REPORT OF THE JOINT MEETING OF REPRESENTATIVES OF THE COASTAL PELAGIC SPECIES MANAGEMENT TEAM, COASTAL PELAGIC SPECIES ADVISORY SUBPANEL, AND SCIENTIFIC AND STATISTICAL COMMITTEE COASTAL PELAGIC SPECIES SUBCOMMITTEE ON ISSUES RELATED TO MANAGEMENT OF THE CENTRAL SUBPOPULATION OF NORTHERN ANCHOVY

EXECUTIVE SUMMARY

This report represents the results of a Pacific Fishery Management Council (Council) requested meeting to consider information and options relative to the management and science of the central subpopulation of northern anchovy (CSNA). Key discussion items included evaluation of nearshore estimation methodologies necessary to complement the acoustic-trawl method (ATM) survey, a review of André Punt's analysis of frequency to revisit the overfishing limit (OFL), discussion of recommendations for an appropriate frequency for assessment and management changes to the CSNA, development of options for accountability measures that would be triggered at specific stock levels, and an evaluation of data appropriate for analyzing whether a trigger has been reached. The meeting also considered issues related to the California Department of Fish and Wildlife / California Wetfish Producers Association aerial survey and provided recommendations.

The key conclusions of the meeting in relationship to the primary aims were as follows.

- Saildrones, collaborative research utilizing industry vessels, extrapolation methods, and aerial survey methods are all able to provide estimates for the nearshore areas. There is a clear preference for the use of methods that estimate biomass in nearshore waters based on direct synoptic observations rather than extrapolation, with acoustic sampling conducted by industry vessels being the approach most comparable to the ATM survey used to sample offshore waters. Saildrones, while providing comparable data to that collected by the *Reuben Lasker*, do not cover much additional area and it is more difficult to ensure saildrones can be synoptic with the survey vessel given their speed. Aerial surveys also are a useful method to survey nearshore waters efficiently, particularly when aerial surveys are conducted in coordination with offshore surveys.
- Each of the various approaches for sampling the nearshore have different costs (logistical and financial) and relative ability to sample. There is a need for careful coordination between all parties concerned if estimates of biomass for the entire CSNA (or as much as is feasible) are provided for management decision making.
- The meeting identified an appropriate framework for updating the management reference points, e.g. OFL and acceptable biological catch (ABC), in response to monitoring data. The framework includes the current management structure but is more responsive to new information. This framework can serve as the basis for management of the CSNA but the values for the parameters must be specified. The analyses comparing alternative parameters presented to the meeting were illustrative but not sufficient. The meeting identified additional analyses that should be provided to the November Council meeting to allow the Council advisory bodies to provide advice on the values for the parameters. The analyses comparing alternative parameters assume 100 percent attainment of the ABC. This is not realistic given the history of the fishery over the last 30 years. As such, estimates of risk to

the resource should be considered an upper bound and the analyses interpreted in a relative rather than absolute sense.

- In the long term it may be necessary to repeat the simulation analysis, should a new benchmark assessment indicate that population productivity and life history parameters have either changed or been poorly estimated from historical assessments.
- The ATM survey (with nearshore correction) provides the best index of anchovy biomass (with caveats). Of the remaining sources, ichthyoplankton data analyzed using Daily Egg Production Method (DEPM) and the Southwest Fisheries Science Center juvenile rockfish surveys have the best coverage but the latter requires further evaluation (the DEPM and juvenile rockfish surveys also largely miss nearshore waters). The other data sources, which could be used to compute indices that are correlated with anchovy biomass, are based on limited sampling areas and have yet to be used to develop indices.

1. Introduction

At its April 2019 meeting the Pacific Fishery Management Council (Council) requested that members of the Coastal Pelagic Species Management Team (CPSMT), the Coastal Pelagic Species Advisory Subpanel (CPSAS), the Scientific and Statistical Committee's (SSC) CPS Subcommittee (SSCCPSSC), and staff from the Southwest Fisheries Science Center (SWFSC) meet to consider information and options relative to the management and science of the central subpopulation of northern anchovy (CSNA), one of the Council-managed coastal pelagic species (CPS) stocks. More specifically, the Council asked the meeting participants to evaluate the nearshore estimation methodologies necessary to complement the acoustic-trawl method (ATM) survey, review André Punt's analysis of frequency to revisit the overfishing limit (OFL) and make recommendations for an appropriate frequency for the CSNA, develop options for accountability measures (AMs)[1] that would be triggered at specific stock levels, and determine which data to use to analyze whether a trigger has been reached.

The meeting participants (Appendix 1) agreed to also consider issues related to the California Department of Fish and Wildlife (CDFW)/California Wetfish Producers Association (CWPA) aerial survey, which was reviewed by a Council Methodology Review Panel in 2017.

The Council has considered management of the CSNA and reports from various advisory bodies and *ad hoc* workshops several times in recent years. In September 2016, the Council considered a report from a stock assessment workshop that was designed to identify optimal approaches for assessing CPS stocks – particularly northern anchovy – with relatively low data available (NOAA and PFMC, 2016), and a white paper on management options for northern anchovy (PFMC, 2016). More recently, the CPSMT and the SSC CPS Subcommittee wrote a joint report (PFMC, 2017a) describing options for generating a new or updated OFL for the CSNA.

The primary tasks of the meeting are summarized as:

- Task 1: Evaluate and make recommendations on nearshore biomass estimation methods to complement the ATM survey. Methods include, but are not limited to, saildrone technology, collaborative research utilizing industry vessels, extrapolation methods, and aerial survey methods.
    - Task 1a: Evaluate submitted materials for informal review of the nearshore CDFW/CWPA aerial survey variance estimator, bias correction factor, and to consider expansion of survey estimates to unsampled areas. This follows recommendations from a 2017 methodology review report (PFMC 2017b).
- Task 2: Develop options and make recommendations relative to an appropriate frequency for OFL and acceptable biological catch (ABC) updates, including review of an updated version of André Punt's analysis, and consideration of specific stock levels or other factors (e.g., conservation or socio-economic concern) that would trigger review of management reference points. The potential trade-offs of various options will be evaluated, as will data

[1] In the context of this meeting, the term 'accountability measures' differs from the definition in National Standard 1 (NS1). NS1 defines AMs as management controls to prevent ACLs from being exceeded, and can include in-season or post-season action. The CPS Fishery Management Plan already has the necessary AMs for all stocks to prevent catches from exceeding an ACL. Accountability measures in the context of this meeting refer to the potential need to adjust OFLs/ABCs and/or the need to conduct a new stock assessment.

streams (e.g., ATM survey, juvenile rockfish survey, CalCOFI data, etc.) for potential use in determining whether triggers have been met relative to stock status and management.

Appendix 2 lists the adopted agenda. The meeting was chaired by André Punt (University of Washington), except when his work was discussed, when Owen Hamel (Northwest Fisheries Science Center) chaired the meeting. John Budrick (CDFW), John Field (SWFSC), and Owen Hamel acted as the primary rapporteurs, with assistance from the chair.

Several documents relevant to the issues identified in the above tasks were provided in advance of the meeting. These documents (documents #1-7; Appendix 3) are publicly available on the Council's ftp site: ftp://ftp.pcouncil.org/pub/CPS/CPSMtgOct2019/. Some of the documents provided information for stocks other than the CSNA, but the meeting restricted its focus to those aspects of the documents related to the CSNA, except for the review of the CDFW/CWPA aerial survey methodology, which also considered methods and results for Pacific sardine as more data collections and analysis have been completed for that species than for northern anchovy.

This report summarizes the material provided for each of the tasks and the discussion during the meeting (the discussions and recommendations related to Task 1a can be found in Appendix 4). Section 4 of the report summarizes the conclusions and recommendations arising from the workshop.

2. Task 1. Nearshore biomass estimation methods to complement the NOAA acoustic-trawl survey

Due to their size and draft, National Oceanic & Atmospheric Administration (NOAA) Fisheries survey vessels cannot usually operate in waters shallower than 30m without considerable limitations. This constraint impedes the ability to sample fish populations in nearshore waters about 1 to 3 km wide. Four methods to estimate biomass shoreward of the ATM survey were presented and discussed: (a) a collaborative acoustic survey using smaller vessels to better access nearshore waters, (b) saildrones, (c) extrapolation of ATM survey results; and (d) an aerial survey. Juan Zwolinski (UC Santa Cruz/SWFSC) presented the first three methods, and Kirk Lynn (CDFW) and Emmanis Dorval (SWFSC) presented the aerial survey conducted by the CDFW in collaboration with the CWPA. Following the presentations, the meeting discussed several considerations regarding nearshore estimation methodologies. In addition, it discussed the logistics of providing biomass estimates in a timely fashion if the goal was to have information available by the advanced briefing book deadline for the November Council meeting each year.

