ECOSYSTEM SCIENCE TOPICS PROPOSED FOR SCIENTIFIC AND STATISTICAL COMMITTEE REVIEW IN 2018

Topic: New upwelling indices for the US West Coast

Presenter: Dr. Michael Jacox, Southwest Fisheries Science Center

Justification: Wind-driven coastal upwelling is among the most important oceanographic processes for the California Current ecosystem. Spring/summer upwelling provides nutrients that fuel primary productivity, and it also has strong influence on water chemistry, water temperature, and other properties. The timing, intensity and duration of the upwelling season varies along the coast and from year to year, which necessitates effective regional indices of upwelling. To date, we have primarily used a Cumulative Upwelling Index (CUI), which tracks the cumulative volume of downwelled/upwelled water at a given coastal latitude over the course of a year. However, this index, based on the Bakun Upwelling Index and derived from atmospheric pressure fields estimated by the U.S. Navy Fleet Numerical Meteorological and Oceanographic Center, is unable to capture some of the dynamics that drive upwelling variability, and is less reliable in some regions of the coast such as the Southern California Bight, due to its south-facing shore and complex topography.

Upwelling is the primary driver of California Current productivity, and PFMC advisory bodies have specifically requested that the CCIEA team continue to report on upwelling and provide additional information on the role upwelling plays in other ecosystem dynamics (e.g., nutrient levels, ocean acidification, hypoxia, larval transport, heterogeneity of coastal temperatures, etc.). Thus, it is important that we provide an upwelling index that is informative, robust and accurate throughout the system. CCIEA team members are developing new upwelling indices that incorporate recent technological and scientific advances to address several shortcomings of the existing index. Specifically, the new indices (i) use data products that more accurately capture the magnitude and variability of winds along the West Coast, (ii) account for the influence of ocean circulation that can hinder or augment wind-driven upwelling, and (iii) provide information on not just the magnitude of upwelling but also the nutrient content of upwelled water, which can influence primary productivity independent of the upwelling strength.

The CCIEA team seeks SSC-ES input on the utility of these new indices to the PFMC and the desired form of presentation for the indices (e.g., spatial and temporal scales).

Background reading: TBD

Topic: Using the J-SCOPE approach for short-term forecasts of ocean conditions and species distribution

Presenters: Dr. Isaac Kaplan, Northwest Fisheries Science Center; Dr. Samantha Siedlecki, University of Connecticut

Justification: Understanding how seasonal and annual variations in ocean conditions affect the distribution of key species has been the focus of fisheries research in the California Current ecosystem for decades. The growing ability to make short-term forecasts of climate and weather patterns, coupled with regional downscaling methods and linkages between climate models and oceanographic models, means that we are on the cusp of skilled, short-term projections of the distribution and some biological or ecological dynamics of focal marine species. Such projections could be of great value to informed spatiotemporal management of fisheries in the California Current.

One of the most well-established tools for making short-term forecasts of ocean conditions and species distributions is J-SCOPE (JISAO's Seasonal Coastal Ocean Prediction of the Ecosystem), developed at the University of Washington Joint Institute for the Study of the Atmosphere and Ocean (JISAO) along with colleagues at several NOAA line offices and most recently at the University of Connecticut. The J-SCOPE model aims to provide experimental seasonal forecasts (6- to 9-month) of upper ocean properties, based on operational simulations by NOAA's Climate Forecast System (CFS) model, and dynamical downscaling with a high-resolution version of the Regional Ocean Model System (ROMS) that includes a state-of-the-art biogeochemical module. J-SCOPE provides forecasts of specific oceanic properties crucial to the nearshore and coastal marine ecosystem such as water temperature, upwelling, pH, and oxygen concentration. Forecasts are based on ensembles of three models, initialized in January and April, and autumn forecasts are also being developed. From the January and April projections, forecasts of sardine distributions have been developed, and ongoing work is focused on forecasts of Pacific hake distribution and Dungeness crab distribution and condition.

The CCIEA team seeks SSC-ES input on technical aspects of this model as well as advice on how its performance, value and model outputs might best be communicated to the Council for timely and effective use in management.

Background reading:

http://www.nanoos.org/products/j-scope/ (J-SCOPE forecasts and information)

Siedlecki, S.A., et al. 2016. Experiments with seasonal forecasts of ocean conditions for the northern region of the California Current upwelling system. *Scientific Reports* **6**(27203).

Kaplan, I.C., et al. 2016. Cloudy with a chance of sardines: forecasting sardine distributions using regional climate models. *Fisheries Oceanography* **25**:15-27.

Topic: Drivers of albacore distribution and availability to fisheries in the California Current

Presenter: Dr. Barbara Muhling, Southwest Fisheries Science Center

Justification: Annual indices of spawning stock biomass and recruitment for the entire North Pacific albacore stock are available through the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC), and were included in the CCIEA report for the first time this year. However, actual availability of this species to U.S. west coast fisheries may be more influenced by local environmental processes than overall stock productivity. Albacore catch rates and landings are highly variable from year to year, in terms of both total catch and where areas of highest catch are concentrated. California albacore landings have been very low since 2005, while catches off Oregon have been stable, and those off Washington have been increasing for the past 20 years. The mechanisms behind this variability are still not well understood. As a result, the capacity of fisheries targeting albacore to anticipate and adapt to environmentally driven shifts in albacore availability is limited.

