SCIENTIFIC AND STATISTICAL COMMITTEE ECOSYSTEM SUBCOMMITTEE REPORT

Pacific Fishery Management Council

Via Webinar

September 16, 2022

The Scientific and Statistical Committee's Ecosystem Subcommittee (SSC-ES) met via webinar September 16, 2022 to review new analyses conducted by the National Marine Fisheries Service (NMFS) California Current Integrated Ecosystem Assessment (CCIEA) team that may potentially inform future annual Ecosystem Status Reports (ESRs) to the Pacific Fishery Management Council (PFMC) on the state of the California Current Ecosystem. The SSC-ES reviewed two topics: A) Strategic review of the salmon indicator portfolio and B) Climate Change Appendix.

Dr. Kristin Marshall chaired the meeting. She noted that in their March 2022 statement on meeting topics, the SSC conveyed the complexity inherent to both topics and that follow up meetings with additional PFMC advisory bodies would likely be needed. To that end, the Salmon Technical Team (STT), Salmon Advisory Subpanel (SAS), Ecosystem Working Group (EWG), and Ecosystem Advisory Subpanel (EAS) were invited to attend. However, this meeting should be considered a first opportunity for the SSC-ES to review and provide guidance for the CCIEA team's plans as they refine the suite of salmon indicators and develop the climate change appendix to the ESR. Meeting participants are listed in Appendix A.

A. Strategic Review of the Salmon Indicator Portfolio

A.1. Linking ecosystem indicators to salmon life cycles

Dr. Chris Harvey (Northwest Fisheries Science Center [NWFSC]) summarized the indicators relevant to salmon life cycles currently in the ESR and supplementary material and highlighted recent and upcoming changes. The number of candidate indicators for the ESR grows every year, and the diversity of species managed by the PFMC means that most of the indicators have value for at least some participants in the Council process. However, keeping the ESR to a manageable summary document of conditions to consider for a given year, rather than a comprehensive report of a large volume of indicators at numerous scales, requires that the CCIEA team make difficult decisions about where to expand and where to prune. Salmon, with many managed stocks per species and a life cycle that moves from freshwater to ocean and back again, are particularly prone to indicator overload. Thus, guidance on key indicators to maintain or develop for the main report, and indicators to move to the appendix and to other reports, was a particular focus of the SSC-ES discussion.

Current indicators relevant to salmon life cycles are summarized in Table 1. Notable proposed changes include reducing the number of time series graphs in the report, including the CPUE in the annual juvenile salmon surveys off OR and WA (which is also featured in "stoplight tables" and pelagic community cluster analyses), the natural area escapements of many evolutionarily significant units (ESUs) of Coho and Chinook salmon, and hydrological indicators at the Chinook Salmon ESU scale. Possible additions include fishery participation networks focused on salmon, led by Dr. Jameal Samhouri (NWFSC), which combine port-specific information on salmon fishing revenue with network-derived measures of connectivity and importance to better understand the vulnerability and resistance of communities to negative changes in salmon fishing opportunity.

The SSC-ES appreciates the careful thought, hard work, and expertise that goes into the annual ESR and supplementary material, as well as the long-term efforts to improve the products. The SSC-ES supports the focus on indicators of broad interest in the main body of the report, such as those that affect multiple Fishery Management Plans (FMPs) and/or stocks, with more detailed information in the supplement, online material, and in the future, FMP-specific ecosystem indicator reports as suggested in the Fishery Ecosystem Plan (FEP) initiative 2.1. Moving many regional time series to the supplementary material and focusing on coastwide and/or ecoregion indicators in the main body of the report keeps the report centered on the big picture, while still providing resources for those interested in information at a finer scale. Further exploration of data-reduction methods, such as the Ecosystem State Index, is encouraged. The SSC-ES also suggests incorporating more coastwide surveys of prey, including the rockfish and pre-recruit surveys, further exploring the impacts of environmental variability on spatial distribution of fisheries effort, and natural vs. hatchery comparisons.

