Investigating and Improving Applications of Ecosystem Status Reports in U.S. Fisheries Management. Report from a 2021 Workshop organized by the National Marine Fisheries Service Ecosystem-Based Fisheries Management Working Group

W. Morrison, T. L. Rankin, S. A. Oakes, C. J. Harvey, S. Lucey, E. Keiley, M. Mackey, K. Abrams, and K. Osgood (editors)

U.S. Department of Commerce
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National Marine Fisheries Service

NOAA Technical Memorandum NMFS-OSF-11
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Gina Raimondo, Secretary

National Oceanic and Atmospheric Administration
Dr. Richard Spinrad, Administrator

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1.0 BACKGROUND, GOAL, AND DESIRED OUTCOMES

In August 2021, the National Marine Fisheries Service (NMFS) Ecosystem-Based Fisheries Management (EBFM) Working Group held a workshop to evaluate progress on ecosystem status reports (ESR). Ecosystem status reports have been included as important components in multiple recent policy documents, including the NMFS National Climate Science Strategy (Link et al. 2015), EBFM Policy (NMFS 2016a), and Road Map (NMFS 2016b). These documents highlight the importance of ESRs that are produced at varying intervals (annual to periodic) in the Alaska, California Current, West Hawaii, New England, Mid-Atlantic, and Gulf of Mexico regions, with South Atlantic and Caribbean ESRs soon to be released.

The need for this 2021 ESR workshop was identified as a top priority at the 2020 NMFS EBFM Working Group Virtual Meeting. At that meeting, regions shared information about their ESRs, including: content, frequency of production, target audiences, and connection points to management. It became apparent that a deeper dive into the ESRs, the possible use of ESRs, and connections between ESRs and other EBFM Guiding Principles (see NMFS EBFM Policy and Road Map) was needed. There are a variety of ESR users such as state natural resource managers and National Marine Sanctuaries, however, since one of the core missions of the National Marine Fisheries Service is fisheries management, we decided to focus this workshop on the connections between ESRs and fisheries management. The eight fishery management councils are often major users of the ESRs, so we invited council staff to participate in this workshop.

The goals and desired outcomes of this 2021 ESR workshop were to identify ways to integrate ESRs with achieving other EBFM milestones and improve connections with fishery management through:

- identifying management priorities that would benefit from ecosystem information contained in ESRs;
- identifying the types of on-ramps to deliver this information into the fishery management decision-making process; and
- engaging regional offices, fishery management councils, and other policymakers in the use of EBFM science products.

The workshop employed a mix of presentations, plenary sessions, panel discussions, and regional breakout groups to encourage active participation and discussion related to the workshop goals and outcomes.

2.0 WORKSHOP PRESENTATIONS AND PANELS

2.1 Presentation 1. The current state of existing ESRs and pre-meeting feedback from regional office and council staff

Led by Tauna Rankin (Office of Habitat Conservation)

Objectives:

- Review pre-meeting input from regional office and council staff on the use and purpose of ESRs.
- Clarify how current ESRs are being used.
    - What is working well and what could be improved.
    - What management challenges could benefit from more ecosystem information
- Discuss resources needed to produce ESRs relative to other EBFM products in high-level, qualitative terms.

Summary of presentation:

Workshop organizers requested input on how the current ESRs are being used in fishery management and what management challenges could benefit from more ecosystem information. NMFS regional office staff and regional fishery management council staff—the "users" of these reports – contributed feedback. All eight fishery management councils have one or more ESRs produced or in progress in their region (See Table 1). There is wide variety in when these ESRs were first developed, their formats, and frequency. We received 18 responses, 11 from regions that have a current ESR and seven from regions without a current ESR. More information on the regional responses to the pre-workshop survey is available in Appendix D.

Table 1. Information on existing ecosystem status reports as of August 2021.