Albacore are known to associate with frontal structures within a surface temperature range of ~10-20°C (Nieto et al., 2017). However, their distribution is likely also determined by abundance of prey such as anchovy, squid, saury and hake (Glaser et al., 2010). These forage species fluctuate strongly in abundance and distribution through time, which affects their availability to larger predators such as albacore. We are using a suite of distribution models to predict overall albacore habitat suitability in the California Current, incorporating both physical and biological drivers. This involves overlaying statistical Species Distribution Models for albacore from troll fishery data (modified from Nieto et al., 2017), with those of their main prey species (sourced from surveys, e.g. CalCOFI). Habitat suitability indices for albacore, and for their main prey species, will be calculated by averaging results for the south, central, and north U.S. California Current, and used to determine whether albacore availability is primarily determined by oceanographic structure, prey distributions, or a combination of both.

The CCIEA team seeks technical feedback from the SSC-ES on the best way to transition spatial habitat metrics to useful annual indicators, in addition to general review of the tools and analyses presented.

Background reading:

Glaser, S. M., 2010. Interdecadal variability in predator-prey interactions of juvenile North Pacific albacore in the California Current System. *Marine Ecology Progress Series* **414**:209-221.

Nieto, K., et al. 2017. How important are coastal fronts to albacore tuna (*Thunnus alalunga*) habitat in the Northeast Pacific Ocean? *Progress in Oceanography* **150**:62-71.

Topic: Developing effective indicators of shifts in groundfish distributions

Presenter: Dr. Jim Thorson, Alaska Fisheries Science Center

Justification: The CCIEA ecosystem status report presents relatively little novel information for groundfish. While the figure showing the overfished/overfishing status of groundfish stocks is broadly appreciated, it is nevertheless a compilation of stock assessment outputs, and contributes little if any information on how groundfish populations and ecology are affected by ecosystem processes at different spatiotemporal scales. The rich datasets provided by the SWFSC's Juvenile Rockfish Survey and the NWFSC's Groundfish Bottom Trawl Survey thus remain relatively underutilized in the CCIEA indicator portfolio and in our more integrative analyses.

A now well-established tool for estimating dynamics of fish species distributions is Vector-Autoregressive Spatio-Temporal (VAST) modeling, which estimates the probability of occurrence and the expected abundance of a given taxon in a given location at a given time, based on spatiotemporal catch data and a series of fixed and random effects. VAST is already being used to process survey data to generate abundance indices for many stock assessments under the groundfish FMP. VAST has also been applied in several peer-reviewed articles to estimate range expansion/contraction (using a metric of area occupied); to estimate distribution shifts (using a metric of the centroid of the population's distribution); and to identify covarying assemblages of species or life history stages, and apply information from well-sampled species to inform distribution estimates for poorly sampled species. Results from other regions have been evaluated to detect evidence of range expansions or distribution shifts, to estimate linkages to measured environmental covariates, and to attribute observed changes to one or more hypothesized drivers. We wish to explore applying VAST to long-term groundfish monitoring data in order to develop indices of distributions of key populations for inclusion as indicator time series in future reports. Such information could potentially be related to other information such as empirical climate or oceanographic data, outputs from circulation models, the location of West Coast fishing ports, or the siting of current or proposed non-fisheries human activities. VAST is currently used for similar purposes in the NPFMC process, e.g., to interpret survey data from the BASIS program (https://www.afsc.noaa.gov/ABL/EMA/EMA_BASIS.php).

The CCIEA team seeks technical feedback from the SSC-ES on the use of VAST as a tool for developing groundfish distribution indices, and guidance on which species, life history stages, and potential covariates would be most informative.

Background reading:

Thorson, J.T., et al. 2017. The relative influence of temperature and size-structure on fish distribution shifts: a case-study on walleye pollock in the Bering Sea. *Fish and Fisheries* 18:1073-1084.

Thorson, J.T., et al. 2016. Density-dependent changes in effective area occupied for sea-bottom-associated marine fishes. *Proc. R. Soc. B* 283, 20161853.

Topic: Development of a new forage community composition indicator

Presenter: Dr. Andrew Thompson, Southwest Fisheries Science Center

Justification: In essentially all of the CCIEA team's ecosystem status reports, the indicators of the forage communities in the northern, central and southern portions of the ecosystem have been difficult to integrate, either within regions or across regions, which has hindered our ability to provide the Council with meaningful information on forage community status. The reason for this difficulty is that none of the three surveys that produce forage data were designed as comprehensive surveys for forage species, and furthermore the three regional surveys use very different methods. At best, these surveys provide relative estimates of forage species abundance at a regional level, but as of yet we have been unable to offer confident assessments of coastwide forage patterns or linkages between forage stocks and key predators. Because no coastwide, comprehensive forage survey is possible, we are forced to do our best to analyze the data from these three surveys in a way that is robust and informative, and that does not overextend the data themselves.

Members of the CCIEA team and colleagues are exploring dynamic factor analysis (DFA), nonmetric multidimensional scaling (NMDS), chronological cluster analysis, and comparisons via distance matrices to examine shifts in forage community composition to detect synchrony in shifts across regions, and to identify synchrony between any such shifts and changes in predator ecology. We would like the SSC-ES to review the methods we have developed and to provide feedback as to whether either the NMDS approach or the cluster approach (or both) would serve as worthwhile indicators of forage "regimes" within and across regions of the California Current.

Background reading:

Thompson, A.R., et al. 2013. Ecology and evolution affect network structure in an intimate marine mutualism. *American Naturalist* **182**:E58-E72.

And TBD