Table 1. Current indicators related to salmon, as presented by Dr. Chris Harvey to the SSC Ecosystem Subcommittee on 16 September 2022. Topics are followed in parentheses by the salmon life cycle stages most affected by the indicators.

Topic	Main Body	Supplement
Salmon Abundance Indicators (early marine, spawners)		
Juvenile abundance	Juvenile survey catch-per-unit-effort (CPUE) for Coho and Chinook off OR/WA in cluster analyses and stoplight tables	Times series of juvenile survey CPUE for Chinook, coho, chum and sockeye off OR/WA
Adult abundance	Natural area escapement of Central Valley fall Chinook	Model-derived "outlooks" for Chinook ESU returns to Bonneville Dam; plans to expand to include other stocks or populations
Stream Indicators (egg, alevin, fry, smolt in river, spawners)		
Ecoregional Hydrology	Snow water equivalent time series, 7-day minimum flow, 1-day maximum flow, plan to add August maximum stream temperature	Time series of ecoregional hydrology, with plan to add air temperature; April 1 snow water equivalent map
	Cells in Central Valley Chinook stoplight table	Cells in Sacramento River and Klamath River stoplight tables
Ocean growing conditions (early marine, ocean subadults, migrating adults)		
Physical indicators and indices	Standard basin-scale and region-scale physical indicators and	Seasonal time series and maps of basin-scale indicators and indices

Topic	Main Body	Supplement
	indices	
Feeding conditions	Time series of feeding conditions, including Newport copepods, Trinidad krill, and regional pelagic assemblages; plan to add more coastwide prey information	Time series of regional pelagic assemblages
Both	Stoplight table for Northern CCE ocean conditions	Cells in Sacramento River and Klamath River stoplight tables
Integrative		Ecosystem state index (dynamic factor analysis)
Predation (smolts, early marine, ocean subadults, migrating adults)		
Top predator reproductive success	Times series of California sea lions at San Miguel and seabirds at SE Farallon Island; cells in Central Valley Chinook stoplight table	Time series of seabird reproductive success at Yaquina Head
Predator diet		Common murre diets from two colonies
Human dimensions indicators (ocean subadults and migrating adults)		
Coastwide fisheries metrics	Time series of commercial and recreational landings, revenue diversification, revenue concentration	Time series of state-level commercial and recreational landings, coastwide and state revenue
Community metrics	Community vulnerability and commercial fishing reliance graphs, fishery participation networks, plans to expand on output from fishery network studies	Port-level revenue diversification time series, expansion on community vulnerability and commercial fishery engagement work, analyses related to revenue concentration and participation networks

A.2. Best practices for stoplight tables

The SSC-ES received a summary of the use of stoplight tables for Pacific salmon stocks in the Ecosystem Status Report from Dr. Correigh Greene (NWFSC), Dr. Nate Mantua (Southwest Fisheries Science Center [SWFSC]), and Dr. Brian Burke (NWFSC). The presenters emphasized that stoplight graphics are a communication and synthesis tool that summarize the status of relevant indicators across multiple salmon life-stages and habitats (e.g., freshwater juveniles, ocean juveniles, freshwater adults, etc.).

Dr. Greene provided an overview of the stoplight tables in development for the Klamath and Sacramento River fall-run Chinook stocks. Development of stoplight tables was motivated by the rebuilding plans developed in 2012-14 for both stocks. This stoplight table is very large and includes tens of indicators focusing on freshwater habitat (e.g., river temperature, river flow) and large-scale ocean indices (e.g., Pacific Decadal Oscillation [PDO]) which are thought to influence salmon survival and productivity. At present the developers are working on examining the correlations among their indicators to reduce redundancy and simplify the table. They are also developing a stoplight table for the Central Valley spring-run Chinook stock (ESA-listed as threatened).

