ECOSYSTEM WORKGROUP REPORT ON FISHERY ECOSYSTEM PLAN INITIATIVE 2: COORDINATED ECOSYSTEM INDICATOR REVIEW FOR THE ANNUAL CALIFORNIA CURRENT ECOSYSTEM STATUS REPORT

1.0 Introduction

At its September 2015 meeting, the Council decided to move forward with its second Fishery Ecosystem Plan (FEP) initiative, a coordinated review of the ecosystem indicators in the annual California Current Ecosystem (CCE) Status Report. Inspiration for this initiative came from the FEP's objectives for improving ecosystem information in the Council process and from the December 2014 meeting of the Ecosystem-Based Management Subcommittee of the Council's Scientific and Statistical Committee (SSC). At that meeting, the SubCommittee provided the first scientific review of the information and analyses supporting the indicators chosen for and used in the ecosystem status report. In the SubCommittee's report to the Council on its review, they suggested that "A workshop or series of workshops could solicit input from management teams and advisory subpanels on indicators that represent the ecosystem objectives expressed in the Council's fishery management plans (FMPs) and FEP, and are relevant to Council decision-making" (March 2015, SSCES Report at E.1.c).

To launch this initiative, the Ecosystem Workgroup hosted the following webinar series featuring speakers from the National Marine Fisheries Service's (NMFS's) Integrated Ecosystem Assessment (IEA) team:

- January 12: Contents of the Annual California Current Ecosystem Status Report; physical oceanography indicators (lead presenter, Dr. Toby Garfield, SWFSC)
- January 14: Biological indicators (lead presenter, Dr. Chris Harvey, NWFSC)
- January 26: Human dimensions indicators (lead presenter, Dr. Karma Norman, NWFSC)
- January 28: Freshwater, estuarine and marine habitat indicators (lead presenter, Dr. Correigh Greene, NWFSC)
- February 2: Risk assessments and applications of indicators to decision making (Dr. Jameal Samhouri, NWFSC, and Dr. Elliott Hazen, SWFSC, presenting)

These webinars were intended to give Council advisors and the public opportunity to hear from the IEA team on the contents of the anticipated 2016 ecosystem status report and past reports, while looking forward to how annual reports or related efforts might be improved starting in 2017. The Ecosystem Workgroup is serving in a coordinating role with this initiative, to facilitate communication with the Council's advisory bodies and propose ideas for improved connections between ecosystem indicators and analysis and the specific management issues arising under each FMP.

The Ecosystem Workgroup thanks the California Current IEA scientists from NMFS's Northwest and Southwest Fisheries Science Centers for their webinar presentations and thanks the numerous additional IEA scientists who participated in webinar question and answer sessions. We also appreciate all the work Council staff did to manage the technical aspects of the webinars and to post the recorded webinars on the Council's website for this initiative (http://www.pcouncil.org/ecosystem-based-management/coordinated-ecosystem-indicator-review-initiative/). The Ecosystem Workgroup also thanks the many Council advisory body members and members of the public who joined the webinars as audience members and discussion participants.

This report focuses on the January-February informational webinars. On March 8, 2016, we will meet at the Council meeting in Sacramento, California, and plan to discuss the contents of the ecosystem status

report in relation to the FEP's objectives, and the Council's overall fishery management objectives and schedule. Ultimately, the annual ecosystem status report will be most useful to the Council if its advisory bodies and the public will review that report and consider whether the report is informative for managing the species, fisheries, and habitat under the Council's authority. To provide guidance on future ecosystem status reports, advisory body members and the public may wish to view the recorded webinars, or may wish to consider the 2016 report presented at agenda item D.1.a. NMFS Report, along with the summaries in this Ecosystem Workgroup report.

