SCIENTIFIC AND STATISTICAL COMMITTEE REPORT ON CALIFORNIA CURRENT ECOSYSTEM AND INTEGRATED ECOSYSTEM ASSESSMENT (IEA) REPORT AND SCIENCE REVIEW TOPICS

The Scientific and Statistical Committee (SSC) received a presentation by Drs. Chris Harvey (Northwest Fisheries Science Center) and Toby Garfield (Southwest Fisheries Science Center) on the 2019 California Current Integrated Ecosystem Assessment (CCIEA) California Current Ecosystem Status Report (Agenda Item E.1.a, IEA Team Report 1, March 2019). The report is a concise source of information on trends in climate and oceanographic, biological, social, and economic indicators. It continues to be an important contribution to the Council process that provides an ecosystem perspective on West Coast fish stocks, fisheries, and coastal communities.

The SSC appreciates the CCIEA team's continued responsiveness to suggestions by the Council and SSC on previous reports and continuing efforts to augment and improve the Status Report with additional information useful to the Council. The 2019 Status Report includes several new indicators and analyses that were reviewed by the SSC Ecosystem Subcommittee (SSCES) in September 2018 including: a new statistical approach to analyze forage time series and improve comparability between regions (section 4.2); an analysis of shifts in availability of petrale sole and sablefish to four major ports (section 6.3); and the seasonal forecasts of ocean conditions off Washington and Oregon (Section 7.2). Other new additions include: an indicator of the occurrence of harmful algal blooms (section 3.2) and a time series of krill length off of Trinidad Head in northern California (section 4.1). There are also a number of new additions in the Supplementary Materials (Agenda Item E.1.a, IEA Team Report 2, March 2019). The CCIEA team was not able to address some additional requests due to the partial government shutdown; however, the SSC commends the team's efforts to provide the report in a timely manner allowing time for review despite the shutdown.

For the first time there are numerical forecasts of salmon returns included in the Status Report (Figures H.3.1 and H.3.2 in the Supplementary Materials). These forecasts are not comparable to the forecasts used by the Salmon Technical Team (STT) for salmon management. The SSC will work with the CCIEA team to review these forecasts and determine how best to communicate this information in future CCIEA reports.

The SSCES has regularly met with members of the CCIEA prior to the September Council meeting to review selected indicators proposed for inclusion in the annual ecosystem Status Report. A report on the September 2018 SSCES review of new CCIEA topics is attached to this statement as supplementary information. The four topics reviewed were all included in the 2019 Status Report. An additional indicator of the distribution and availability of Albacore in the California Current had been scheduled for joint review by the SSCES and the SSC Highly Migratory Species (HMS) subcommittee in a webinar in January, but the review was not completed and will need to be rescheduled due to the partial government shutdown.

In March 2018 the EWG recommended the SSCES consider holding future reviews of new CCIEA topics on a biennial basis in even years because of the large workload reviewing groundfish assessment in odd years. However, the SSCES is no longer constrained by a conflict with a SSC

Groundfish Subcommittee meeting which has been moved to August. The IEA continues to evolve rapidly and new indicators and analyses may benefit from timely feedback. The SSC therefore recommends that it continue to evaluate requests for reviews from the CCIEA team annually in March and schedule reviews at SSCES meetings the following September if needed.

The CCIEA team has proposed one potential topic for review in September 2019 - Spatial indicators of bottom contact by trawl gear and fixed gear. The SSC agrees this would a useful topic to review in September. The SSCES needs to reschedule the review of the Albacore distribution and availability forecasts, and this could be included in the September meeting rather than rescheduling it as a webinar. As noted above, the SSCES also proposes reviewing the salmon forecasts and the stoplight indicators that were presented in the Supplementary Materials. Since the review of the albacore topic was to be done jointly with the SSC Highly Migratory Species subcommittee, and the review of salmon forecasts would benefit from joint review with the SSC Salmon Subcommittee, it may be necessary to hold at least part of the September SSCES subcommittee meeting jointly with these other subcommittees.