Comparing the extrapolation from the ATM survey to the direct observations based on the estimates from the aerial survey for 2017, there are substantial differences for both sardine (142mt vs 21,045mt) and anchovy (45,446mt vs 78,608mt) despite the ATM and CCPSS surveys having occurred within 0-4 days of each other in 2017. This supports the preference to have direct observations as opposed to the use of extrapolation, provided that the inshore and offshore observations are made acceptably close together in time. The observations from the aerial survey show that the lack of the ATM survey in the inshore areas in Monterey Bay and the Half Moon Bay region may result in significant omissions that should be accounted for.

Table 1 summarizes the total distance from shore not sampled by *Reuben Lasker*, the remaining transect distance sampled and left unsampled for each alternative survey on each transect by latitude, as well as the depth that the survey stopped sampling. The advantages and disadvantages of each estimation method, including its ability to be comprehensive and synoptic with the ATM survey, are summarized in Table 2. The characteristics of the ATM survey, saildrone, and acoustic sampling from industry boats are summarized in Table 3.

During discussion, SWFSC staff noted that while it is now feasible to conduct nearshore surveys, issues that remain to be addressed include: 1) funding and execution - who pays for the additional ship time, sample collection and processing; 2) cost/benefit analysis - do the benefits of conducting the nearshore survey exceed the costs, and particularly the cost of diverting resources from ongoing projects to conduct a nearshore survey; and 3) utility for management - will the results of the nearshore survey affect management.

2.1. Saildrones

In 2018, Saildrone (www.saildrone.com) provided a wind-powered unmanned surface vehicle (USV) equipped with a dual-frequency echosounder operating at 38 and 120 kHz to sample the nearshore regions between Cape Flattery and Point Conception. The sampling design for the USV survey was such that it progressed latitudinally at a rate equivalent to that of the *Reuben Lasker*. There were no significant differences in acoustic backscatter collected by the two platforms where Saildrone and the *Reuben Lasker* overlapped. Despite this encouraging result, saildrone did not increase substantially the sampling of the nearshore region when compared to the *Reuben Lasker*. An issue of potential importance that was not discussed in detail is how uncertain are the saildrone estimates of density and how much would uncertainty increase if the ATM density estimates were replaced with saildrone estimates of density in the area of overlap.

The backscatter from the saildrone and the *Reuben Lasker* was compared for transects where there were overlapping data from both for 20-70m depth. *Reuben Lasker* had a higher proportion of zeros for shallower waters, although it recorded a higher density in deeper depths. There was no overall difference in backscatter integrated across all depths, which was hypothesized by the SWFSC to indicate that fish are moving down under the *Reuben Lasker* rather than off to the side and going undetected[2]. The conclusion made by the SWFSC was that the estimate of biomass derived from the saildrone can be assumed to be comparable with that from the *Reuben Lasker*, although the saildrone tended to "see" more fish in the nearshore areas while the NOAA vessel saw more fish in offshore areas. The transducer for the saildrone is mounted 2m below the surface compared to 7m for *Reuben Lasker*, providing observations over a larger proportion of the water column in shallow depths. A remaining consideration is the degree to which the *Reuben Lasker* can detect fish while sampling in shallower depths where fish may not be able to move deeper, that would be captured by the saildrone or by the nearshore acoustic surveys with smaller vessels. Overall, the saildrone allowed observations closer to shore compared to the *Reuben Lasker*. However, the saildrone did not comprehensively cover waters unsampled by the *Reuben Lasker* (Table 1). It also only sampled from San Francisco to Point Conception in 2018 leaving out the Southern California Bight and had difficulties navigating reliably in light and variable winds. In 2019 the saildrones were again used from Cape Flattery, WA to Point Conception.

2.2 Collaborative acoustic survey

[2] This hypothesis is disputed by fishermen who have documented fish vessel avoidance behaviour.

In 2017, the SWFSC collaborated with Andy Blair, fisherman and owner of the Fishing Vessel (FV) *Lisa Marie* and Greg Shaughnessy, Chief Operating Office of Ocean Gold Seafoods in Westport, Washington. The collaboration involved outfitting *Lisa Marie* with a General Purpose Transceiver and associated hardware to operate a 38 kHz hull mounted transducer. This allowed *Lisa Marie* to use similar equipment to the *Reuben Lasker* while sampling the nearshore waters off Oregon and Washington. While very few observations of fish schools were made from the *Lisa Marie*, this survey demonstrated the viability of collaborative surveys with the industry for the sampling of nearshore regions.

In 2019, FV *Lisa Marie,* and FV *Long Beach Carnage*, were used in conjunction with the *Reuben Lasker* to sample the nearshore areas of Oregon/Washington and the Southern California Bight, respectively. While the data collected are currently under analysis, only the fishing vessels were able to substantially extend the *Reuben Lasker*'s survey into the nearshore and collect biological samples. For example, the nearshore acoustic sampling by both the *Lisa Marie* and *Long Beach Carnage* allowed for the collection of biological samples that provide information on species composition and size distribution to assign to acoustic signals.

Meeting participants noted differences in the frequency of biological sampling in the nearshore acoustic surveys conducted north and south of Point Conception and the need to maintain consistent sampling density and frequency across the full range of the species of interest.

2.3 Extrapolation of ATM results

Due to the shallow seabed and other nearshore hazards to navigation, acoustic sampling with NOAA survey vessels may not encompass the eastern extents of the surveyed stocks. To investigate the potential biomass of CPS in areas where neither the *Reuben Lasker* nor the saildrone could safely navigate, acoustically sampled biomass along the easternmost portions of transects were extrapolated to the 5m isobath in the unsampled nearshore areas. The biomass densities along the unsampled nearshore extension of the transect were assigned the values measured along the eastern end of the transects along a distance equal to that from the end of the transect towards the 5m isobath. The calculations of the biomasses in the nearshore unsampled strata were the same as those used for the sampled area, assuming the extrapolated biomass densities were measured (see Stierhoff et al., 2019 and Zwolinski et al., 2019 for more details). The extrapolations of the ATM survey observations from eastern extent of the transect to the unsampled nearshore waters were presented and discussed.

The extrapolations are subject to considerable uncertainty owing to whether density at (or near) the coastward end of transects provides an appropriate estimate of density nearshore of the survey track, and due to the high coefficient of variance (CVs) of the resulting estimates (see Table 4 for CVs). The biomass density data used to calculate the biomass in the nearshore area are taken from an interval in the nearest acoustic transects, with a length equal to the distance between the transect endpoint and the 5m isobath. This method may underestimate the biomass of the CSNA, given that anchovy are generally found in higher densities closer to shore at low population biomass, and young (i.e. age 1) anchovy are found in nearshore waters at both high and low population size, thus are largely unsurveyed. Under the current method the further offshore the transect is discontinued, the higher the contribution of offshore waters to the extrapolation (Figure 1). As a result, the segment of the ATM transect used as the basis for extrapolation not only starts further offshore, but extends further offshore and results in disproportionate representation of offshore waters where densities are expected to be lower, potentially biasing them low.

The method for extrapolation should be selected and justified by the analysts and the meeting suggested that the analysts explore using a fixed distance from the shoreward termination of ATM survey line as the basis for extrapolation if extrapolation is required. The fixed distance could be the minimum distance from shore, the maximum distance from shore or a fixed distance based on the density of the species in question with distance from the shoreward end of the ATM transect lines in the stratum in question. Comparison of estimates of biomass from the nearshore acoustic survey, saildrone and aerial survey to the extrapolations from observations that are sufficiently synoptic to prevent double counting might provide a means to validate the extrapolations and gauge the accuracy of alternative extrapolation methods. Such analysis was not available for the review, but is recommended for the future.

2.4 Aerial survey methods

The focus of the California Coastal Pelagic Species Survey (CCPSS) has been to provide estimates of the biomass of sardine and anchovy for nearshore areas not covered by the ATM survey, for use in stock assessments. A nearshore cooperative survey (NCS) project was conducted under an Exempted Fishing Permit (EFP) in the Southern California Bight (SCB) in summer 2018 and spring 2019 to estimate bias and variance for the aerial survey (see Appendix 4).