System	First year produced	Frequency	Written report?	Publicly presented?	Automated?	Data portal?	Main target audience
New England	2002*	Annual since 2016	Y	Y	partly	Y	NEFMC
Mid-Atlantic		Annual since 2017	Y	Y	partly	Y	MAFMC
South Atlantic	2021	TBD	Y	Y	no	no	SAFMC
Caribbean	TBD	TBD	Y	Y	no	TBD	CFMC
Gulf of Mexico	2013	Intermittent	Y	Y	partly	Y	GMFMC, academia
California Current	2012	Annual since 2014	Y	Y	partly	Y	PFMC
Eastern Bering	1994*	Annual	Y	Y	no	Y	NPFMC
Gulf of Alaska		Annual	Y	Y	no	Y	NPFMC
Aleutian Islands		Annual	Y	Y	no	Y	NPFMC
West Hawai'i	2015*	Intermittent	Y	Y	no	N	State managers

*The Alaska, Northeast, and Pacific Islands fisheries science centers produced early versions of Ecosystem Status Reports as Ecosystem Considerations in Stock Assessment and Fishery Evaluation (SAFE) Reports and a Report on the Status of the NE US Continental Shelf Ecosystem (Link & Brodziak 2002). The Alaska Fisheries Science Center has produced separate, annual reports for the Eastern Bering Sea, Gulf of Alaska, and Aleutian Islands since 2016, though there was no Aleutian Islands report in 2017 or 2019.

Many of the respondents mentioned that ESRs are a great reference, education, and communication tool. Responses about the most useful or informative part of the report varied: some answered the whole report or the indicators as a whole, while others specified certain sections such as the summary report cards or the risks to management sections. To date, there is limited direct connection between the ESRs and management decisions, nor is there a requirement for there to be one. Some are interested in using the information more directly in management decisions, but most are unsure how. When asked to suggest changes that would improve the ESRs, responses were informative:

- Create more linkages with socioeconomic and community health indicators.
- Add more linkages to stock assessments.
- Address trade-offs related to indicators and management decisions.
- No improvements needed.

Regions and councils are encountering a lot of EBFM-related challenges, especially related to climate and socio-economic impacts (Fig. 1). Many respondents are also dealing with process-related challenges of implementing EBFM, such as integrating ecosystem information into management, interpreting complex information, and communicating uncertainty. Respondents noted that developing ESRs can require considerable resources and that opportunities to enhance ESRs may come with trade-offs, as the ESR authors are the same experts working on other EBFM products and without additional resources they cannot add or expand projects without taking from other projects.