The key task with this Initiative is to identify the most appropriate of the indicators available to the IEA team that may be useful to the Council and to achieve a more explicit understanding of their connection to the Council decision-making. The Ecosystem Workgroup's preliminary reaction to the webinar presentations is that while the Council may be able to use many of these indicators for *informational* purposes, drawing clear connections to *management decisions* may require additional, more focused analysis. For example, many of the datasets available to IEA scientists may not have been collected at geographic scales relevant to particular Council decisions; therefore, using indicators in support of particular decisions would require careful scrutiny and review by the SSC. Nonetheless, the informational value of the annual reports is beneficial for building general ecosystem awareness and literacy that may lead to new applications of the information in the future. As with any scientific information used in the Council process, managers need to understand how to ask the right questions of the scientists, so that scientists can help us better understand the answers they're able to provide. In turn, scientists need to understand the priorities and questions that managers have to answer to better focus their analytical efforts. Therefore, building opportunity for iterative dialogue between the IEA team and Council advisors will be important for advancing new uses of ecosystem information in Council decision-making.

Following the presentations in each webinar, we discussed how to connect the presented indicators to PFMC management questions and challenges. The presenting IEA scientists were open to suggestions and questions on revising current indicators or providing different information in future reports. IEA scientists were curious about how the Council might use the ecosystem status report and sought suggestions on making it more relevant to Council decision-making.

2.0 Webinar Summaries

The five webinars addressed a broad range of topics, as summarized below. Each webinar included a slide presentation by IEA scientists followed by a lengthy opportunity for questions and open discussion. A total of 143 individuals attended one or more webinars, approximately a quarter of whom were either Council members or Council advisory body members. (Recordings of the webinars are available on the Council's website, see the Coordinated Ecosystem Indicator Review Initiative page.)

Overview and Physical Oceanography Indicators. The January 12 2016, webinar provided an overview of the contents of past ecosystem status reports, described the basis for selecting meaningful indicators, and presented the physical oceanography indicators that NMFS has historically included in the reports. The larger IEA process includes a broader array of analyses (http://www.noaa.gov/iea/CCIEA-Report/pdf/index.html,) only some of which are presented in the annual ecosystem status report to the Council. In addition, Dr. Garfield offered three new indicators, warm water anomalies (e.g., the blob), snow water equivalents in watershed basins, and harmful algal bloom concentrations, and used them as examples for a new section in future ecosystem status reports to cover unusual, recent, or otherwise important events not addressed by historical indicators. Initial attendance was good with nearly 80 participants; others may have subsequently viewed the recorded session. The oceanographic indicators are fairly commonly used and understood, and participants had few questions. In general, identifying the most appropriate indicators, given available data, and achieving a more explicit understanding of their connection to the council's goals and decisions were key themes in the presentation and discussion. Although the

indicators in the report use a vast amount of existing data, there is still an on-going need for monitoring and filling data gaps. Other questions and comments focused on how useful indicators could be for forecasting future conditions, such as juvenile fish survival. While the general relationship between these oceanographic indicators and the productivity of the CCE are well known, connecting trends in the indicators to a particular Council decision will likely require specialized analysis.

Biological Indicators. The January 14 2016, webinar presented the biological indicators that NMFS has historically included in the reports, discussed challenges with developing indicators on different types of species, and suggested ideas for new indicators that might be useful in future reports.

Several biological indicators related to trends in forage abundance were presented which have previously appeared in reports. An informative low trophic level indicator for predicting abundance of higher-level predators (e.g., Chinook and coho salmon, groundfish) is relative abundance of northern versus southern copepods. Abundance trends of several central and northern CCE forage fish, or juvenile stages of higher trophic level species (i.e., young of year rockfishes, sanddabs or hake) show that abundance of some species increase while others decrease and that the trend for a particular species within the same year may vary greatly between central and northern areas. The Ecosystem Workgroup questioned how representative an indicator from one section of the coast would be for other areas (i.e., copepods only surveyed in Newport, OR). Several metrics were represented using only a single "aggregate" plot to demonstrate current status of multiple species compared to sometime in the past: Chinook salmon stocks and the extent to which each stock was increasing or decreasing and above or below recent abundance averages, and 34 individual species of groundfish relative to B_{MSY} and F_{MSY}. This single plot of present status is an alternative to presenting 30+ single species time series plots. The presenters also included a new time-series "stoplight" chart, using green, yellow and red colors to depict good, moderate and poor conditions for Chinook and coho salmon for a large number of physical and biological indicators. When most of the indicators are good, the ecosystem is generally favorable for salmon production. Biological indicators for non-FMP species included time series for California sea lion pup abundance and condition as well as seabird population density. Pup counts are an indicator of future adult populations, and condition is an indicator of pup survival. Pup condition can also be an indicator of forage availability for sea lions, other mammals and fish species that depend on the same forage fish community. Seabirds were represented by shearwaters (surface fish feeders), murres (diving fish eaters) and auklets (diving zooplankton feeders).