PFMC
03/07/19*

Scientific and Statistical Committee Ecosystem Subcommittee (SSCES)

Cascade 11 Room
Doubletree by Hilton Hotel Seattle Airport
18740 International Blvd. Seattle 98118

Members in Attendance

Dr. Evelyn Brown, Lummi Nation, Bellingham, WA
Dr. John Field, SSC Chair, National Marine Fisheries Service, Southwest Fisheries Science Center, Santa Cruz, CA
Dr. Michael Harte, Oregon State University, Corvallis, OR
Dr. Dan Holland, (SSCES Chair), National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, WA
Dr. Galen Johnson, Northwest Indian Fisheries Commission, Olympia, 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
Dr. Aaron Berger, National Marine Fisheries Service, Northwest Fisheries Science Center, Newport, OR (Dr. Berger is an SSC but not SSC ES member)

Members Absent

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

SSC Recusals for the September 2018 Ecosystem Subcommittee Meeting		
SSC Member	**Issue**	**Reason**
Dan Holland	Recreational Fishery Engagement	Supervisor
Ole Shelton	Shifts in Groundfish Dist.	Co-author
John Field	Forage Composition Indicator	Co-author

A. Call to Order

The SSCES Chair, Dr. Dan Holland, called the meeting to order at 8 a.m. The agenda was approved and rapporteur duties assigned. Three recusals were noted (see table above).

Chris Harvey gave an introduction with an overview of the talks and the purpose of getting SSC review of the new potential indicators. He noted that the CCIEA strives to include in the report to the Council the highest priority indicators that are statistically robust and theoretically and mechanistically appropriate, and that the team values the feedback of the SSC ES in improving the methods and presentation of the indicators.

B. Using the J-SCOPE Approach for Short-Term Forecasts of Ocean Conditions and Species Distribution *(rapporteur Galen Johnson)*

Drs. Samantha Siedlecki (University of Connecticut) and Isaac Kaplan (NWFSC) presented their work on seasonal forecasts of physical and biogeochemical attributes of the northern California Current using the JSIAO's Seasonal Coastal Ocean Prediction of the Ecosystem (J-SCOPE) and their efforts to link those attributes to fisheries management questions. Seasonal forecasting for this discussion referred to forecasts on the scale of weeks to months. In terms of both performance and predictability, J-SCOPE is more successful in terms of prediction skill in the northern portion of the California Current System, and for the middle and the bottom of the water column compared to the surface. Although the downscaled product has only been used to forecast forward from January and April, forecasts could be made starting in any month. J-SCOPE outputs can be tailored to relevant spatial and temporal scales for different uses.

J-SCOPE produces forecasts of attributes such as temperature, oxygen, pH, aragonite saturation state, and upwelling that could be included in the CCIEA, where presently only the history and current state of those attributes is reported to the Council. Forecasts of PDO and ENSO are also available from other programs, and should also be considered if the IEA is expanded to include forecasts. The J-SCOPE products could also cover a larger spatial scale than some of the ecosystem attributes currently presented to the Council that are often limited to one or a few sites (e.g. the Newport Line).

Currently, J-SCOPE is being explored for use in a number of fisheries management applications including sardines, hake, and Dungeness crab. For sardines, a general additive model using temperature and salinity can be used to predict potential sardine habitat. When J-SCOPE forecasts were used to forecast sardine presence/absence for 2013 and 2014, they had high predictive ability (AUC 0.86 and 0.97, respectively).

Predictions could be helpful for fisheries management on large-scale questions such as whether the sardine population might straddle international borders in a given year. In an ongoing project, J-SCOPE output is being used along with information on hake spatial distribution, biomass and age distribution to better understand what drives the northern migration of hake in the summer. Preliminary results suggest non-stationary temperature effects, with anomalously warm water in the north correlated with more hake/greater hake biomass in the north and anomalously warm water in the south correlated with fewer hake/lower hake biomass in the south. A potential application of this work may be a better understanding of the core hake area, which could guide improvement of survey design. Results can also help the fishing community identify areas of potentially higher hake density.

JSCOPE has potential utility as a tool to help WDFW, ODFW, and the Quinault Indian Nation manage their Dungeness crab fisheries. In the summer, forecasts of bottom oxygen can be used to modify soak times of gear or institute area closures or pulling of gear to lessen or avoid the effects of hypoxia. Ongoing work is investigating the effect of factors such as bottom temperature and pH on catch rates, to help with timing of fishery openings.