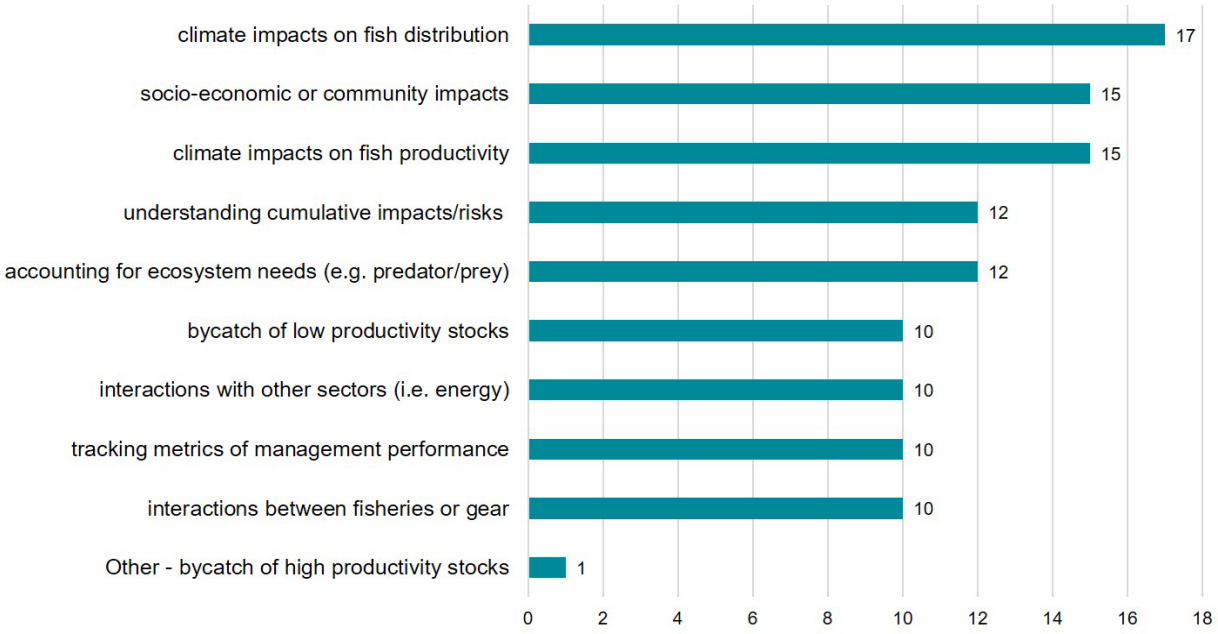

Figure 1. Responses to pre-meeting question: "Which of the following are current or expected future challenges for your council? Check all that apply." There were 18 respondents.

ESR authors were happy to learn that current ESRs are mostly meeting regional office and council expectations. During the discussion participants also learned that a primary audience for the Mid-Atlantic State of the Ecosystem Report is the Council's Scientific and Statistical Committee (SSC).

This is similar to the North Pacific Fishery Management Council, but different from some other regional ESRs and influences how the information is used by the Council. The discussion also brought out challenges of applying EBFM principles and increasingly complex ecosystem information to current fishery management regulations and policies.

Relevant Links

- NOAA's Integrated Ecosystem Assessment landing page for Ecosystem Status Reports
- Western Pacific Annual SAFE Reports, which contain some ecosystem information

2.2 Presentation 2. Ecosystem considerations in management: West Coast regional example

Led by Toby Garfield (Southwest Fisheries Science Center)

Objectives:

- Learn about how:
    - ESRs provide important contextual content for understanding the potential impacts of ecosystem change
    - A conceptual model can help visualize an ecosystem
    - A habitat compression index can help reduce whale entanglements

Summary of presentation:

The California Current Large Marine Ecosystem is characterized by strong seasonal upwelling, high species diversity, and a variety of coastal, nearshore, and offshore habitats. Multiple fisheries occur within the ecosystem, including four fishery management plans (FMPs) managed by the Pacific Fishery Management Council (PFMC), and multiple state-managed fisheries. The California Current Integrated Ecosystem Assessment (IEA) Program began in 2010 and the first ecosystem indicator report was produced in 2011. In 2013 PFMC published its Fishery Ecosystem Plan, which included guidance on what is expected in an ESR. In 2015 PFMC initiated through the Fishery Ecosystem Plan an initiative to review the indicators in the ESR and make recommendations for improvements. The initiative included multiple webinars and solicitations for feedback from PFMC advisory bodies. Based on the feedback received, the ESR is a 20-page document (with a lengthy appendix) provided annually to the PFMC and is well received by the PFMC. The California Current ESR is very important for educating the PFMC about the ecosystem and what is changing. The managers continually stress that the success of an ESR should not be measured by the number of management decisions it has influenced. Meaningful outcomes and successes include:

- Contributes to an overall elevation in quality and volume of ecosystems-related discussions and activities in the PFMC.
- Spurs engagement with other users interested in using indicators (NMFS West Coast Regional Office, West Coast Ocean Alliance, Sanctuaries, states).
- Gives a seat at the table for discussions about emerging issues, implementing strategies, scenario planning, survey considerations, etc.
- Promotes interdisciplinary collaboration across West Coast marine scientists and institutions.

The California Current IEA program has created conceptual models of the socio-ecological system to help the PFMC and stakeholders visualize and agree on the key components, processes, and linkages that characterize the system. It is an important grounding exercise that helps ensure people are on the same page about how the system is perceived, and it can be used to identify indicators related to each of the components or linkages.

