussion and STAR Panel requests	
17h00	Adjourn	

Friday, 10 December		
08h30.	Assessment Team Responses	Kuriyama/Hill
10h30	Break	
11h00.	Discussion and STAR Panel requests	Panel
12h30	Lunch	
13h30	Finalize STAR Panel Report	Panel
15h00	Break	
15h30	Finalize STAR Panel Report	Panel
17h00	Adjourn	

Appendix 4: STAR Panel Summary Report (Template)

- Names and affiliations of STAR Panel members
- List of analyses requested by the STAR Panel, the rationale for each request, and a brief summary the STAT responses to each request
- Comments on the technical merits and/or deficiencies in the assessment and recommendations for remedies
- Explanation of areas of disagreement regarding STAR Panel recommendations
  - Among STAR Panel members (including concerns raised by the CPSMT and CPSAS representatives)
  - Between the STAR Panel and STAT Team
- Unresolved problems and major uncertainties, e.g., any special issues that complicate scientific assessment, questions about the best model scenario, etc.
- Management, data or fishery issues raised by the public and CPSMT and CPSAS representatives during the STAR Panel
- Prioritized recommendations for future research and data collection

Appendix 3: Panel membership or other pertinent information from the panel review meeting

Name	Affiliation
Stock Assessment Review Panel	
André Punt	SSC/University of Washington, Chair
John Budrick	SSC/CDFW
Marisol García-Reyes	SSC/Farallon Institute
Will Satterthwaite	SSC/SWFSC
Gary Melvin	Canada Department of Fisheries and Oceans
Henrik Sparholt	Denmark, Independent Scientist
Advisers	
Diane Pleschner-Steele	CPSAS
Greg Krutzikowsky	CPSMT
Stock Assessment Team	
Peter Kuriyama	SWFSC
Juan Zwolinski	UC Santa Cruz / SWFSC
Kevin Hill	SWFSC
Steve Teo	SWFSC
Other attendees	
Dale Sweetman	SWFSC
Kirk Lynn	CPSMT/CDFW
Juan Zwolinksi	SWFSC
Alan Sarich	CPSMT
Angela Forristall	NMFS
Brad Erisman	SWFSC
Briana Brady	CDFW
Brittany Schwartzkopf	SWFSC
Chelsea Protasio	CDFW
Emmanis Dorval	SWFSC
Heather Fitch	Alaska Department of Fish and Game
John Field	SWFSC
Josh Lindsey	NMFS
Julie Thayer	Farallon Institute
Kelsey James	SWFSC
Lorna Wargo	CPSMT/WDFW
Owyn Snodgrass	SWFSC
Richard Parrish	Independent
Steve Crooke	CPSAS
Kevin Piner	SWFSC
Taylor Debevec	NMFS
Trung Nguyen	CPSMT/CDFW
Alex Jense	U Washington
Anne Frieire de Carvalho	SWFSC
Barb Muhling	SWFSC
Ben Enticknap	Oceana

Bill Sydeman	Farallon Institute
Brian Wells	SWFSC
Conception Enciso	INAPESCA
Corey Niles	PFMC/WDFW
Dana Myers	CDFW
Desiree Tommasi	SWFSC
Dianna Porzio	CDFW
Ed Weber	SWFSC
Erin Satterthwaite	SWFSC
Geoff Shester	Oceana
Jarrod Santora	SWFSC
Jon Walker	SWFSC
Josiah Renfree	SWFSC
Josh Lindsay	NMFS
Julia Coates	CDFW
Katie Grady	CDFW
Kelly Kloos	CDFW
Martin Hernandez Rivas	Instituto Politécnico Nacional, Mexico
Megan Human	SWFSC
Michelle Horecxko	CDFW
Mike Cornman	CPSAS/Ocean Gold
Mike Okoniewski	CPSAS/Pacific Seafood
Noelle Bowlin	SWFSC
PY Hernvann	UC Santa Cruz
Rebecca Miller	NWFSC
Robert Wildermuth	UC Santa Cruz
Sherri Charter	SWFSC
Tara Brock	Oceana
Theresa Tsou	SSC/WDFW
Will Fennie	Moss Landing Marine Labs
William Watson	SWFSC

CDFW = California Department of Fish and Wildlife
CIE = Center of Independent Experts
CPSAS = Coastal Pelagic Species Advisory Subpanel
CPSMT = Coastal Pelagic Species Management Team
NMFS = National Marine Fisheries Service
NWFSC = Northwest Fisheries Science Center
PFMC = Pacific Fishery Management Council
SSC = Scientific and Statistical Committee
SWFSC = Southwest Fisheries Science Center