Dr. Mantua described a second approach to developing a stoplight table for the Sacramento River Fall Chinook (SRFC) stock. This stoplight table is derived from an analysis by Friedman et al. (2019) and uses four indicators that were correlated with escapement to natural spawning areas for SRFC: 1) Natural area spawning escapement of the parent generation, 2) Fall (Oct-Dec) river temperatures during the egg incubation period, 3) February river flow during the juvenile period, and 4) an ocean predation index during the early marine period. This stoplight table is currently featured in the main text of the ESR. Since the publication of the Friedman paper, recent measures of the ocean predation index have not been available, suggesting this stoplight table may be modified in the near future. Dr. Mantua also discussed how the recent rapid rise in anchovy abundance presents an emerging challenge for the SRFC stock – it simultaneously provides abundant prey for Chinook salmon but appears to be a proximate cause for thiamine deficiency which may lead to reduced egg-to-fry survival.

Dr. Burke presented a summary of the ongoing challenges in developing and communicating the output from stoplight tables. Defining appropriate bins to define color schemes to convey information efficiently continues to be challenging. Most stoplight charts currently sort indicators into terciles (thirds; red, yellow, and green) but schemes using deviations from the long-term means (e.g., colors correspond to changes of 1 standard deviation or more from the mean) and therefore placing emphasis on extreme values were suggested as potentially preferable alternatives. The SSC-ES supports moving toward statistical approaches over quantiles, however typically reported summary statistics like a mean and variance may be less useful for indicators that are not normally distributed. Analysts should be cognizant of how candidate indicators are distributed, check assumptions of normality, and summary metrics with clear interpretations for other distributions may need to be explored. Dr. Burke also highlighted the potential for non-stationary relationships between the measured indicators and salmon stocks to cause difficulty for interpreting stoplight charts in a changing climate - what may have been a strong indicator historically may no longer be closely linked to stock performance – and discussed potential methods for accounting for non-stationarity.

The SSC-ES appreciates the work presented and supports the use of the stoplight charts for salmon stocks in the ESR. SSC-ES members highlighted that all the salmon stocks discussed had a substantial contribution from both natural-origin and hatchery components, and that these components may increasingly diverge in their response to environmental conditions (e.g., many SRFC hatchery fish are now transported to the San Francisco estuary and do not experience river conditions similar to natural-origin fish). This suggests distinct indicators for natural- and hatchery-origin stocks could be considered in the future. The SSC-ES agreed with the presenters' concerns about the potential for non-stationarity in indicators and suggested that regularly revisiting the indicators used for each stock may be an approach for identifying any non-stationarity.

A.3. Ecosystem indicator-based "outlooks" and next steps

The next section of the salmon indicators item was "Nonstationarity and Projections" presented by Drs. Correigh Greene (NWFSC) and Brian Burke (NWFSC). This presentation examined non-stationarity and its consequences for interpreting salmon indicators. Nonstationarity occurs when the statistical properties of a time-series change over time. The CCIEA team presented evidence for nonstationarity in relationships between some key drivers and salmon abundance, commercial harvest, and recruitment. There are multiple possible reasons for this, such as increasing climate variability, habitat loss, hydrologic changes, hatchery practices, introduction of new predators, and changes in harvest patterns could alter salmonid life cycle parameters.

The CCIEA team proposed three statistical models that can accommodate nonstationarity, a standard regression model, a dynamic linear model, and an autocorrelated error model, and showed how parameters in these models could be shifting over time. The CCIEA team further illustrated how forecast performance is better at a stock-specific level.

The SSC-ES and CCIEA team discussed how these analyses could contribute to the ESR and inform management. The current stoplight indicators are qualitative assessments that relate current conditions to the past years (e.g., is this year better or worse than previous years?). The stock-specific forecasting models are quantitative assessments with outputs that are similar to information produced for use in salmon stock assessment. The SSC-ES therefore recommends that the CCIEA team continue to work with the STT and other advisory bodies to minimize confusion about how these forecasts are interpreted and used. The CCIEA also indicated that a primary purpose of the forecast models is to validate stoplight indicators, not necessarily to forecast abundance next year. These models can identify cases where relationships among indicators and salmon metrics are changing (non-stationarity) and assess the relative importance of individual indicators.