There were several issues discussed during the webinar related to enhancing biological indicators in the future which ranged from acquiring relevant and sufficiently comprehensive datasets, determining best formats for displaying information, and the need for greater connections among the indicators provided. For example, time series of appropriate forage species in the southern California Bight from California Cooperative Ocean Fisheries Investigations (CalCOFI) have yet to be presented because of backlogs in sample processing. Thus condition of California sea lion pups at in Southern California could only be considered relative to forage abundance indicators available from northern and central California. Bird data available to the IEA has been limited, because much is proprietary, or what is available may be too variable to be useful for indicators. No indicators were presented specifically for highly migratory species (HMS) and coastal pelagic species (CPS,) but the IEA would like to develop indicators for these groups in the future and would like suggestions from the Council, its advisory bodies and the public on indicators to consider. There are some HMS data available, but because of the migratory character of HMS species, changes in abundance from year to year may be more from fish moving into or out of the study area than from actual changes in abundance. One area of future investigation is in correlating oceanographic time series data geographically with forage indicators using a new web-plotting tool that can relate different variables. The presenters also noted that the Council is already using indicators, such as using sea surface temperature in a model to determine how much fishing effort to apply in the sardine fishery.

Human Dimensions Indicators. The January 26 2016, webinar addressed human dimensions indicators, some of which were new with the March 2015 ecosystem status report, and some of which will be new for 2016. The IEA team has developed Human Dimensions indicators because questions about the desired state of ecosystems are societal questions for a diverse group of stakeholders about a set of trade-offs reflecting regional values. One of the Human Dimensions indicators NMFS has provided in prior ecosystem status reports is a Fishing Diversification Indicator, meaning the diversity of fisheries from which West Coast and Alaska vessels derive income. Fishing businesses tend to be more resilient over time if they participate in multiple fisheries, which gives them access to diverse revenue streams. NMFS has also been developing a Personal Use Indicator, which looks at where and how much fish are identified on state fish tickets as "personal use" landings. The Ecosystem Workgroup notes that this indicator is only applicable to Washington and California, addresses less than 1% of total landings, and includes landings from state marine waters and inland lakes. Dr. Norman also presented Community Social Vulnerability Indices, which are intended to track community and ecosystem changes over time to weigh overall vulnerability of fishing communities to socio-economic changes against the particular dependency of those communities on fishing income and fisheries participation. The Ecosystem Workgroup thought these indices might be useful to the Council, particularly when weighing the potential cumulative effects of different management actions on different fishing communities, but noted that the weighting analysts assigned to different datasets within the indices seemed to have effects on the ultimate scoring of "more" or "less" vulnerable communities.

Of the planned future Human Dimensions efforts discussed during the webinar, we were particularly interested in the assessment of coastal community vulnerability to ocean acidification risk and wondered if that assessment could address expected effects of climate change beyond ocean acidification. Areas where the Ecosystem Workgroup believes Human Dimensions indicators work could expand to the benefit of the Council process include: (1) information on recreational fisheries and how community participation in recreational fisheries might affect its rankings of fisheries dependency and social vulnerability, (2) more connection to the types of analyses the Council must regularly produce as part of its management processes, such as the potential economic effects of its actions on small businesses, (3) some discussion of major fisheries costs and how those might affect fisheries participation levels, and (4) information on the vulnerability of different communities to some of the physical changes we might expect from climate change, such as sea level rise and flooding.