The SSCES supports the exploration of the utility of the J-SCOPE forecasts for informing fishery management, especially in the areas in which J-SCOPE currently has the best performance and predictability—namely, the northern portion of the CCE and at depth. If forecasts are to be added to the CCIEA report presented to the Council in March of each year, the SSCES suggests a focus on areas with the best performance and predictability. It may be possible to communicate some forecast information in the text rather than in figures. Forecasts should be given at the spatial scale of most interest to fishery managers, which may vary by factor and species of interest. The SSCES recommends that the investigators work with different management teams to fit the forecasts of physical and biogeochemical factors in the CCIEA to what is needed by the Council. In response to questions from the presenters regarding other species to recommend for study, the SSCES mentioned: (1) pink shrimp as a good match for responsiveness to high-performance/good predictability factors; (2) forecasts of salmon distributions to aid avoidance of salmon bycatch in groundfish fisheries (especially hake and midwater trawl rockfish); (3) forecasts of anchovy distribution; and (4) forecasts of albacore distribution and availability. It was noted that forecasts of anchovy and albacore might present difficulties for J-SCOPE given its weak predictive ability for surface water, and in Southern areas. The SSCES also supported ongoing work by the team to explore historical data as well as looking forward. As this work develops, it has potential to provide the Council a basis for using not just current oceanographic conditions but also seasonal forecasts in making management decisions**.**

C. Community-level recreational fishery engagement and reliance indices *(rapporteur Michael Harte)*

Dr. Karma Norman (NOAA NWFSC) and Dr. Anna Varney (Pacific States Marine Fisheries Commission) presented to the SSCES on Coastal Community Recreational Fishing Indices for the CCIEA. These indices link place-based communities to recreational fishing and complement existing community level commercial fishing indices using similar Community Social Vulnerability Index (CSVI) methods. Indices of fishery dependence and community vulnerability support reporting against National Standard 8 and can be used to track community and ecosystem changes over time.

The SSCES view the recreational fishing indices as providing a comparable level of information to commercial fishing indices although they rely on different types of data. Together the commercial and recreational community indices provide a more complete picture of community fishery dependence and social vulnerability. The subcommittee provided feedback to the presenters with respect to data issues, interpretation of findings and additional analyses likely to be useful in Council processes.

The recreational fishery indices do not utilize data on recreational landings or angler effort because comparable data at the appropriate scale cannot to obtained for all states covered by the indicator (CA, WA, OR). Analysts were not able to obtain RecFIN data on recreational catch and effort in California. The data exists, but there remain administrative issues preventing its use by the CCIEA team. There may also be issues with the sampling design in California that constrain the ability to use the data at the community spatial scale required by the CCIEA team to construct indicators. The SSCES recommends that the CCIEA team and Council staff work with California and the RecFIN Technical Committee to investigate further whether California RecFIN data can be obtained and used, perhaps at a coarser scale. It was also noted that there may be potential problems with charter boat effort data for Puget Sound since this data is not available in RecFIN. It was unclear to the SSCES how this issue was addressed in recreational community indices for Washington. The SSCES also suggested that recreational fisheries for shellfish should be included in recreational fishing indices since these are important recreational fisheries in the Northwest.

The SSCES and analysts also discussed the appropriate spatial scale of the indicators. One issue is that small "inland" communities such as Elkton OR and Glide OR were scored as having a high reliance on recreational fishing. Data sources used to construct the recreational dependence and reliance indices do not distinguish between marine and non-marine species, therefore, high dependence or reliance values may reflect the level of fishing for steelhead, salmon and other anadromous species. The SSCES notes that these values may be best presented as a map, rather than a table, to make this issue clear.

The SSCES discussed alternative spatial scales for analyzing recreational fishing community indices. One alternative discussed was to use IOPAC port groupings. These groupings are based on economic linkages and could help overcome issues associated with: the high number of reliant communities; the inclusion of inland communities; and the unavailability of port-level data for California communities. If this approach is taken, analysts may wish to consider using additional variables, such as catch and effort, available at coarser scales. These analyses would complement the finer scale analysis rather than replace it, providing the Council with additional mesoscale measures of recreational engagement and reliance. Finally, the SSCES noted that the recreational community indices had potential utility for the Climate and Communities Initiative.