Regarding the forecasting models, weighting more recent observations makes sense for short term forecasting, especially if there are concerns of nonstationarity. Over longer terms this may obscure long period cycles or structural breaks and introduce some risk of overfitting. Therefore, it is not clear that weighting the most recent relationship more highly would be preferable.

The SSC-ES noted that stoplight indicators could be used to develop risk tables to inform setting precautionary buffers into harvest control rules. The SSC-ES also recommends working closely with end users to identify how stoplights are used, or could be used, e.g., in alignment with the timeline of FEP initiative 2.1. The presentation of the stoplights (e.g., color choice) should then be tailored to enable end users to easily extract the information they need.

The CCIEA team expressed interest in convening a virtual workshop on the topic of salmon indicators in 2023 to further these discussions, particularly if FEP initiative 2.1 prioritizes salmon-focused activities. Potential workshop topics include next steps on many of the issues discussed at this meeting: prioritizing and improving salmon indicators and developing and testing more stock-specific stoplight tables and forecast models. The SSC-ES recommends that the CCIEA team work with relevant advisory bodies to prioritize topics. SSC members could participate in such a workshop, if supported by the Council.

B. Climate Change Appendix: Quantifying Forecasting Skill and Confidence, Standardizing Terminology

B.1. Overview and Physical Indices

The SSC-ES received a presentation on the climate change appendix to the ESR, with a focus on quantifying forecasting skill and confidence and standardizing terminology, from Drs. Andrew Leising (SWFSC), Desiree Tommasi (SWFSC) and Karma Norman (NWFSC). The climate change appendix was new to the ESR in 2022, and added to respond to a request by the Ecosystem Advisory Subpanel in March 2021 (Agenda item I.2.b, Supplemental EAS Report 1). Both the CCIEA team and the SSC-ES consider this discussion as the start of a multi-step process to develop this component of the report. Discussions focused on reviewing material from the March 2022 report and the development of terminology and potential tools to inform future iterations of the appendix.

Dr. Leising highlighted the value in tracking the effects of climate change to fisheries and marine ecosystems given the observed and projected changes in variables like sea surface temperatures. The CCIEA team has discussed the extent to which current indicators in the CCIEA annual report are sufficient and useful for tracking the effects of climate change, or whether there is need to develop new or different indicators as part of ongoing ecosystem initiatives or other activities. The CCIEA team is specifically seeking guidance on refining the potential scope and utility of the climate change appendix. The 2022 appendix included an overview of forecast scales to set context, and a review of associated terminology (e.g., hindcast versus reanalysis, prediction versus projection). The SSC-ES found the definitions accurate and useful. There was also discussion of how to assess the skill of both predictions and projections based on both retrospective forecasts, various model evaluation approaches, and the ability to quantify uncertainty.

Dr. Tommasi provided examples of skill assessments, such as one in which a seasonal global climate prediction was downscaled with a regional ocean model for the California Current. Forecast skill is generally assessed for anomalies around a climatological (average) seasonal cycle, and in this example, it was shown that the seasonal sea surface temperature (SST) cycle could be predicted well, but anomalies around the seasonal cycle, which are likely to be more helpful with respect to management, were more difficult to predict. When retrospective forecasts are available, quantitative evaluation of forecast skill for seasonal to decadal climate forecasts are possible. In contrast, longer-term climate projections are evaluated by looking at the uncertainty in the direction of change due to the forced climate signal across different types of uncertainty. In an evaluation of California Current model projections across climate models, radiative forcing scenarios, and ensemble members, it was found that for some model outputs (such as SST), scenario uncertainty is the dominant component, but in others (such as primary production) the climate model uncertainty is greater than the scenario uncertainty (Pozo-Buil et al. 2021).