The 2017 and 2019 CCPSS aerial surveys were coordinated with the ATM survey. Two transects within a band 2,400m off the shoreline were conducted with one spotter in the plane. The surveys in both years included sampling on days within the first half of August that matched the timing of the ATM survey at the same latitudes within 0-5 days in areas from north of Fort Bragg to south of Morro Bay. In 2019, sampling toward the end of August into early September also matched the latitudes covered by the ATM survey in the SCB within a similar timeframe.

Running the aerial survey in conjunction with ATM survey is preferable. Doing so avoids making assumptions regarding movement of fish between the timing of the two surveys.

2.5 Coordination of methods for estimating biomass in nearshore waters

Multiple partners may need to collaborate and coordinate timing depending on the method(s) used to inform the nearshore estimate. This is true not only to ensure sampling targets are met to produce synoptic results, but also for the timelines related to data processing and producing final results. Additionally, consideration would need to be given to the desired timing of finalization of the data. For example, if the goal was to have information available by the advanced briefing book deadline for the November Council meeting, it may be possible that the SWFSC could provide estimates from the previous standard summer ATM survey by then. However, incorporation of estimates for the nearshore area would depend on other partners, as well as the SWFSC to analyze data from nearshore acoustic surveys. A clear plan for when and how data are to be shared is essential. If nearshore estimates cannot be provided in a timely fashion, providing the Council with the relative magnitude of the biomass contribution from the nearshore would be helpful in understanding the degree to which estimates from the ATM would underestimate biomass from preliminary data. However, it was noted that the proportion of the total biomass in nearshore waters was likely to differ as total biomass changes. Thus, determining a single fixed proportion allowing an adjustment applicable in any given year is presently infeasible.

3. Task 2. Frequency, triggers, and accountability measures for revisiting reference points

The meeting reviewed and discussed documents #2 and #4. It also reviewed additional data and survey sources that could inform triggers. Document #2 provides a potential framework for accountability measures that utilize and evaluate a range of data sources to determine an appropriate interval for updating OFLs and ABCs, and whether thresholds or triggers based on short- and long-term biomass estimates are met. Document #4 describes the parameters needed to apply the framework. These parameters (and range of values proposed for future analyses) are:

- The interval between benchmark stock assessments (4, 8, 16 years)
- The frequency for considering updates to the OFL (1, 4, 8 years)
- The frequency for considering updates to the ABC (1, 2, 4 years)
- The frequency for updating the long-term biomass estimate from scientific surveys (1, 5, 10, 60 years)
- The frequency for updating the short-term biomass estimate from scientific surveys (1, 2, 3 years)
- Potential changes to Q (the buffer between OFL and ABC, currently 0.25) (0.05 – 0.95)
- The threshold for whether to change the OFL due to changes in the long-term average biomass estimate (x_1)(0.1, 0.2, 0.3)
- The threshold for whether to reduce the ABC in response to a low short-term average biomass estimate (x_2)(0.1, 0.2, 0.3).

3.1 Selection of trigger limits/Accountability measures

The framework of Figure 2 recognizes that the current management structure for CSNA is based on long-term OFLs and ABCs, and maintains the approach of using both long-term and short-term information to minimize changes in OFLs and ABCs, with the intent of being responsive to new information from both recent surveys and less frequent benchmark stock assessments. The framework had its origins in the simple illustrative example of the trade-offs related to the frequencies of updating OFL specifications discussed in April 2019 (Punt, 2019).

The simulations contain many of the aspects of a management strategy evaluation (MSE), which was suggested by the Center for Independent Experts review as a necessary step before the results from the ATM could be used for management (PFMC, 2018). However, this is not a full MSE, because for example, the scenarios considered to date do not explore the implications of the extent to which the estimates from ATM provide absolute estimates of abundance.

The framework involves a flowchart (Figure 2) that outlines the process of regularly comparing the estimates of the biomass of the CSNA relative to thresholds triggering management actions that would update the OFL and/or ABC. This flowchart informed the simulation modelling (document #4), which can be used to examine and evaluate the trade-offs between conservation and catch associated with the different values for parameters in Figure 2. The flowchart and the modelling work represent a structure with three primary decision points each year. Starting with an existing OFL and default ABC (where ABC is a function of a buffer, *Q*, multiplied by the OFL), the decision points include asking the following questions: 1) should a new assessment be conducted (from which long-term biomass estimates, and associated estimates of B_{MSY} and E_{MSY} are derived); 2) should the OFL be updated (by updating the long-term biomass), and 3) should the default ABC be changed if short-term biomass estimates are below threshold values.

The flowchart in Figure 2 extends that in document #2 by including a parameter X that is the frequency with which changes to the ABC made be made given a change in the value of short-term biomass. The original version of Figure 2 in document #2 corresponds to X=1, i.e. the ABC may be changed from ABC_d every year.

To inform the framework, a suite of plausible assumptions and range of parameter values are explored in document #4. The parameters include: 1) the interval between benchmark stock assessments; 2) the frequency for updating the long-term biomass estimate from scientific surveys; 3) potential changes to Q (currently 0.25); 4) the threshold for whether to change the OFL due to changes in the long-term average biomass estimate; and 5) the threshold for whether to reduce the ABC in response to a low short-term average biomass estimate. The flowchart includes a step that if the ABC is changed due to low short-term biomass and the catch is approaching the default ABC, an assessment the next year could be triggered. This step was not included in the modelling owing to the lack of an ability to model attainment.

Importantly, the modelling approach did not examine alternatives where the ACL and/or ACT would be set below the ABC, and a very important (but necessary) constraint to the analyses was the assumption that attainment of ABC values was 100 percent. There is clear evidence that this is not the case (in reality, the entire ABC has not been achieved in this fishery since 1983). Another key option was whether to set a "maximum allowable catch" (MAXCAT), as a proxy in the model that would essentially cap catches to the maximum perceived capacity or need by the industry. It should be noted that inclusion of MAXCAT in the modelling is not meant as a proposal for a new management policy for this stock. Rather, MAXCAT is included in the analysis as a proxy to limit catch to help evaluate what happens to the modelled biomass when ABC attainment is limited. The conservation-related statistics reported in document #4 therefore overestimate risk, meaning that they should represent an upper bound on the implications of fisheries removals. This is true even for the model runs with a MAXCAT of 25,000mt because fishery take has not exceeded 20,000mt since 1982. While it is desirable to model attainment, this is impossible to predict in any given year due to the combination of factors contributing to it, though MAXCAT attempts to provide some indication of the effect of less than full attainment.

The existing management system can be considered one set of parameters within this framework, i.e. when the OFL is based on a three-year average of biomass estimates, E_{MSY} is based on analyses of the results of a stock assessment (albeit one from the 1990s; Jacobson et al., 1995), and the buffer between the OFL and the ABC is 75 percent (i.e. Q=0.25). However, within the proposed framework, the three-year average of biomass estimates would be routinely updated, and monitored to evaluate whether it has triggered a threshold. This is essentially row 4 of Figure 2, in which a new B_{ST} is developed, a determination is made as to whether $B_{ST}*Q*E_{MSY}$ is less than the ABC_d by a proportion of at least X_2, and if so, the ABC would be reset to $B_{ST}*Q*E_{MSY}$. When the ABC is changed for this reason, if there is substantial fishing pressure it could trigger an assessment the following year.

The framework of Figure 2 provides a formal approach for evaluating the trade-offs between risk and fishing opportunity relative to our best indicators of stock biomass and productivity. A key presumed objective related to the design and the associated explorations was to attempt to achieve consistency (e.g., to moderate volatility in OFL and ABC levels) in the face of a highly volatile population that exhibits both high and low frequency variability in productivity for which our estimates of biomass are imprecise. An ideal management scheme would implement changes when necessary, but not more frequently than necessary. The frequency of changes should be balanced by the objectives of limiting both the conservation risk and disruption to the fishery. The simulation results in document #4 provide an initial evaluation of the potential risks and trade-offs related to both alternative biological factors (specifically, the form of the spawner-recruit curve, regime periodicity and amplitude, among others) as well as the performance of various alternative values for parameters such as assessment frequency, ABC update frequency, maximum catch levels, and the size of buffer between the OFL and the ABC (*Q*). The latter parameter is among the most important in evaluating control rule behavior and performance. In general, lower values for Q are associated with lower long-term ABC values and also necessitating fewer changes to those values.