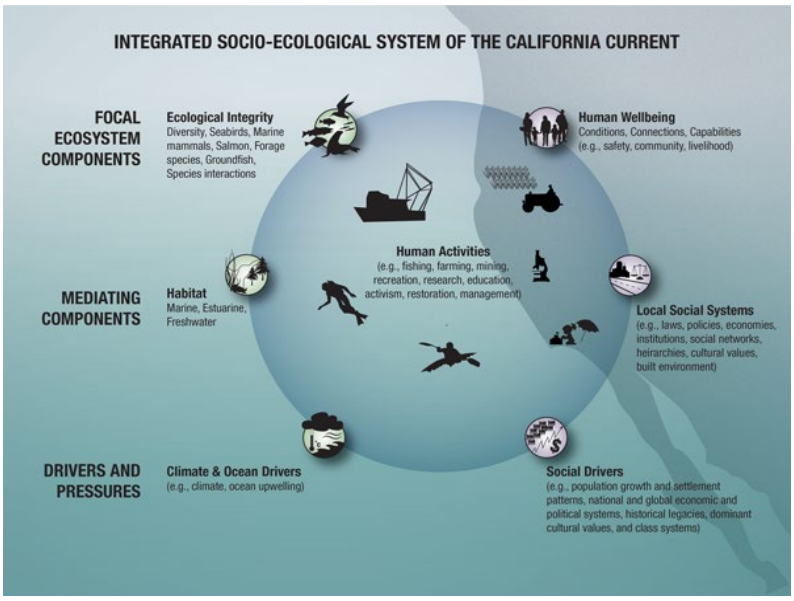

Figure 2. Conceptual model of the California Current socio-ecological system.

The model represents the complex and inextricable connections between ecological components (left) and human components (center, right). These components are arranged in three tiers: focal ecosystem components, which are often associated with broad objectives such as ecological integrity and human wellbeing; mediating components, such as habitat and local social systems; and drivers and pressures, which are generally external forces on the ecosystem. Human activities are placed at the center to emphasize their broad extent and because they are where management actions are directly implemented in order to achieve objectives elsewhere in the system. From Levin et al. (2016).

The contextual nature of the ESR allows targeted responses. For example, one of the challenges the California Current is experiencing is marine heat waves. These heat waves impact all aspects of the ecosystem. In 2016, a delay in the state-run Dungeness crab fishery due to red tides, combined with changes in the location of krill and anchovies resulted in a 400 percent increase in confirmed whale entanglements in fishing gear. In response, NMFS introduced the Habitat Compression Index as a measure of the fraction of cold water (<12° C) within 150 km of the coast between 35.5 and 40° N. Combining this habitat compression index with other indices, NMFS created a whale entanglement dashboard that allows stakeholders to explore the indices that contributed to the whale entanglements. The ultimate goal is to transition from delivering this information once a year to providing automatic updates in a timely manner.

Habitat compression and oceanographic indicators are shown in figure 3. The upper panel illustrates a time series that tracks the spatial area of coastal upwelling habitat. The Habitat Compression Index is a regional indicator used to assess the likelihood of ecosystem shifts and shoreward distribution patterns of top marine predators like whales. Smaller values indicate periods when cool habitat is compressed onshore, heightening whale entanglement risk. The whale icon summarizes the key events and environmental conditions during 2016 that led to entanglements. In this instance, the conditions are very low upwelling during winter and winter El Niño conditions. (Santora et al. 2020) The lower panel plots the time series of the two oceanographic conditions that influence the foraging location of whales, the oceanic Niño index (green line), and the Coastal Upwelling Transport Index (blue line).