Habitat Indicators. The January 28 2016, webinar reported on development of freshwater, estuarine, and marine habitat indicators. The ecosystem status report has not historically included habitat indicators, but the Council's Habitat Committee asked that this initiative process include consideration of habitat indicators in future reports. Dr. Greene presented an overview of potential habitat indicators, using a conceptual habitat model developed by the IEA to provide a framework for evaluating and selecting habitat indicators. The model includes four general macro-habitat types; Freshwater, Estuary/Nearshore, Pelagic and Seafloor. Each habitat type mediates drivers and pressures through unique links to create conditions experienced by ecosystem components of interest. Drivers and pressures include climate and ocean drivers, human activities and ecological interactions. The proposed habitat indicators fell into one of three categories: 1) Indicators of how fisheries impact habitat (e.g. disturbance), 2) indicators of how habitat affects fisheries or FMP species (directly or indirectly; e.g. snow pack for salmon or euphotic depth for CPS), and 3) indicators of habitat effects on non-FMP species but related to FMP fisheries.

More specific conceptual models were developed for each macro-habitat, in order to identify and prioritize potential habitat indicators. Priority indicators were selected for each macro-habitat to cover the attributes habitat quantity, habitat quality and habitat pressures. This presentation identified overlaps in indicators useful in a habitat context as well as relative to management or abundance of FMP species; for example, the importance of snow pack as a potential indicator of salmon habitat quantity and quality as well as predicting future production and survival.

Dr. Greene provided some general considerations regarding presentation and use of indicators. For example, some indicators are best tracked and presented as time-series analyses while others are best presented and evaluated in spatial displays (maps). The habitat indicator selection process also considered indicator gaps; indicators that have strong theoretical or scientific support but lack data. These should be considered when thinking about future research or development efforts.

The presentation highlighted recent work to develop habitat indicators. A recurring theme was determining the appropriate geographic scale for indicators. Habitats are inherently spatial, so a special hierarchical framework was developed to capture spatial variation. Dr. Greene presented an attempt to do that for marine waters at several scales; first eco-regions (Salish Sea, North Coast, Central Coast, and Southern CA Bight,) then smaller scale separations into estuaries, nearshore and pelagic habitats. Seafloor Habitat is traditionally partitioned by bathymetry and substrate type. The Freshwater Habitat framework divides the West Coast into six freshwater eco-regions based on the biogeography of fishes. One indicator under development uses data for freshwater stream flows, which are important for ecosystem processes and human wellbeing. Time series of maximum and minimum flows were presented, as well as trends in 1-day maximum flow anomalies and in the 7-day minimum flows. Another indicator under development is disturbance from fishing gear (i.e., trawl and fixed gear) for the Seafloor Habitat. Future additions will include additional climate sensitivity indicators like dissolved oxygen across the water column and mapping of systems sensitive to sea level rise. Next steps include developing habitat indicators that put human activities in spatial context and present metrics of submerged aquatic vegetation (i.e., kelp and eel grass) on spatial scales and in time series formats.

Much of the discussion revolved around the relative roles, uses and values of suites of multiple indicators versus single indicators and their respective values in interpretations. Keeping a full suite of multiple indicators preserves flexibility for addressing individual questions that arise in the Council process, although the interpretation over varying spatial scales and increases in monitoring demands were considerations. Other areas of discussion related to the use or role of habitat indicators in the context of future efforts for habitat enhancement or restoration, the number of potential habitat indicators available versus how many should be presented in a report, and whether or how reference points might be used with habitat.

Risk Assessments and Applications of Indicators to Decision-Making. The February 2 2016, webinar presented IEA work on risk assessments and potential applications of indicators to decision-making. Although IEA scientists have been developing these concepts within the Centers, these types of analyses have not been included in past ecosystem status reports. When the Science Centers presented the 2015 ecosystem status report to the Council at the March 2015 meeting, the Council encouraged IEA scientists to think about what types of indicators and analyses they might want to add in to future reports. The Centers shared some of their ideas for responding to that Council request during the February 2nd presentation.