The simulations explicitly account for low frequency variability in population biomass, which is understood to exist, despite a poor appreciation for the actual oceanographic or biological mechanisms. However, the simulations do not explicitly account for future climate change effects on the ocean and reductions in potential fishery yields in the California Current Ecosystem that may occur (IPPC 2019), or other changes outside of the scope of historical conditions (e.g., shifts in predation mortality). There was considerable discussion regarding many other population parameters, particularly productivity, but also natural mortality, and recruitment variability. New benchmark assessments will tremendously aid the ability to better parameterize key population characteristics.

The meeting participants noted that in the long-term it may be necessary to repeat the simulation analysis, should a new benchmark assessment indicate that population productivity and life history parameters have either changed or been poorly estimated from historical assessments. Nevertheless, there was agreement among the meeting participants that the framework of Figure 2 was a useful means of moving forward with considering a management structure for the CSNA. In simple terms, the Council should understand the limits of the modelling work done under this framework. The meeting participants agreed that this model is useful, but only to show the relative values of the various options examined.

A range of additional analyses that would inform the trade-offs relative to the frequency of assessments, the definitions of long- and short-term biomass, and the performance of constant ABC scenarios were identified. Some scenarios were run after day 1 of the meeting and the results presented to the meeting on day 2; these in turn provided guidance into reasonable bounds for the alternatives that will be explored in the complete analysis. The additional analyses included cases where a constant ABC would be set and the catch would equal the ABC irrespective of current biomass. Not surprisingly, the constant catch scenarios tended to lead to stock collapse in many simulations, although such collapses were (intuitively) slightly less frequent with the lower constant catches (e.g., ABC =5,000mt). This confirms the intuitive result (also discussed in the April 2019 white paper; PFMC 2019) that constant catch management strategies are seldom ideal, although the point was also made that the assumption that a constant catch of the ABC is always attained is not realistic, given shifts in stock availability, market constraints and fishery behaviour at low biomass levels.

The meeting was unable to make specific recommendation for the values of the parameters needed to apply the approach in Figure 2. Instead, it agreed to develop ranges for each parameter and values for each parameter that should be analyzed for the November 2019 Council meeting (Table

5) to enable the Council's advisory bodies to more deeply consider the trade-offs associated with the choices. A range (and corresponding intervals) of values for the simulation analysis were agreed upon, and it was noted that those related to shifts in the frequency of ABC updates, given a broader range of Q values, were likely to be among the more informative specifications. A more rigorous exploration of factors may be more appropriate after Council guidance regarding the current direction of the evaluation.

The meeting participants noted that the five performance statistics (probably of biomass dropping below B_{MSY} and $0.5B_{MSY}$ and of ABC dropping between 25,000mt, 10,000mt and 5,000mt) in document #4 did not directly address the risk of overfishing. In principle, the catch in each year could be compared with the "true" OFL (i.e. the product of the "true" modelled biomass and the "true" E_{MSY} for each year). However, it was noted that calculation of year-specific E_{MSY} is not computationally feasible in the time available. Instead, the meeting participants agreed to include an additional performance statistic, the probability that the annual catch is greater than the "true" modelled biomass multiplied by the E_{MSY} value when account is not taken of cyclic changes in productivity, recognizing that the absolute value of the statistic is not meaningful, but relative differences among alternatives should provide useful information on the relative risk of each alternative. A second additional performance statistic is the probability of the biomass dropping below a reference level computed as the lower 5th percentile of biomass[3] in an unfished state (equivalent to the lower 5th percentile of "dynamic B_0"). These two new metrics will provide additional information regarding the increased risk of being at low biomass levels under the alternatives, and are anticipated to be in the document to be provided in November 2019.

3.3 Determine which data to use to analyze whether a trigger has been reached

The meeting noted that several data sources are available to estimate trends in the abundance or biomass of the CSNA (Table 6). It should be noted that the estimates of biomass from the various data sources will relate to different components of the population. For example, the Daily Egg Production Method (DEPM) provides estimates of spawning biomass, whereas the ATM surveys should provide estimates of total biomass (albeit subject to levels of bias that cannot be fully quantified at present), but only if an appropriate nearshore correction factor is applied. In addition, none of the data sources considered provide recent data on anchovy in Mexican waters, although some of these anchovy are likely to be from the same biological stock as those in the CSNA.

Section 2 of this report discusses the ATM survey and how survey methods such as the CDFW/CWPA aerial survey, extrapolation, saildrones, and collaborative inshore acoustic sampling can be used to account for biomass the ATM survey misses in nearshore waters. An estimate of the biomass of the CSNA has been obtained using the DEPM for spring 2017 and a DEPM estimate is planned for spring 2020. The SSC has agreed that the DEPM estimates of biomass can be used for management purposes without further review. The DEPM is expected to provide an estimate of biomass that encompasses both offshore and nearshore biomass of adult anchovy and thus provides a way to validate the combined estimates from the ATM and other means of estimating nearshore biomass, though is subject to its own uncertainties.

[3]A low value that represents a relatively rare occurrence for comparison, but not so low that the model will be unable to estimate the relative proportion of occurrence.

The May 2016 PFMC workshop (NOAA & PFMC, 2016) on CPS assessments considered alternative indices based on egg and larval surveys, including the use of egg/larval data when there are no data on egg/larval mortality and the adult parameters needed to convert egg numbers to estimate of biomass. This "DEPM light" method uses egg and larval densities estimated from surveys to calculate the number of newly released eggs that yielded the observed number of older eggs and larvae, with egg/larva age typically estimated from a temperature-dependent growth curve, and lab-derived mortality estimates used to account for losses over the intervening period. The stock size required to release this number of eggs is then estimated from biological data about adults (ideally these data are from corresponding data obtained by trawling from the year of estimation), including sex ratio, spawning fraction, and size/fecundity of adults. As these corresponding demographic and reproductive ecology parameters are rarely available for each annual estimate, long-term average values are more frequently used. NOAA & PFMC (2016) discusses the advantages and disadvantages of the DEPM light approach and identified recommendations for additional work. The meeting noted that some evaluation of the extent to which the adult parameters may have changed could be done by comparing the values for these parameters estimated for the spring 2017 survey and those on which the historical estimates are based.

John Field (SWFSC) provided a summary of several alternative additional data sources:

- The SWFSC Rockfish Recruitment and Ecosystem Assessment Survey (RREAS). This trawl survey is now conducted from Cape Mendocino to the Mexican border and regularly encounters anchovy. It provides data on trends in young-of-year (YOY) and adult anchovy. Preliminary analysis (not including data for 2019) suggest that indices based on a delta-GLM are well correlated with both the results of the ATM survey and the DEPM light method. Survey CVs have been computed for anchovy and are ~0.6. Data are available on length-frequency of anchovy since 1999 (adults) and 2013 (young of the year).
- Acoustic data are routinely collected on the RREAS, but have yet to be processed or otherwise evaluated with respect to total anchovy biomass.
- Data, including anchovy, are collected during the Applied California Current Ecosystem Studies (ACCESS) survey (Thayne et al., 2019). This survey covers a more limited geographic region than the ATM survey and the RREAS. However, the survey vessels typically survey closer to shore than either the ATM or RREAS, and the survey takes place typically three (or more) times each year during multiple seasons. The indices for anchovy from this survey are correlated with data from other sources (such as seabird diets and results from the RREAS).
- Data from power plant impingement exist, but this source of data is unlikely to continue into the future and the historical data have not been analyzed to provide indices to compare with other time-series.
- CDFW has conducted a long-term monitoring program in San Francisco Bay, based on midwater trawling, providing length composition data and indices of biomass for adults and YOY (Cloern et al., 2010).
- Seabird and marine mammal diets provide indices of biomass in the form of the proportion of prey items in the diet as well as the length composition of prey. The length of the time-series of diet proportions differs among species (e.g., nearly 40 years for California sea lions in Southern California). These data can provide information on broad trends, but their interpretation is complicated by the impacts of changes in the abundance of other prey

species and the predator preferences for prey. Diet data can be used to estimate time-series of removals by predators, which could inform trends in natural mortality in future assessments.

Several of these data sets (and other data sources such as live bait catches) collect data on length-frequency, which could be included in a future assessment.