How best to convey to audiences that the scores are relative indices based on transformed data was discussed. The indices do not provide absolute measures of recreational engagement, providing only ordinal rankings of communities. The SSCES discussed how the factors scores were ranked and whether there were other ways of representing the data. Currently, the factor scores ranked as high (> 1.00 Standard Deviation (SD)), moderate (.500-.999 SD) and low (<.500 SD). Exploring the distribution of factor scores further may show other potential breakpoints (potentially arising from a non-normal distribution in factor scores) that are less arbitrary.

D. Developing Effective Indicators of Shifts in Groundfish Distributions *(rapporteur Ole Shelton)*

Dr. Jim Thorson (AFSC) and Dr. Eric Ward (NWFSC) presented methods and applications of spatial-temporal statistical approaches for assessing the abundance and distribution of marine species. Dr. Thorson present the underlying statistical approach as implemented in the R package *VAST* (Vector Autoregressive Spatio-Temporal model) and some example results from spatial-temporal datasets including the CALCOFI larval surveys, groundfish surveys in the Bering Sea, and west coast groundfish trawl surveys. *VAST* provides an efficient factor analysis approach for estimating spatial-temporal models for abundance or biomass. *VAST* includes diagnostic templates (e.g., observed-predicted plots, spatial residuals) and a variety of model outputs including estimated spatial and spatial-temporal fields (estimated for each factor with associated species-specific loadings), derived estimates of spatial and spatial-temporal covariation among different species. These outputs can be used to generate spatial projections of species abundance and biomass for each species of interest. The SSCES engaged in a wide-ranging discussion of potential applications and limitations of these methods, noting that the package is already used to develop relative abundance indices from the NWFSC bottom trawl survey to inform groundfish stock assessments.

The SSCES supports the continued development of spatial-temporal statistical models for a wide range of applications. From an ecosystem perspective, these methods can be useful for (*1*) examining distributional shifts of groundfish species including both the identification of hotspots and large-scale biogeographic shifts and (*2*) developing spatial indicators of the availability of certain species or species groups to particular ports. Achieving both of these goals would require post-processing of current *VAST* outputs.

The SSCES encourages additional l areas of inquiry likely to be valuable. First, the SSCES suggest that intuition and interpretation of results might be improved by incorporating environmental covariates into the statistical models rather than relying solely on interpretation of spatial fields. Second, there were questions about the ability of these model types to address management relevant spatial questions – most notably issues surrounding identifying the spatial location and causes of local depletion of particular species.

This work has the potential to help improve ecosystem indicators by providing methods that can be used to generate spatially explicit indicators for a range of groundfish species and other species for which there is appropriate, spatially explicit data.

E. Development of a New Forage Community Composition Indicator *(rapporteur Will Satterthwaite)*

Dr. Andrew Thompson (SWFSC) presented on work describing the status and trends of the pelagic forage community in the California Current Large Marine Ecosystem to the SSCES. This work was also described in a draft manuscript distributed to the SSC in advance of the meeting. The work presented here was an attempt to synthesize information on forage species abundance across disparate datasets based on different sampling techniques: the NWFSC juvenile salmon trawl which samples the upper 20m of the water column during the day off Oregon and Washington, the SWFSC midwater trawl which samples at night at a depth of 30m off central California, and larval fish bongo tows from CalCOFI sampling off southern California (depth-integrated from 200m to the surface, collected day and night). Data on krill were excluded from all regions because they were likely poorly sampled, and data on species exhibiting strong diel vertical migrations (defined here as sardine, anchovy, and sanddabs) were excluded from the NWFSC survey which occurred near the water surface during the day. For all surveys, at each location, raw species counts were standardized by effort, log transformed, and an annual mean was calculated (with rare species excluded)

using a delta model implemented via the delta.dist function in the R package Fishmethods. These analyses implicitly assume constant gear selectivity within each region. This assumption is important, but may be justifiable because gear type remained constant within each region, and a consistent sampling frame was considered across years for each region. The work presented was intended to address earlier concerns raised by the SSC and others regarding differences in the sampling programs and regions for forage indicators reported in earlier IEA ecosystem status reports.