Ecological risk assessments are intended to consider a species' sensitivity to a stressor, meaning how dramatically that species' population may respond to stressors like fishing harvest rates, changes in sea surface temperature, or marine pollution. An example familiar to the Council of different species' responses to a stressor comes from our experience rebuilding overfished species – different species recover from historic overfishing at different rates, depending on a variety of factors like species' life histories, ocean and climate conditions, and habitat availability and condition. A risk assessment can also look at how different stressors affect a single species. For example, the presenters provided an English sole example risk assessment, where the Centers had looked at the English sole's exposure and sensitivity to a variety of stressors like ocean acidification, sea surface temperature, ocean-based pollution, nutrient input, invasive species presence, and others. The Productivity-Susceptibility Analysis that the Council used to evaluate the vulnerability of groundfish stocks to overfishing uses a similar technique.

In this webinar, Dr. Hazen introduced the concept of dynamic ocean management, which he referred to as "management that changes in space and time, at scales relevant for animal movement and human use." Dr. Hazen presented an example that combined sea surface temperature data, with data on where top order predators tend to migrate within the northern Pacific Ocean, with data on human use of marine areas to develop maps of areas where commercial shipping vessels may be more likely to strike whales as those whales migrate through marine waters around the Channel Islands. The Centers are working with other researchers, HMS managers, and fishermen to look at whether the long-term seasonal spatial closures in the drift gillnet fishery are appropriately mapped to areas of potential high bycatch of leatherback turtles and other protected species. Remote sensing of habitat characteristics (e.g., sea surface temperature,) known habitat preferences of protected species and target species, and real-time observations of protected species sightings (e.g., via mobile apps) are integrated into maps the Centers hope will help the Council and guide HMS fishermen to geographic areas with high predicted catch per unit of effort for target species and low bycatch rates for protected species.

The presenters additionally discussed an assessment of the vulnerability of marine forage species in the California Current Ecosystem to climate change. This assessment is part of a larger effort by all of NMFS's fishery management centers around the nation to look at the vulnerability of our managed species to climate change. For this presentation, Dr. Samhouri included a variety of fished and unfished, nearshore and offshore forage species within the vulnerability assessment. By "vulnerability," the presenters were considering the strength of each species' potential reaction, positive or negative, to the effects of climate change. Some forage species, like Pacific herring, might be more exposed to the coastal area effects of climate change, yet are less sensitive to (less likely to be affected by) climate change. Other species, like northern anchovy, might be less exposed to the effects of climate change, yet more likely to be affected by climate change. Dr. Samhouri also discussed the potential vulnerability of *fisheries* to changes in fish stocks, discussing the levels of dependency of fisheries on particular species, and whether those particular species are themselves vulnerable to the effects of climate change.

The presenters closed with some examples of how IEA scientists hope to refine future analyses to better serve the Council and other stakeholders. Specifically, the Centers are interested in:

- Revising the geographic scales of their analyses so that they are presenting coastwide information for decision-makers like the Council, which needs coastwide analyses, but also scaling analyses up or down so that decision-makers working at larger or smaller geographic scales can better use IEA information;
- Closing some of their data gaps so that they can provide more specific information than general assessments of whether effects of different stressors are positive or negative;
- Event-based assessments, which would be ways for the Centers to more quickly assess the potential effects of unusual events like the warm blob or harmful algal bloom events;
- Refining human activities indicators;
- Work on tuna, sharks, and other HMS, and the potential effects of climate change on those species;
- Developing management strategy evaluations, which are assessments that simulate the behavior of ecosystems to attempt to predict the potential ecosystem consequences of applying different management options to managed species.