Dr. Tommasi then presented and described an Intergovernmental Panel on Climate Change (IPCC) matrix used to summarize uncertainty and confidence in projection results, based on the interactions between evidence for a given change or model outcome, and the level of agreement among models for a given change or outcome. Essentially, there is the least confidence in outcomes with limited evidence and low model agreement, and the greatest confidence in outcomes with robust evidence and high model agreement. Based on this matrix and approach, the level of confidence in projections for different types of indices can be characterized. The CCIEA team intends to use this confidence scale in evaluating information that will be provided in upcoming reports and framing discussions with advisory bodies to develop future products. The SSC-ES is supportive of this approach to characterize and communicate confidence in future projections in ways consistent with the IPCC.

One example presented as an application of model evaluation of climate projections was a comparison of three recent studies focused on the subpopulation of Pacific sardine (Fiechter et al, 2021, Koenigstein et al., in press, Smith et al. 2021). There was high confidence across the three modeling approaches in projected northward distributional shifts and in a decline in the fraction of landings in California relative to the Pacific Northwest, but low confidence in landings trends more generally. Although the southern subpopulation of Pacific Sardine was not explicitly included in this evaluation, the SSC-ES discussed how these results would also speak to the value of considering management of the southern subpopulation to also be a high priority in the face of future climate change.

B.2. Biological and Ecological Indices

Dr. Andrew Leising (SWFSC) described oceanographic modeling products that are available to support predictions and projections of biological and ecological indices. He described examples of near-term predictions that depend upon Regional Ocean Modeling System (ROMS) and long-term projections that use ROMS outputs from downscaled climate models. Of note is that many of the ROMS used to date are academic products that depend upon continuing funding if they are to continue to be used as the basis of operational ecological predictions.

Examples of near-term ROMS predictions are the West Coast Ocean Forecast System (WCOFS), a high resolution NOAA product that predicts ocean conditions at short-term time scales (days), and the Joint Institute for the Study of the Atmosphere and Ocean (JISAO) Seasonal Coastal Ocean Prediction of the Ecosystem (J-SCOPE), which is coupled with a Nitrogen-Phytoplankton-Zooplankton-Detritus (NPZD) model and predicts ocean conditions from days to months ahead. The WCOFS product has supported efforts to predict and reduce whale entanglements and the J-SCOPE product supports predictions of sardine and Pacific hake distributions.

Long-term physical oceanographic model projections for capturing statistical properties of time series were also discussed, e.g., SST in the California Current System, and the use of ensembles of multiple model runs for capturing future uncertainty in physical projections. Long-term projection studies can use historical fits to data to capture the statistical properties of time series, then project forward to look at how these statistical properties may change in the future. Linking climate projections to mechanistic processes, e.g., metabolic indices, can be used to identify how species distributions may shift due to climate change impacts.

Species Distribution Model (SDM) analyses may need to be completed across a range of spatial scales to better understand changes in species distributions, to derive environmental niches, e.g., temperature preferences, and to couple with climate projections to better understand how the long-term statistics of species distributions may change (e.g., Liu et al. in prep.). A recent analysis using petrale sole survey data found that the choice of spatial scale impacted projection results from a SDM. Specifically, the center of gravity estimated for petrale sole on a coast-wide basis did not show a lot of change (Barnett et al. 2021), while individual regions show different patterns (see eric-ward.shinyapps.io/wcbts). SDMs for coastal pelagic species hosted on the scientific data server ERDDAP show maps of predicted habitat over the historical period that also allow for showing changes at a specific location. Looking at future habitat projections using general circulation models (GCMs) for species like sardine, North Pacific albacore, and highly migratory species can show how available habitat may change at long time scales.

The SSC-ES discussed the potential for standardizing the use of terminology like prediction, forecast, and projection across different types of science products used by the PFMC. For example, clarifying how these terms are used in stock assessments and unifying the usage of terms across stock assessments and ocean models would be helpful. It was noted that assessment predictions are forced by the catch and consider uncertainty in ecosystem state, and like decadal climate predictions, are dependent on both initial conditions and external forcing (e.g., a catch scenario). A forthcoming paper from the Future Seas project (Smith et al. in review) may aid in convergence on term usage.