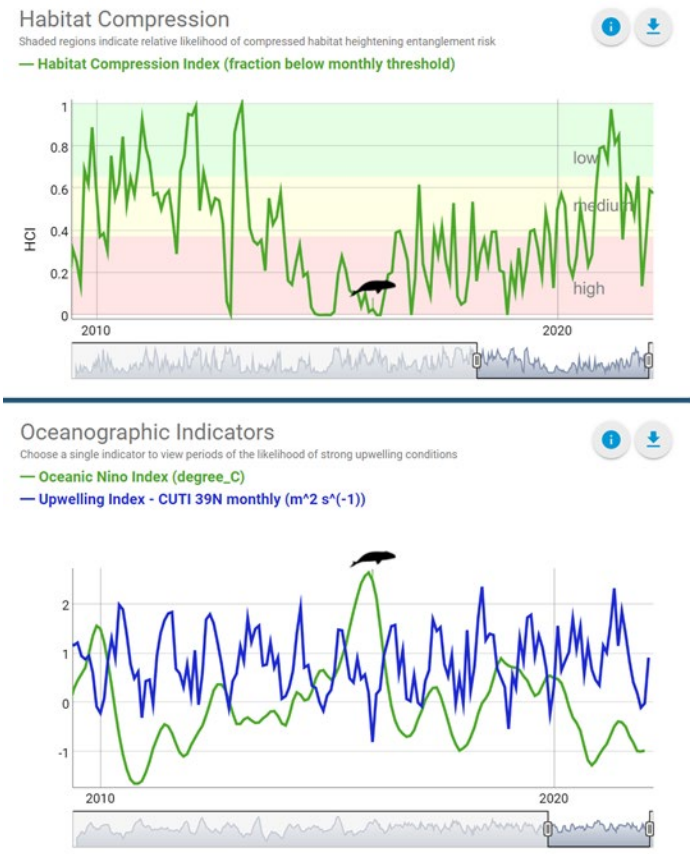

Figure 3. Habitat Compression.

https://oceanview.pfeg.noaa.gov/whale_indices/

While the California Current ESR is a success, it also continues to have challenges. It requires a lot of work, despite improvements in process and efficiency; both the ESR authors and end users suffer issues of heavy workload and limited bandwidth, and the reporting schedule/capabilities may not align with their needs. As mentioned above, it is a contextual report, but "context" is in the eye of the beholder. For example, pinniped pup counts can be seen as an indicator of forage availability or as indicator of fishery resources being lost to seal predation. Another major challenge is climate change and its impact on not only individual species, but also the baseline conditions of the ecosystem. It is important to focus on creating a report that is useful but not perfect.

Questions after the presentation prompted a discussion about the challenges of setting thresholds for indicators in ESRs and other EBFM products and their utility for management. One challenge that was raised was the problem of shifting baselines. Another challenge was that a threshold for one management issue may be very different for another management issue. The broad utility of ESRs and the challenge of creating a concise document was yet another challenge.

Relevant Links

- ESR report
- Ecosystem Status Report Technical Memo
- Whale entanglement dashboard
- Levin et al. 2016 - Socio-ecological conceptual model paper
- Welch et al. 2019 - Loggerhead turtle bycatch risk threshold analysis paper
- Hausner et al. 2021 - Blue whale ship-strike risk threshold analysis paper
- Samhouri et al 2017 - Ecosystem threshold paper
- Large et al. 2013 - Defining trends and thresholds of ecological indicators
- Tam et al. 2017 m- apples to oranges paper

2.3 Presentation 3. Ecosystem considerations in management: NPFMC example

Led by Stephani Zador (Alaska Fisheries Science Center)

Objectives:

- Learn about:
    - How ESRs, Ecosystem Socio-economic Profiles (ESPs), and risk tables provide ecosystem information that can be incorporated into Acceptable Biological Catch levels
    - The use of ecosystem caps, an example of an Ecosystem Level Reference Point, to limit overall fishing mortality and require discussion of trade-offs between fisheries

Summary of presentation:

The Alaska Fisheries Science Center (AFSC) has been producing ESRs annually since 1994, starting with the Gulf of Alaska (NPFMC 1994) and expanding to include the Eastern Bering Sea and Aleutian Islands. They have closely linked report production timing with the annual groundfish stock assessment cycle to maximize the uptake of the ESR information into groundfish harvest management. One important lesson from their experience is that understanding the management process is essential for identifying opportunities to provide the appropriate science to best address management questions. Regular communication between the scientists and information users is critical to tailor scientific information to managers' information needs. The main user of the ESRs is the Scientific and Statistical Committee of the North Pacific Fishery Management Council (NPFMC). The AFSC ESR staff are actively expanding outreach products based on the ESRs. These include 4-page ESRs briefs, web stories, videos, and story maps.