To synthesize dynamics in these region-specific annual mean abundance estimates, Dr. Thompson and his colleagues used a variety of multivariate statistical techniques to 1) define when assemblages change (using chronological clustering based on Bray-Curtis dissimilarity matrices among years), 2) identify groups of species that tend to fluctuate together (using hierarchical clustering based on Bray-Curtis dissimilarity matrices among species), 3) visualize these groupings (via heat maps of z-scores in relative abundance), and 4) identify years with similar species composition (using non metric multidimensional scaling). In general, pelagic species tended to vary together (with adult sardine and anchovy somewhat distinct from mesopelagics), as did benthic species (as indicated by pelagic early life history stages, such as larvae or pelagic juveniles).

To examine synchrony across regions, the analysts evaluated correlations among regions in the Bray-Curtis dissimilarity matrices calculated within each region across years (using Mantel tests) and calculated correlations across regions in the abundances of selected individual species. The Mantel tests indicated generally synchronous changes in assemblages across regions, although individual species tended not to be closely correlated across regions.

Results indicate that there are common trends in the forage assemblages across regions over time, implying a common forcing mechanism, despite some differences at the individual species levels (for trends) and differences in the life history stages sampled. The SSC found this conclusion sound, although caution is needed in extrapolating these results beyond the spatial areas covered by the core areas of the respective surveys. The SSC noted methodological modifications, additions, or refinements to consider:

- Applying a log(n+1) transformation to the data is not necessary since a delta model is used later.
- Alternative distributional assumptions, such as a zero-inflated negative binomial, may be more appropriate.
- Multivariate generalized linear models may be less likely to confound location and dispersion effects than distance-based multivariate analyses such as those used here (Warton et al. 2012, Methods in Ecology and Evolution 3:89-101).
- Dynamic Factor Analysis (DFA) is an alternative method that is increasingly used to characterize synchrony and attempt to identify its drivers. Dr. Thompson noted that attempts to apply DFA to these data have been made, and tended to yield similar insights, but encountered convergence problems.
- VAST also provides tools to do this sort of analysis (see also agenda item D), but no attempt has been made to apply VAST to these data.

The next step in making these analyses useful to the Council will be developing ways of distilling the extensive outputs provided here into a few easily understood indices suitable for presentation in the annual CCIEA report on the State of the California Current Ecosystem. There was general agreement that heat maps of annual relative abundance, with species sorted vertically based on synchrony in their dynamics,

would be the easiest to interpret for a broad audience. Further consideration is warranted on whether clustering is best illustrated through branching diagrams in the figure margins, lines through the heat maps at breakpoints, and/or color coding.

Dr. Thompson presented briefly on attempts to link changes in forage assemblage to hypothesized basin wide (PDO/NPGO) or regional (upwelling) level drivers by calculating Euclidean dissimilarity matrices among years in the hypothesized basin- or regional-scale drivers and performing Mantel tests with the abundance dissimilarity matrices. There appeared to be significant basin-scale correlations but not regional-scale correlations. These suggest changes in forage assemblages concomitant with basin-scale changes from El Nino to La Nina conditions. The SSCES did not discuss these results in detail.

Finally, Dr. Thompson presented attempts to link the diet composition of San Miguel Island sea lions (inferred from otoliths in scat) to regional forage abundance, using redundancy analysis (constrained ordination combined with model selection via permutation-based pseudo-AIC values). The most parsimonious models of diet composition for these sea lions included sardine and anchovy abundance measures from southern California as well as market squid abundance measures from central California. The mechanistic interpretation of increasing sardine and anchovy in diets when these species are locally abundant is straightforward, interpreting the modeled effect of central California market squid abundance is more nuanced but likely reflects sea lions taking longer trips to target market squid when sardine and anchovy are locally scarce. It is important to realize that these results should not be extrapolated to sea lions in other regions, and in may not be suitable for application to other predators that are not central-place foragers.

References

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