B.3. Human and Social Indices

Dr. Karma Norman (NWFSC) presented an example of a human dimension index and analysis done with Dr. Cameron Speir (SWFSC) and others that might be included in the Climate Appendix or a future climate change report. The research was undertaken to advance the human dimensions component of the CCIEA with a focus on resilience at the port level. The researchers looked at different types/definitions of resilience and chose to focus on the capacity of a community to "bounce back" from a shock. The example discusses a method to assess community resilience to climate shocks as well as policy changes. This analysis was not designed to provide a time-series indicator that would be updated regularly in an annual report, but it does have relevance to understanding impacts of climate change and climate variability on communities and is the kind of analysis that might feature in a climate research report.

The specific measure the researchers evaluated is a "Relative Stability Index" which measures how a port's or group of ports' shares of coast-wide revenue changes in response to a shock. The premise is that ports whose revenues are less impacted relative to other ports may be considered more resilient. The analysis considers ecological shocks related to climate events (e.g., El Niño) and policy shocks (e.g., fishery closures, vessel buyback, major management actions) and evaluates relative stability of revenue of specific ports to these shocks. The relative stability index metric can be positive even if there was a loss in revenue if the port's share of coast wide revenues grew although total coast wide revenues fell. The focus is on change in share of revenue vs. absolute change because it is thought that this is a better measure or resilience – how well is a community able to mitigate or mediate the shock rather than how big the shock is in an absolute sense.

The analysis found that resilience to the marine heat wave shock was different than prior El Niño shocks because the heat wave heavily impacted crab fisheries in California through a harmful algal bloom event. Different responses to El Niño shocks over time for different ports may relate to changes in reliance on stocks impacted by El Niño. This suggests that resilience (in terms of relative revenue stability) may not be a very general characteristic of a community but rather it may depend on what fisheries are affected by a particular shock and how. This raises the question of whether there are measures of resilience that are more general or whether we really need to think about resilience in the context of individual fisheries and how resilient communities are to shocks to those fisheries.

B.4. Summary guidance and next steps

The SSC-ES recommends that the CCIEA team continue to work with the Council and its advisory bodies to refine the purpose and structure of the Climate Change Appendix. The SSC-ES and CCIEA team discussed several potential ways forward and agreed that input from other advisory bodies is needed. The SSC-ES suggests that combining information on near-term predictions and long-term projections in the same report may be confusing to users because confidence and skill of those products may be different even for the same indicator (e.g., temperature). Therefore, the SSC-ES recommends separating near-term predictions and long-term projections into two separate reports or chapters of the ESR. Moreover, near-term forecasts and long-term projections would likely be most useful to two different types of decisions, such that the PFMC and CCIEA team will need to work together to draw distinctions between current ecosystem indicators that are updated annually for current decision making versus what is useful for longer term strategic questions of interest to the PFMC. The SSC-ES supports the idea of splitting the Climate Change Appendix into two products, one that provides long-term projections as a separate report that would be provided periodically, and a second that provides near-term predictions in an extension of the current ESR. The SSC-ES discussed the increased workload implications of separating climate prediction and projection products for the PFMC, both for the review by the SSC and the substantial increase in workload for the CCIEA team. The CCIEA team identified that their current resources are insufficient to produce a new separate climate change report focusing on long-term projections.

The SSC-ES and CCIEA team discussed the potential utility of a report focusing on exclusively long-term projections of ecosystem conditions for PFMC planning and decision-making. One specific use may be to help inform groundfish stock definition discussions. A report focused on long-term projections could also inform follow-up discussions from the Climate and Communities Initiative, and the outstanding list of tasks identified by the Ecosystem Working Group (EWG) in September 2022 (Agenda Item C.8.a EWG Supplemental Report 1). The SSC-ES discussed that a report focused on long-term projections would not need to be updated or reviewed as frequently as the annual ESR. Instead, it could be updated upon the publication of new IPCC reports and modeling frameworks. However, at this time it is unclear who would be responsible for creating and updating a long-term climate projections report, as current CCIEA team resources are not sufficient to support such an effort. The SSC-ES suggests that if a separate climate change report focusing on long-term projections is developed, the PFMC would need to work with the CCIEA team to establish an appropriate process for reviewing and updating it.