A recent development in providing ecosystem information to the NPFMC groundfish management process is the creation of ESPs, which compile ecosystem and socioeconomic indicators that can be evaluated qualitatively and quantitatively relative to metrics for a managed stock. An ESP is specific to a stock and is produced as an appendix for a stock assessment. This is in contrast to an ESR, which is produced for a large marine ecosystem. ESPs have been developed for several stock assessments and are expanding to more stocks. The process to create the ESPs includes coordination across stock assessment, climate, and ecosystem scientists. NEFSC is running a pilot

based on the AFSC process, and AFSC is looking to expand this concept nationally. Other regions should understand that creating ESPs requires coordination across multiple scientific disciplines and thus requires significant resources.

Another recent development has been the introduction and adoption of risk tables, which provide a semi-quantitative summary of considerations that may influence the true maximum Acceptable Biological Catch (ABC) but are not accounted for within the stock assessment model. Stock assessment scientists can recommend an ABC level that is lower than the level estimated by the stock assessment model if there are large or multiple uncertainties not accounted for in the stock assessment model. Considerations are categorized based on whether they apply to the assessment model, the population dynamics, ecosystem or environmental conditions, or fisheries-derived information on the stock. Information from both ESRs and ESPs are used to inform the risk tables. Risk tables were successfully piloted on a few stocks in 2018 and are now included in all full stock assessments.

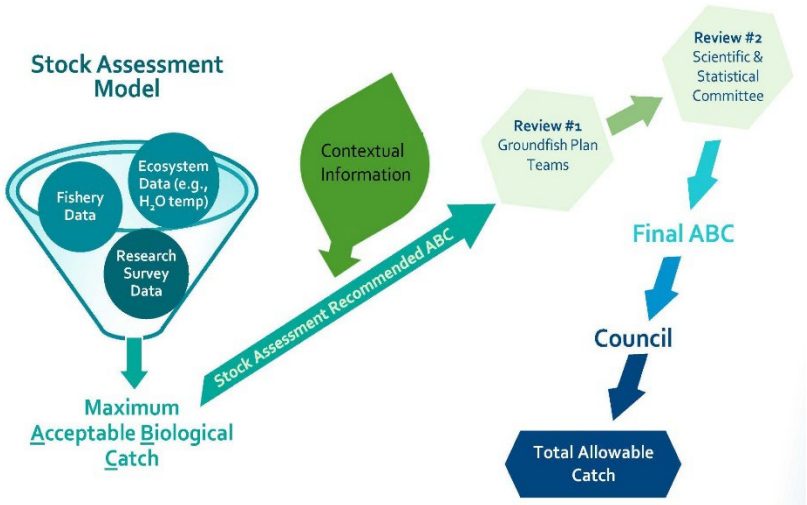

Figure 4. The annual catch limit–setting process for groundfish in the North Pacific Fisheries Management Council.

The leaf icon (Figure 4) labeled "contextual information" is where ESR and ESP information enters the cycle. A risk table in the stock assessment justifies whether the model-estimated Maximum Acceptable Biological Catch should be reduced based on contextual information as categorized in the risk table. Thus, the Recommended Acceptable Biological Catch (ABC) may be lower than the Maximum ABC. The Recommended ABC is reviewed first by Plan Teams and then by the SSC. The sum of the Total Allowable Catches (TACs) across stocks must not exceed the Optimum Yield cap.

The NPFMC has a mandated Optimum Yield cap or upper limit on the overall amount of fish that can be removed from an ecosystem in any year, thus the cap serves as an ecosystem-level reference point. The sum of the individual stock TACs (i.e., quotas) in the Bering Sea/Aleutian Islands and the Gulf of Alaska may not exceed the ecosystem cap (2 million MT and 800k MT, respectively). The cap has not been limiting in the Gulf of Alaska but is limiting in the Bering Sea. When the sum of the individual stock ABCs in the Bering Sea/Aleutian Islands exceeds the cap, this triggers the NPFMC to evaluate trade-offs between fisheries to establish the final TACs, each of which may not exceed the final ABC for a stock.