Overall, the meeting agreed that the ATM survey (with nearshore correction) provides the best index of anchovy biomass. The DEPM (and DEPM light) and the SWFSC juvenile rockfish surveys have the best coverage of the remaining data sources but require further evaluation. The other data sources, which could be used to compute indices that are correlated with anchovy biomass, are based on limited sampling areas and have yet to be used to develop indices that can be compared with, for example, the results from the ATM survey, DEPM, and DEPM light in a synoptic fashion. These indices are also potentially useful data sources to consider in the development of benchmark assessments, which would be assumed to be conducted more frequently under the framework.

4. Conclusions, Recommendations, and Next Steps

4.1 Conclusions and recommendations: Task 1

- The four methods considered during the meeting are all able to provide estimates for the nearshore areas. Table 2 provides an overall summary of the advantages and disadvantages of each method. The meeting participants in general defer to the assessment analysts to determine the most appropriate method for estimating biomass in nearshore area, so long as the caveats and limitations of different approaches are considered.
- There is a clear preference for the use of methods that estimate biomass in nearshore waters based on direct synoptic observations rather than extrapolation, with acoustic sampling based on industry vessels the approach most comparable to the ATM survey used to sample offshore waters.
- Aerial surveys also have been conditionally approved for use, with an appropriate variance estimator, to measure nearshore biomass, when conducted synoptically with AT surveys. Aerial surveys are an efficient and cost-effective way to survey a broad area in a relatively short time period.
- Saildrones, while providing comparable data to the *Reuben Lasker*, do not cover much additional area and it is more difficult to ensure saildrones can be synoptic with the survey vessel given their speed.
- Each of the various approaches for sampling the nearshore has different costs (logistical and financial). In particular, there is a need for careful coordination between all parties concerned if estimates of biomass for the entire CSNA (or as much as is feasible) are to be provided.
- There is a need during industry acoustic surveys to maintain consistent sampling density and frequency of biological sampling across the full range of the species of interest.
- Consider using a fixed distance from the shoreward termination of ATM survey line as the basis for extrapolation. The fixed distance could be the minimum distance from shore, the maximum distance from shore or a fixed distance from the coast based on the density of the species in question.

4.2 Conclusions and recommendations: Task 2

- Figure 2 (as described in Document #2) is an appropriate framework for updating the management reference points OFL and ABC in response to monitoring data. The framework of Figure 2 includes the current management structure but is more responsive to new information. This framework is appropriate as the basis for management of the CSNA but the values for the parameters must be specified.
- The analyses in Document #4 are illustrative but not sufficient to select the parameters of Figure 2. The meeting identified additional analyses that should be provided to the November Council meeting to allow the Council advisory bodies to provide advice on the values for the parameters.
- The framework in Document #4 assumes 100 percent attainment of the ABC. This is not realistic given the history of the fishery over the last 30 years. As such, estimates of risk to the resource should be considered an upper bound. Document #4 does not address ACL or ACT (except indirectly through MAXCAT).
- Given the considerable uncertainty regarding the biological parameters and status of the CSNA, the results of the simulations should be interpreted in a relative rather than absolute sense.
- Some of the predicted OFLs and ABCs can be very high. The meeting supported analyses based on imposing a maximum on the catch (MAXCAT).
- In the long term it may be necessary to repeat the simulation analysis, should a new benchmark assessment indicate that population productivity and life history parameters have either changed or been poorly estimated from historical assessments.
- The ATM survey (with nearshore correction) provides the best index of anchovy biomass. Of the remaining sources, the DEPM, DEPM light and the SWFSC juvenile rockfish surveys have the best coverage but require further evaluation. The other data sources, which could be used to compute indices that are correlated with anchovy biomass (Table 6), are based on limited sampling areas and have yet to be used to develop indices that can be compared with, for example, the results from the ATM survey and DEPM light.

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NOAA & PFMC. 2016. Report of the NOAA Southwest Fisheries Science Center & Pacific Fishery Management Council Workshop on CPS Assessments. Agenda Item E.2.a. September 2016 Council meeting (38pp).

PFMC 2016. Coastal Pelagic Species Management Report on Anchovy Management Update Agenda Item E.3a. CPMST Report (10pp).

PFMC 2017a. Joint Scientific and Statistical Committee/Costal Pelagic Species Management Team Repot of Central Subpopulation of northern anchovy overfishing limit process. Agenda Item G.2a, Joint SSC/CPSMST report (4pp).

PFMC 2017b. Southern California Coastal Pelagic Species Aerial Survey Methodology Review Report. June 2017 Pacific Fishery Management Council Agenda Item D.2, Attachment 1 (22pp).

PFMC 2018. Methodology Review Panel Report: Acoustic Trawl Methodology Review for Use in Coata Pelagic Species Stock Assessments. April 2018 Pacific Fishery Management Council Agenda Item C.3, Attachment 2 (75pp).

PFMC 2019. Whitepaper on frequency of assessments and updates to OFLs, ABCs, and ACLs for the central subpopulation of northern anchovy. April 2019 Pacific Fishery Management Council Agenda Item E.4, Attachment 2.

Punt, A.E. 2019. An approach for computing F_{MSY}, B_{MSY} and MSY for the CNSA. Agenda Item E4, Attachment 1. April 2019 Council meeting. (18pp).

Thayne, M.W., Santora, J.A., Saenz, B., Warzybok, P. and J. Jahncke. 2019. Combining seabird diet, acoustics and ecosystem surveys to assess temporal variability and occurrence of forage fish. *Journal of Marine Systems* 190:1-14.

Table 1. Total, mean, and median distances from shore from the easternmost point of *Reuben Lasker* transects in the regions where alternative platforms were used: Oregon and Washington using *Lisa Marie* in 2017, Central and Southern California using saildrone in 2018 (see Zwolinski et al. 2019 and Stierhoff et al. 2019 for details). The alternative platform distances covered refer to the distances surveyed in the nearshore area not covered by *Reuben Lasker*. Off Oregon and Washington, *Lisa Marie* was able to increase the sampling effort 3.25 nmi per transect, in average, which corresponds to about 81 percent of the inshore area not sampled by the *Reuben Lasker*. Off Central California in 2018, saildrone extended the *Reuben Lasker* transects, in average, 0.54 nmi, which corresponds to about 31 percent of the nearshore area not sampled by the *Reuben Lasker*.

Survey	Region	*Reuben Lasker* - distance to shore (nmi)			Alternative platform – distance covered (nmi)		
		Median	Mean	Total	Median	Mean	Total
2017	Oregon/Washington	4.36	3.99	71.76	3.62	3.25	56.94
2018	Central/Southern California	1.19	1.82	43.60	0	0.57	11.34

Table 2. Advantages, disadvantages, and guidance provided on the use of saildrones, collaborative inshore acoustic survey, extrapolation of the ATM survey and the aerial survey to estimate CSNA biomass shoreward of the ATM survey.

Method	Advantages	Disadvantages	Guidance
Saildrone	• Covers more of the water column	• Slow speed limits the area that can be surveyed and the degree to which data can be provided that are synoptic with the ATM survey • Only limited additional coverage of nearshore waters relative to the ATM • Performed poorly in the Southern California Bight • No biological sampling	
Collaborative Inshore Acoustic Survey	• Smaller mesh net when needed to sample smaller YOY anchovy • Synoptic (within three days) with the ATM • Provides biological data to supplement the acoustic data and validate species composition • Can sample to as shallow as 7m	• Limited access to the shallowest nearshore depths, i.e. surf line, due to the draft of the vessel	• Maintain consistent sampling frequency north and south, including frequency of biological sampling • Continue efforts to conduct sampling that is as synoptic as possible with the ATM survey
Extrapolation of ATM Estimates Shoreward	• Data are readily available facilitating application • This is the only data source for the historical period to account for biomass shoreward of the ATM survey • Provides backup in years when the preferred approach to nearshore survey is unavailable	• Current methods are likely biased low especially when biomass is low • Actual observations from other methods are preferred • CVs are very high, making estimates extremely uncertain	• Produce estimates that use a constant distance across all transects as the basis for extrapolation instead of using segments the same size as the distance of the ATM transect to shore • Compare extrapolations from the alternative methods to those from the current method for periods and areas where synoptic data are available
Aerial Survey	• Can sample from the end of the ATM survey transect to the shore • Can sample a large area of coastline in a single day • Allows flexibility of sampling within a single day, to best align with offshore efforts	• Requires supplemental biological sampling by vessels either fishing or sampling to provide length/age composition • Requires interagency coordination • Is limited more by weather than any of the other methods • Is presently limited to a very small number of trained observers	• Continue to develop variance estimation • See Appendix 4

Table 3. Characteristics of available platforms for acoustically surveying CPS populations off the West Coast of the US. Green, yellow and red colours are used to highlight ideal, workable, and non-workable features.