The SSC-ES suggests that the development of short-term predictions may be most usefully focused on those indicators that are most relevant for tactical decision making. Again, such ecological predictions are dependent upon continued funding of the currently used ROMS outputs as NOAA does not yet have an operational seasonal forecast system for the entire California Current. The SSC-ES discussed that J-SCOPE and some derived products were previously reviewed by the SSC-ES and characterized as promising seasonal forecasting approaches. Future research application and skill assessment of J-SCOPE will require identification and prioritization of individual species and their covariates. Thus, the PFMC needs to identify species and management issues that are the most critical needs prior to being able to evaluate if the J-SCOPE ocean model is skillful for near term predictions. The SSC-ES supports using the FEP 2.1 initiative process for identifying and incorporating near-term predictions that are more focused on individual species or FMPs into PFMC advice.

The SSC-ES agreed that the PFMC and CCIEA team should work together to prioritize which species should be the focus of future research using climate-forced SDMs and that the PFMC and its advisory bodies should contribute to guidance on what would be useful for decision making. One option suggested was to prioritize development of SDM projections on species showing extreme changes or differing trends in species distributions or abundance trends, both increasing and decreasing, across regions.

The SSC-ES agreed that it would be appropriate for the CCIEA team to expand and incrementally update the Climate Change Appendix for the March 2023 briefing book. Simple examples of current capabilities could be included in the 2023 report even though the SSC will not yet have reviewed these in detail. For example, the CCIEA team proposed adding projections from some SDMs that use the sdmTMB (species distribution model in Template Model Builder) tool that was recently approved via SSC groundfish methodology review. Applications of this tool to survey data would be reasonable to include. The SSC-ES supports the CCIEA team's proposed meetings with PFMC advisory bodies in March 2023 so that the CCIEA team can continue conversations about the Climate Change Appendix by presenting material that advances incrementally on last year's report.

Relevant to the salmon indicators and the Climate Change Appendix, the SSC-ES appreciates the adaptability of the CCIEA team and recommends continuing to leave space in the report for emergent hot topics or recently completed research updates. As the suite of indicators continues to be evaluated and some indicators are shifted to appendices or the online data portal, more space could be created in the main report or in a "hot topics" appendix. For example, some human dimensions research topics may not be suitable for development into indicators that are annually updated but could still be included in the ESR report in more flexible sections. Thiamine deficiency in juvenile salmon is one emergent topic that has been discussed in the ESR in recent years. Another example is the marine heat wave time series that was recently added to the report. The SSC-ES supports maintaining flexibility in the ESR for the CCIEA team to respond to emergent issues in the ecosystem.

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Appendix A. Meeting Participants

SSC Ecosystem Subcommittee Members Present

Dr. John Field, National Marine Fisheries Service Southwest Fisheries Science Center, Santa Cruz, CA

Dr. Melissa Haltuch, National Marine Fisheries Service Northwest Fisheries Science Center, Seattle, WA

Dr. Dan Holland, National Marine Fisheries Service Northwest Fisheries Science Center, Seattle, WA

Dr. Galen Johnson, SSC Chair, Northwest Indian Fisheries Commission, Olympia, WA

Dr. Kristin Marshall, Chair, National Marine Fisheries Service Northwest Fisheries Science Center, Seattle, WA

Dr. André Punt, University of Washington, Seattle, WA

Dr. William Satterthwaite, National Marine Fisheries Service Southwest Fisheries Science Center, Santa Cruz, CA

Dr. Ole Shelton, National Marine Fisheries Service Northwest Fisheries Science Center, Seattle, WA

Dr. Cameron Speir, National Marine Fisheries Service Southwest Fisheries Science Center, Santa Cruz, CA

Dr. Tien-Shui Tsou, Washington Department of Fish and Wildlife, Olympia, WA

CCIEA Team Members Present

Dr. Brian Burke, National Marine Fisheries Service Northwest Fisheries Science Center, Seattle, WA