Relevant Links

- Alaska ESRs
- Update for NPFMC on ESPs

- Example Full ESP for Sablefish 2019 (pp. 157-202)
- Dorn & Zador 2020 - Risk table publication

2.4 Presentation 4. Prioritizing vulnerabilities and risks: MAFMC example

Led by Sarah Gaichas (Northeast Fisheries Science Center)

Objectives:

- Learn about:
  - How the Mid-Atlantic Fishery Management Council's (MAFMC) risk assessment is tied to the ESR (called the State of the Ecosystem report in New England and the Mid-Atlantic) and informs other processes in MAFMC's Ecosystem Approach to Fisheries Management (EAFM).
  - The EAFM conceptual model.

Summary of presentation:

ESRs for the Mid-Atlantic and New-England Fishery Management Councils are called State of the Ecosystem (SOE) reports and focus on the fishery-relevant subset of ecosystem pressures and interactions, with the councils as the main audiences. SOE reports were modeled after the California Current ESR, but have been evolving since they were first introduced in 2016. One of the reactions to the first report in 2016 was, "what are we supposed to do with this?" The scientists interpreted this as a challenge worth addressing. They found that an iterative, collaborative approach has been key to getting the information used. The current SOE reports clearly link the ecosystem indicators to management objectives and provide a synthesis of what the results mean for the big picture. Results related to human well-being have been placed first in the report. The 2021 report includes a short 2-page report summary that provides the key takeaways as a supplement to the more extensive, approximately 30-page report.

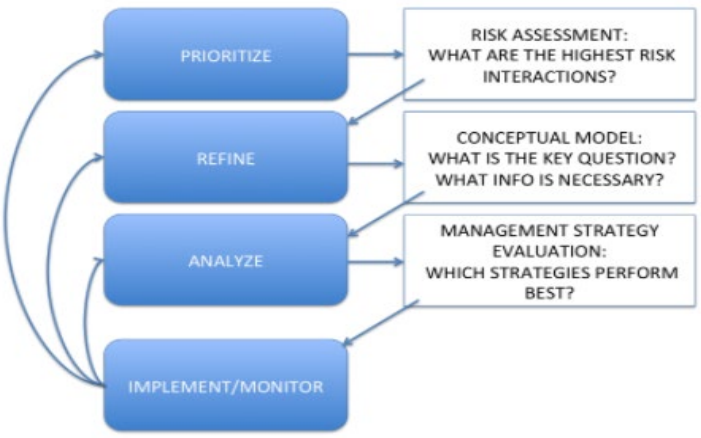

Figure 5. Mid-Atlantic Fishery Management Council Ecosystem Approach to Fisheries Management framework (Gaichas et al. 2016).

The presentation covered MAFMC's Ecosystem Approach to Fisheries Management that has been in place since 2016. The MAFMC has been very clear about using an EAFM approach that incorporates ecosystem considerations into the current management system. The approach follows the EAFM framework process (see Figure 5) the MAFMC created to assess risk, identify management challenges, create a conceptual model, and complete analyses of management options via management strategy evaluation (MSE). The approach is a modification

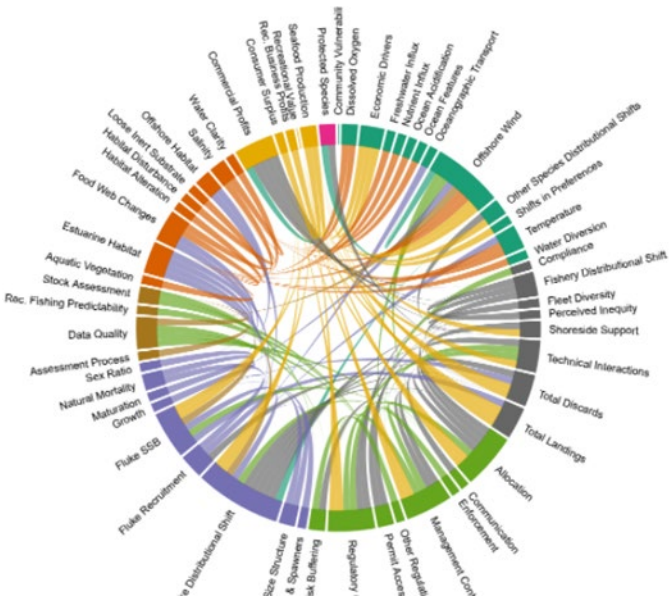

Figure 6. Full summer flounder (fluke) conceptual model (DePiper et al. 2021).