Feature / **Platform**	**Saildrone**	**Industry Vessel**	**Research Vessel**
Echosounder type	Dual-frequency	Pole mounted Multiple-frequency capable	Multiple frequency
Multibeam sonar availability	No	No	Yes
Sonar availability	No	Fisheries Sonar	Scientific Sonar
Real time viewing	No	Yes	Yes
Scientific Remote capability	No	Moderate	Yes
Fish sampling	No	Yes	Yes
Environmental sampling	Surface	CTD capable	Surface and CTD
Daily sampling consistency	Highly weather-dependent	High	High
Area of Operation	West Coast, excluding SCB	West Coast, including SCB	West Coast, including SCB
Daily sampling range (nm; 12 hour day)	18 nm (1.5 kt average speed)	84 nm (7 kt average speed)	120 nm (10 kt average speed)
Minimum Operating Depth	~ 20 m	~ 5 m below the keel	~ 20 m below the keel
Minimum Distance to Shore	Few thousand m	Few hundred m	Few thousand m
Maximum Distance to Shore	Hundreds of miles	Tens of miles	Hundreds of miles

SCB: Southern California Bight; CTD: Connectivity, temperature and depth recorder.

Table 4. Statistics for extrapolations of biomass from the ATM survey to the nearshore area for all surveyed stocks (see Zwolinski et al. 2019 and Stierhoff et al. 2019 for details). NSNA – Northern Subpopulation of Northern Anchovy; CSNA – Central Subpopulation of Northern Anchovy; NSPS – Northern Subpopulation of Pacific Sardine; CSPS – Central Subpopulation of Pacific Sardine; PM – Pacific Mackerel; JM – Jack Mackerel; PH – Pacific Herring.

Survey	Stock	Area (nmi^2)	Average distance (nmi)	Biomass	
				Point estimate (t)	CV (%)
2017	NSNA	733	4.47	9	83
	CSNA	815	3.5	45,466	30
	NSPS	1,918	2.52	146	57
	PM	2,107	2.5	1,106	32
	JM	2,104	2.23	1,543	29
	PH	1,418	2.55	7,410	68
2018	NSNA	607	2.54	1,310	84
	CSNA	464	1.33	3,623	63
	NSPS	702	1.94	308	86
	CSPS	271	1.4	1,870	74
	PM	988	1.78	1,320	75
	JM	1,547	1.99	9,954	75
	PH	1,154	2.24	8,449	52

Table 5. The parameters and the levels to be considered in the modelling for the November Council meeting.

Parameter	Values to consider
Frequency of assessment (Y)	4, 8, 16
Frequency OFL update (Z)	1, 4, 8
Frequency ABC update (X)	1, 2, 4
Q	0.05 to 0.95 in steps of 0.1
x_1 (proportional change in long-term biomass required for OFL update)	0, 0.1, 0.2, 0.3
x_2 (proportional change in ABC_d required for ABC update)	0, 0.1, 0.2, 0.3
Definition of long-term biomass	1, 5, 10, 60
Definition of short-term biomas2	1, 2, 3
MAXCAT	None, 25,000mt

Table 6. Summary of the data sources for the CSNA that could be used to calculate biomass estimates (or indices of biomass) that could be used to trigger accountability measures. Note that the population component designation is approximate.

Data source	Years available	Population component	Notes and limitations
ATM survey (with nearshore corrections)	2015 – present	Total biomass	Methods for extrapolating biomass estimates into the nearshore are still to be finalized.
DEPM	2017	Spawning biomass	Conducted infrequently.
DEPM light	1994 – present	Spawning biomass	Assumes that the egg/larval mortality and the adult parameters needed to convert egg numbers to estimate of biomass are constant over time.
SWFSC CalCOFI suvey (winter; SD-SF; CA)	1951 - 2012	Spawning biomass	
SWFSC CalCOFI suvey (spring; SD-SF; CA)	1951 - present	Spawning biomass	Used in the DEPM light method.
SWFSC RREAS	2004 – present	??	2004 is the first year that the entire CSNA has been surveyed; a core area of Central California has been surveyed annually since 1983; further evaluation of the relationship between the data from this survey with those from the DEPM and ATM surveys are needed.
Acoustic data from RREAS survey	2001- present (some missing years)	Total biomass	The data have yet to worked up for anchovy.
Applied California Current Ecosystem Studies (ACCESS): surveys in Central California	2004-present	??	Limited area; further evaluation of the relationship between the data from this survey are those from the DEPM and ATM surveys are needed.
CDFW/CWPA survey (SCA) (NCA)	2013 – present 2017 - present	Nearshore biomass	An underestimate of the total biomass in the range of the CSNA.
Sea bird and marine mammal diets	Various	??	The proportion of anchovy in the diet depends on the abundance and preference for other prey but these data might provide information on broad trends and/or population demographic structure.
CDFW San Francisco survey	1980-present	??	Limited area; further evaluation of the relationship between the data from this survey are those from the DEPM and ATM surveys are needed.