Dr. Toby Garfield, National Marine Fisheries Service Southwest Fisheries Science Center, La Jolla, CA

Dr. Chris Harvey, National Marine Fisheries Service Northwest Fisheries Science Center, Seattle, WA

Dr. Elliot Hazen, National Marine Fisheries Service Southwest Fisheries Science Center, La Jolla, CA

Dr. Mary Hunsicker, National Marine Fisheries Service Northwest Fisheries Science Center, Seattle, WA

Dr. Mike Jacox, National Marine Fisheries Service Southwest Fisheries Science Center, Monterey, CA

Dr. Isaac Kaplan, National Marine Fisheries Service Northwest Fisheries Science Center, Seattle, WA

Dr. Andrew Leising, National Marine Fisheries Service Southwest Fisheries Science Center, La Jolla, CA

Dr. Nate Mantua, National Marine Fisheries Service Southwest Fisheries Science Center, Santa Cruz, CA

Dr. Karma Norman, National Marine Fisheries Service Northwest Fisheries Science Center, Seattle, WA

Dr. Jameal Samhouri, National Marine Fisheries Service Northwest Fisheries Science Center, Seattle, WA

Dr. Desiree Tommasi, National Marine Fisheries Service Southwest Fisheries Science Center, La Jolla, CA

Others Present

Mr. Kelly Andrews, National Marine Fisheries Service Northwest Fisheries Science Center, Seattle, WA
Ms. Yvonne de Reynier, National Marine Fisheries Service West Coast Region, Seattle, WA
Mr. John DeVore, Pacific Fishery Management Council, Portland, OR
Ms. Robin Ehlke, Pacific Fishery Management Council, Portland, OR
Dr. Mark Fina, California Wetfish Producers Association, Buellton, CA
Dr. Correigh Greene, National Marine Fisheries Service Northwest Fisheries Science Center, Seattle, WA
Mr. Steve Haeseker, U.S. Fish and Wildlife Service, Vancouver, WA
Mr. Christian Heath, Oregon Department of Fish and Wildlife, Newport, OR
Ms. Liz Hellmers, California Department of Fish and Wildlife, La Jolla, CA
Ms. Lisa Hillier, Washington Department of Fish and Wildlife, Olympia, WA
Dr. Owen Liu, National Marine Fisheries Service Northwest Fisheries Science Center, Seattle, WA
Dr. Tommy Moore, Northwest Indian Fisheries Commission, Olympia, WA
Mr. Brandon Muffley, Mid-Atlantic Fishery Management Council, Dover, DE
Dr. Stu Munsch, National Marine Fisheries Service Northwest Fisheries Science Center, Seattle, WA
Mr. Corey Niles, Washington Department of Fish and Wildlife, Olympia, WA
Dr. Michael O'Farrell, National Marine Fisheries Service Southwest Fisheries Science Center, Santa Cruz, CA
Ms. Shannon Penna, National Marine Fisheries Service West Coast Region, Long Beach, CA
Ms. Corey Ridings, Ocean Conservancy, Santa Cruz, CA
Ms. Whitney Roberts, Washington Department of Fish and Wildlife, Olympia, WA
Dr. Tanya Rogers, National Marine Fisheries Service Southwest Fisheries Science Center, La Jolla, CA
Mr. Kyle Van der Graaf, Washington Department of Fish and Wildlife, Olympia, WA
Mr. Greg Williams, National Marine Fisheries Service Northwest Fisheries Science Center, Seattle, WA
Ms. Deb Wilson-Vandenburg, California Department of Fish and Wildlife, Monterey, CA
Dr. Eric Ward, National Marine Fisheries Service Northwest Fisheries Science Center, Seattle, WA

SSC Recusals for this Meeting		
SSC Member	**Issue**	**Reason**
Dr. Dan Holland	B.3. Human and Social Indices	Dr. Holland is Dr. Karma Norman’s supervisor.
Dr. Cameron Speir	B.3. Human and Social Indices	Dr. Speir is co-author for one of Dr. Karma Norman’s presented journal articles.