3.0 Upcoming Work on this Initiative

In our September 2015 report at D.1.a., we suggested a schedule for this initiative that called for Council advisory bodies commenting to the Council at this March 2016 meeting with their impressions on the webinars and on the content and future direction of the ecosystem status report. At that September meeting, the Council commented that our schedule seemed somewhat ambitious and recommended receiving comments from advisory bodies in June or September 2016. As we worked through the webinars and

became familiar with the broad array of information considered for and presented in the annual ecosystem status report, it rapidly became clear to us that the Council's thoughts on scheduling work on this initiative had been wise and sensible. For the March-June 2016 period, we recommend that Council advisory body members review our above summaries of the webinars, decide whether they wish to view any of the webinars in full, and then provide guidance to the Council on the FMP-specific issues we identified in our September 2015 report, and which we reproduce here. In particular, it would be helpful if the FMP-specific advisory bodies would consider whether the information in the ecosystem status report helps us better understand:

- Total and FMP-specific fishery removals within the U.S. portion of the CCE, and the ecosystem effects of those fishery removals;
- Stock status of Council-managed fisheries
- Total and FMP-specific discard levels;
- U.S. West Coast fisheries' landings, by both volume and value;
- Metrics to assess fisheries' effects on essential fish habitat, and essential fish habitat effects on fisheries;
- Efficiency, profitability, and employment in FMP fisheries and fishing community stability;
- Metrics to assess the potential effects of near-term climate shift and long-term climate change on managed species and West Coast fisheries;
- Metrics to assess effects of major weather events on fisheries activity;
- Available forage base levels for FMP-managed, marine mammals, and species managed under the Endangered Species Act.
- Effects of non-fishery activities on Council-managed fisheries, fishing communities affected by those fisheries, and essential fish habitat.

If advisory bodies are looking for other ecosystem information or analyses beyond those presented in the current ecosystem status report, the Centers made it clear in their webinar presentations that they are open to requests for new analyses or ways of presenting information. In addition to these FMP-specific questions, the Habitat Committee and the SSC may wish to consider whether the ecosystem status report addresses their goals and priorities. Past ecosystem status reports have not included habitat indicators, so the Ecosystem Workgroup would be particularly interested in comments from the Habitat Committee on habitat-related management goals that could be addressed with indicators in future ecosystem status reports that are best related to the Council's habitat-related decisions. For example, would indicators that support Council and advisory body five-year reviews of essential fish habitat, or that support reviewing the potential effects of non-fishing activities on essential fish habitat be useful?

The SSC might specifically look at whether the ecosystem status report meets the priorities it identified in its 2013 Research and Data Needs document:

- Identify key physical and biological indicators for prediction of salmon early ocean survival and groundfish recruitment, as well as other conditions that are directly applicable to management.
- Identify indices of ecosystem state:
  - upwelling, El Niño, Pacific Decadal Oscillation, Sea Surface Temperature, etc.;
  - abundance of key ecosystem process indicators, such as zooplankton and forage fishes;
  - larval and juvenile fish abundance;
  - total annual production and surplus production;
  - species diversity and other measures of ecological health and integrity; describe rationale underlying each;
  - a measure of ocean acidification and its associated impacts on marine resources and ecosystem structure and function.

- Estimate total catch for target and nontarget species and their prey and predators.

At our March 8, 2016, meeting the Ecosystem Workgroup plans to review the ecosystem status report and information presented in the webinars against the FEP's objectives for this report. We plan to discuss with each other and report to the Council whether and how the report can help us better understand:

- the effects of physical oceanographic processes on the biological community, and on the abundance and distribution of fishery resources and other ecosystem components interacting with fishing vessels (e.g., marine mammals, sea turtles, seabirds and others);
- the effects of fishing activities on the marine ecosystem, particularly on trophic flows within the ecosystem;
- whether and which non-fishing activities have effects on the abundance and distribution of fishery resources and other ecosystem components interacting with fishing vessels (e.g., marine mammals, sea turtles, seabirds and others);
- which fishing communities are most dependent upon fishery resources and which types of fishery management decisions have the greatest effects on those communities;
- how existing or additional indicators or analyses, if any, may support the Council's climate change initiative.