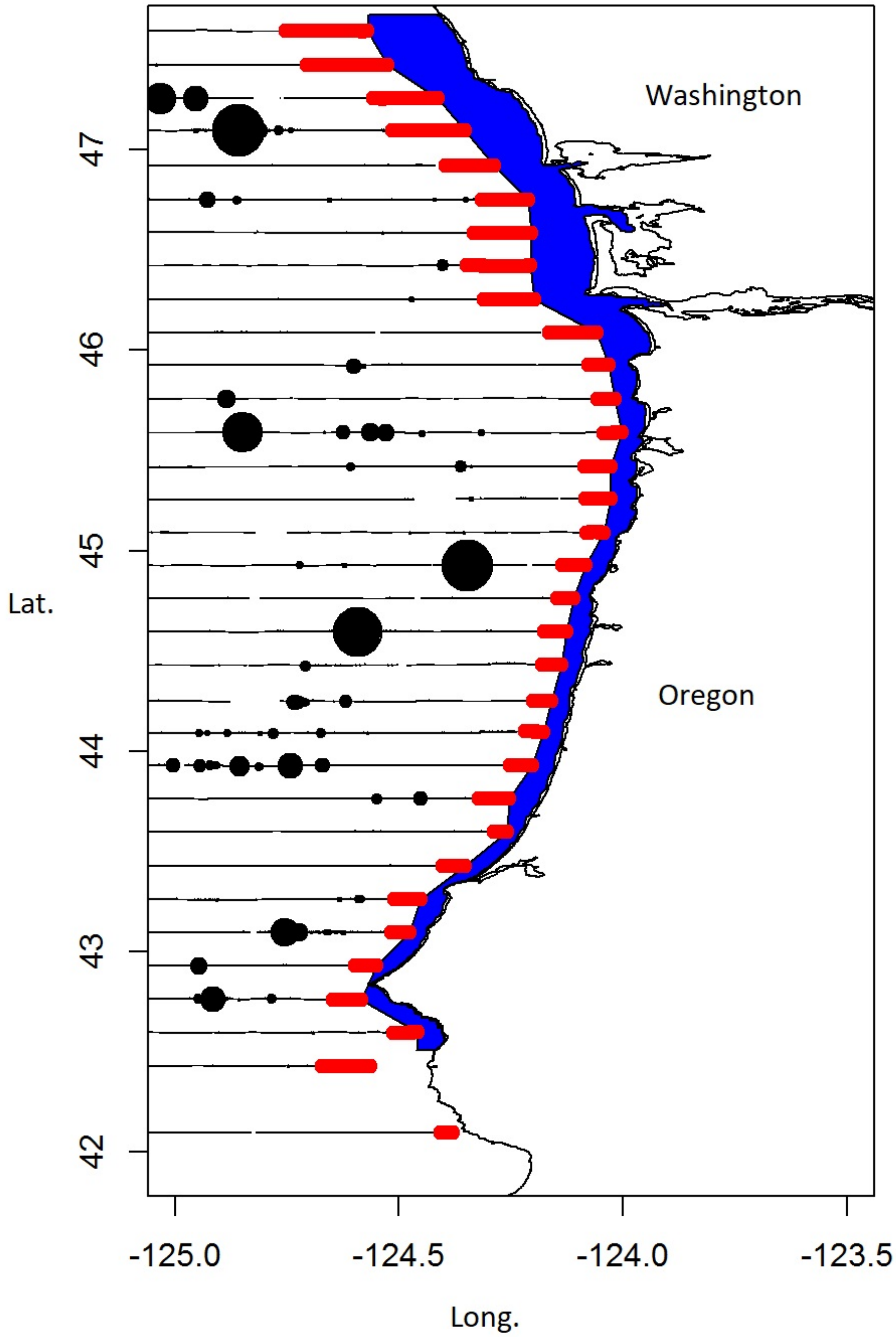
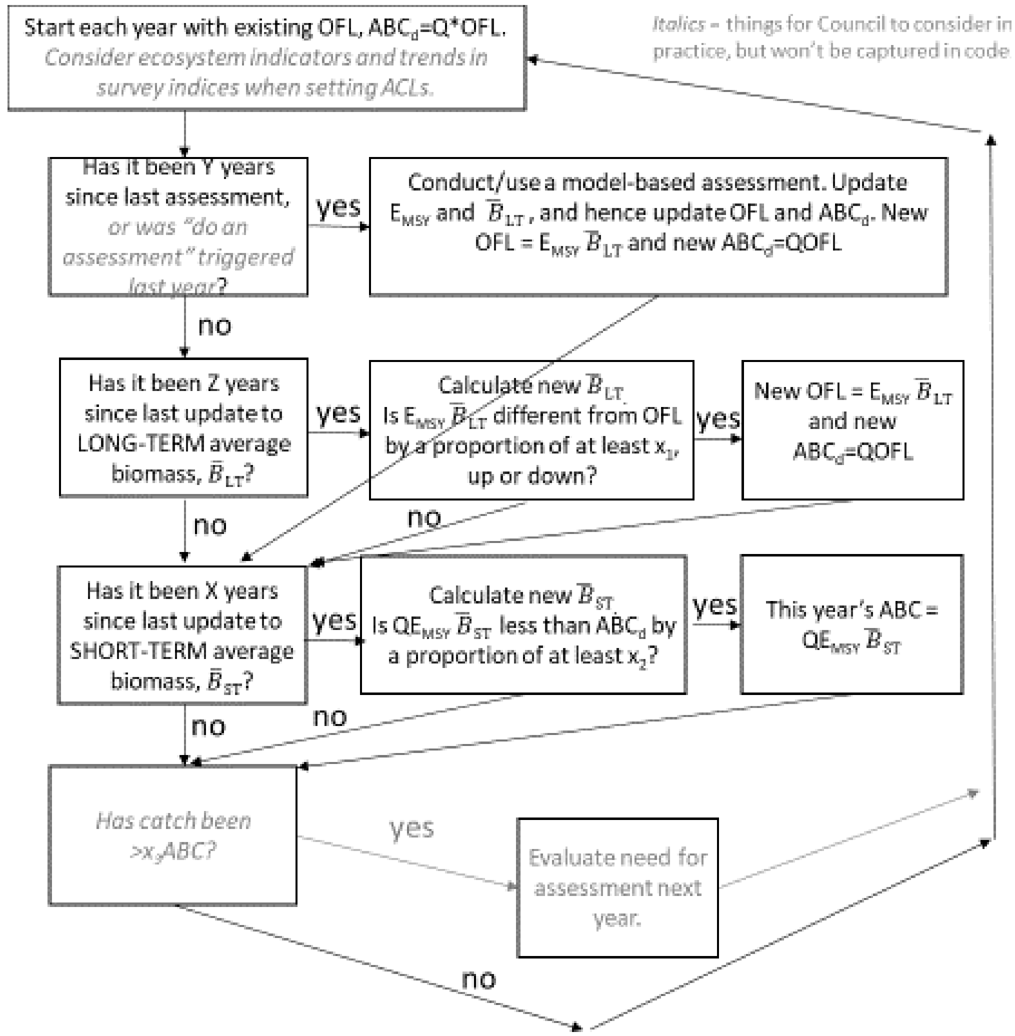


Figure 1. Depiction of the basis for CPS extrapolations using the distance from the eastern end of the ATM transect to the 5 m isobath as the distance sampled along the ATM transect for the shoreward extrapolation.



Y = interval for full assessments regardless of trigger (could be infinity)

Z = interval for updating long-tem biomass (from survey)

X = interval for updating short-tem biomass (from survey), X≤Z≤Y.

Q = ABC buffer. Now 0.25, might be larger with more frequent updates.

X_1 is the threshold for changes in OFL due to changes in B_{LT}

X_2 is the threshold for reducing ABC in response to low B_{ST}

X_3 is a threshold for attainment

Figure 2. The framework considered in this document. Note that the boxes in light font are not evaluated in the simulation modelling.

Appendix 1
Meeting Attendees

Name	**Affiliation**
Meeting principals	
André Punt	SSC/University of Washington, Chair
John Budrick	SSC/CDFW
Emmanis Dorval	SWFSC
Kerry Griffin	PFMC
Owen Hamel	SSC/NWFSC
Steve Crooke	CPSAS
John Field	SSC/SWFSC
Greg Krutzikowsky	CPSMT/ODFW
Diane Pleschner-Steele	CPSAS
Kirk Lynn	CPSMT/CDFW
Dale Sweetnam	SWFSC
Juan Zwolinski	SWFSC
Will Satterthwaite (via webinar)	SSC/SWFSC
Other attendees	
David Demer	SWFSC
Kevin Stierhoff	SWFSC
Josh Lindsay	NMFS WCR
Kevin Hill	CPSMT/SWFSC
Briana Brady	CDFW
Dianna Porzio	CDFW
Bev Macewicz	SWFSC
Trung Nguyen	CPSMT/CDFW
Lynn Massey	NMFS WCR
Paul Crone	SWFSC
Roger Hewitt	SWFSC
Corbin Hanson	Commercial
Joe Ferrigno	Commercial
Julie Thayer	Farallon Institute
Peter Kuriyama	SWFSC
Bullwin Klemoose	
Geoff Shester	Oceana
Kristen Koch	SWFSC
Gilly Lyons	Pew
Joel Van Noord	CWPA
Paul Crone	SWFSC
Scott Mau	SWFSC
Steve Sessions	SWFSC
Richard Parrish (via webinar)	Emeritus

CDFW – California Department of Fish and Wildlife
CPSAS - Coastal Pelagic Species Advisory Subpanel
CPSMT - Coastal Pelagic Species Management Team
CWPA – California Wetfish Producers Association
NMFS – National Marine Fisheries Service
NWFSC - Northwest Fisheries Science Center (National Oceanic and Atmospheric Administration)
ODFW - Oregon Department of Fish and Wildlife
PFMC – Pacific Fishery Management Council
SSC - Scientific and Statistical Committee (of the Pacific Fishery Management Council)
SWFSC - Southwest Fisheries Science Center (National Oceanic and Atmospheric Administration)
WCR – West Coast Region

Appendix 2
Adopted Agenda

Thursday October 3		**Presenter**
8:30am	Call to Order, Administrative Matters, Introductions, assign rapporteurs, etc	Punt, Griffin
9am	Summary of Council's request, and overview of current CSNA management	Griffin
9:30am	Nearshore estimation methodologies	Sweetnam, Zwolinksi
10:30am	Break	
11am	Data streams, current and potential	John Field
12pm	LUNCH	
1pm	CSNA management: frequency of reference points updates, tradeoffs, and considerations, Part 1	Krutzikowsky, Punt
2pm	CDFW/CWPA aerial survey: variance estimators, bias correction, survey footprint	Lynn, Dorval
3pm	Break	
3:30pm	CDFW/CWPA aerial survey: variance estimators, bias correction, survey footprint, continued	Lynn, Dorval
4:30pm	Public comment	
	Adjourn Day 1	
Friday October 4		
8:30am	CDFW/CWPA aerial survey, Part 2; conclusions and recommendations	Lynn, Dorval
9:30am	CSNA management: frequency of reference points updates, tradeoffs, and considerations, Part 2: conclusions and recommendations	All
10:30am	Break	
11am	CSNA management: frequency of reference points updates, tradeoffs, and considerations, Part 2: conclusions and recommendations, continued	All
12pm	Lunch	
1pm	Work Session	
2pm	Report planning and November meeting logistics	Punt
3pm	Nearshore estimation methodologies	Sweetnam, Zwolinksi
4pm	Work session, as needed	All
5pm	Adjourn	

Appendix 3
Primary documents considered during the meeting

1. Dorval, E. and K. Lynn. Accuracy and precision of Pacific Sardine (*Sardinops sagax)* and Northern Anchovy (*Engraulis mordax*) aerial survey biomass estimates in nearshore waters off California.
2. Krutzikowsky, G.K. Developing accountability measures to be triggered at specific stock levels for the Central Subpopulation of Northern Anchovy.
3. Lynn, K., Dorval, E., Porzio, D. and T. Nguyen. California nearshore aerial survey biomass estimates for Pacific sardine (*Sardinops sagax*) and northern anchovy (*Engraulis mordax*).
4. Punt, A.E. An updated analysis of the implications of different choices for the frequency of updates to OFLs and ABCs for the CSNA.
5. Stierhoff, K.L., Zwolinski, J.P. and D.A. Demer. 2019. Distribution, biomass, and demography of coastal pelagic fishes in the California Current Ecosystem during summer 2018 based on acoustic-trawl sampling. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SWFSC-613.
6. 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.
7. PFMC. 2019. Scientific and Statistical Committee report on central subpopulation of northern anchovy management update. Agenda Item E.4.a Supplemental SSC Report 1. April 2019.

Appendix 4
Review of the variance estimator, bias correction factor, and method to expand estimates from CDFW/CPWA aerial survey

The goals of the CCPSS are to document the nearshore biomass of northern anchovy and Pacific sardine and provide values for use in assessments of those two species. The CCPSS was initiated in 2012. The current survey methods have been in place since 2015, with coverage expanding to Northern California in 2017; some of the outer islands in the Southern California Bight were removed from the survey frame in 2018.

The CCPSS continues to make progress in methods, timing, coverage and quantity of data available to provide estimates of nearshore biomass and associated variance that could be combined with the ATM survey.

A methodology review of the CCPSS in April 2017 conditionally approved the use of the survey following evaluation and quantification of survey variance and the bias associated with the use of spotter pilots to estimate biomass. In response, in 2018 and 2019, a nearshore cooperative survey (NCS) was conducted with the goals of quantifying variance and bias. The goals of the NCS were to:

- quantify and compare within- and among-transect variance;
- compute bias for aerial survey estimates of biomass; and
- sample species, length and age composition for CPS schools.

A.4.1 Variance estimation

NCS flights included two spotters (the pilot who also acted as a spotter and a second spotter behind the pilot). A set of three parallel transects each covering 1,200m observation width were flown for each stratum covered on a day, with three replicates of each set of transects. This provided three biomass estimates for each transect (and for the entire area covered), and estimates of biomass for three transects for each replicate. These data were used to provide an estimate of mean biomass, a maximum biomass value, and estimates of variance based on the replicate transects (referred to as "within transects") and among-transect data (referred to as "within replicates").

Results (document #1) indicated that among-transect variance provides similar estimates of variance as within-transect replication. This indicates that surveying across parallel transects can provide reasonable variance estimates without the need for replicate transects More precise estimates will be obtained with more replicates, and the ideal sample design would include replicates as well as multiple transects for each stratum. The information from the NCS could be used to conduct a cost-benefit analysis related to the allocation of survey effort among transects, replicates and strata.

The proponents suggested applying the coefficient of variation (CV) estimates from the NCS to the biomass estimates from the CCPSS survey, as no replicates were flown. The meeting principals agreed that variance estimates from each stratum are required. These can be calculated from the two parallel transects alone, but this is far from ideal, and will lead to estimates with large CVs.

The meeting principals agreed that the mean biomass estimate is an appropriate estimate for nearshore biomass. The maximum biomass estimate across replicates would be appropriate only if there was substantial evidence that the other estimates were underestimates.

It is not possible for the spotters to provide biomass estimates by school when there are large aggregations of schools ("shoals") because the schools tend to be dynamic, frequently combining and breaking apart. Rather than attempting to record biomass for all schools, the number of schools and biomass estimates for a subset of the schools is recorded. The proportion of estimated total nearshore biomass that comes from shoals (within a stratum and among strata) should be calculated, and the potential increase in uncertainty (CV) should be addressed.

A.4.2 Estimates of observer bias when estimating biomass; sampling CPS schools for length and age

To compute bias for survey-estimated biomass, purse seine point set sampling was performed by chartered vessels in water depths of 7- 40m where NOAA hydroacoustic survey vessels typically cannot operate. Compared to the adjusted landed catch, spotters on average underestimated sardine school biomass.

Twenty-four point sets were conducted on sardine schools during 2018 and 2019. Half of these were for schools with biomass less than 10mt, while the other half were spread among schools with biomass of 10-80mt (with more smaller than larger schools captured). Schools were unexpectedly primarily pure sardine, unlike in previous years, and indicative of a large nearshore abundance of sardine. The data for these points sets were analyzed in combination with the 26 point sets conducted in 2010 (the same pilot spotter conducted the 2010 and 2018/2019 point sets, but the second spotter was not involved in the 2010 point sets). Overall, average bias across the two spotters and 50 point sets corresponded to a 14 percent underestimate of biomass. Bias appeared similar across the two spotters, but this should be confirmed by additional analyses.

No point sets were obtained for anchovy during the NCS in southern California. Some schools consisted of small age-0 ("pinhead") anchovy, which are problematic for fishermen and processors, as pinheads are both not marketable and are likely to foul nets by getting stuck in the small mesh. In August-September, five or six anchovy point sets were attempted in Monterey (3 confirmed valid) by the CCPSS, and more are planned. However, no point sets on small age-0 anchovy can be made. An alternative approach to validating the biomass estimate is needed. One approach is to use acoustics coupled with subsampling for age and length.

Point sets across sizes of schools as well as size/age compositions reflecting observed schools are needed. This includes validating schools comprised of small age-0 fish and very large schools that are too large to collect in single point sets. The point sets made in 2018-19 resulted in catches of pure schools and reflect the current distribution patterns of the two species. However, mixed schools have been encountered in the past, and should be expected and accounted for in future research plans.

A.4.3 Extrapolation

The initial design for the aerial survey considered the possibility of extrapolating density estimates from surveyed to unsurveyed areas within the nearshore and offshore at islands in the SCB. The proponents stated that they did not plan use extrapolation to obtain biomass estimates. The meeting participants agreed that such extrapolation is undesirable and estimates from observations in the nearshore are preferable.

Evaluation of the relationship between density offshore and onshore could nevertheless be useful. As populations vary, consistent patterns may emerge from comparison of offshore and inshore density estimates, which may provide a basis for an extrapolation factor that varies with observed offshore density. This factor would have a high variance, but could potentially provide information in the absence of direct observation of the nearshore areas.

A.4.4 Conclusions and recommendations

- The CCPSS continues to make progress in methods, timing, coverage, and quantity of data available to provide estimates of nearshore biomass and associated variance that could be combined with the ATM survey.
- Estimates of variance can be obtained from between-transect variance as well as replicate surveys of a stratum. While basing variance estimates on replicates is the preferred approach, use of between-transect variance is acceptable. Variance estimates for a stratum should be based on data for that stratum and not obtained from a relationship between sampling CV and mean biomass.
- The survey protocol should ensure that schools seen during off-transect school size estimation are not included in the biomass estimates.
- Having multiple spotters is desirable to ensure that the aerial survey can be conducted effectively even if the current pilot no longer participates in the survey. The information from the two spotters will be maximized if they are as independent as possible. The structure of the plane set up should be selected to avoid one spotter being “cued” by the other.
- Analyses should be conducted to evaluate the best allocation of survey effort among transects, replicates and strata.
- The approach for assessing spotter bias and the number of point sets for Pacific sardine is close to sufficient. However, this is not the case for northern anchovy and effort should be made to estimate school biomass for schools of age-0 anchovy (it may be necessary to compare such ways with the current approach for some schools for validation purposes). In addition, point sets are still needed across sizes of schools as well as size/age compositions reflecting observed schools.
- It is currently not possible to obtain biomass estimates for every school in a shoal. Attempts should be made to overcome this problem and/or evaluate the consequences of estimating the biomass of shoals as the product of the number of schools and the biomass of a subset of the schools.
- Extrapolation of aerial survey estimates of density is undesirable. The meeting participants support the proponent’s desire not to use extrapolation to obtain biomass estimates.