of the NOAA IEA framework. The first step is to complete a risk assessment of the managed fisheries to document the relative risk of specific factors to meeting management goals. Many of the indicators used to assess risk are from the SOE report, so the risk assessment is easily updated annually. The MAFMC used the risk assessment to determine further analysis was needed on the summer flounder fishery due to its vulnerability to multiple risks. An interactive conceptual model of the fishery was created and a management question was chosen to explore via MSE. The MSE is currently being completed to "evaluate the biological and economic benefits of minimizing summer flounder discards and converting discards into landings in the recreational sector." It was emphasized that the entire EAFM framework takes time and resources: to create the science needed and to help management understand and support the process. For example, it can take time to understand what information is needed for management (e.g., what timescale is appropriate, and is there a way to incorporate flexibility to use different data if necessary), and how to successfully communicate the information to the MAFMC and stakeholders. Collaboration is a key part of the entire process (across science and management, science and stakeholders, and management and stakeholders). Communication can build trust and show that management is listening to stakeholders. The report requires interdisciplinary work, and also needs to be flexible and able to use multiple data sources.

Relevant Links

- Northeast SOEs
- https://www.mafmc.org/eafm
- Interactive conceptual model of the summer flounder fishery
- Gaichas et al. 2016 - EAFM Framework paper
- Gaichas et al. 2018 - Risk assessment paper
- Muffley et al. 2020 - There is no I in EAFM paper
- Bastille et al. 2021 - Principles of open data science paper
- DePiper et al. 2021 - Collaborative conceptual modeling paper

2.5 Presentation 5. Prioritizing vulnerabilities and risks: Office of Habitat Conservation, Office of Science and Technology, and Office of Protected Resources

Led by Emily Farr (Office of Habitat Conservation) and Matt Lettrich (Office of Science and Technology)

Objectives:

- Learn about habitat, marine mammal, and sea turtle climate vulnerability assessments (CVA)
- Consider if better coordination and collaboration between vulnerability assessments and ESRs could be useful to either effort

Summary of presentation:

A lot of work is being completed to better understand vulnerabilities and risks to a changing climate. Climate vulnerability assessments (CVAs) have been created and implemented for fish and invertebrates, marine mammals, sea turtles, and marine habitats. Most of the CVAs follow similar methodologies that have been modified to accommodate the needs of the resources being evaluated. In short, experts score multiple sensitivity attributes and exposure factors into pre-identified and defined bins (low, moderate, high, very high) to characterize overall vulnerability of the resource to a changing climate. Experts also provide an overall direction of climate effect (positive, negative, or no effect) on the resource. These results can then be used to prioritize science or management. This presentation focused on Northeast habitat, marine mammal, and sea turtle CVAs.

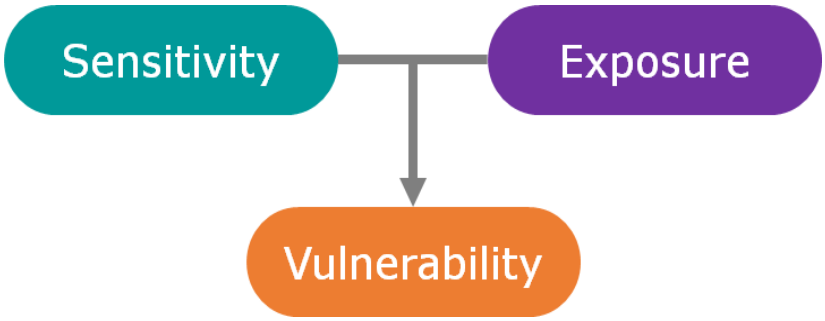

Figure 7. Climate change vulnerability is calculated as a function of the predicted exposure to environmental changes and the estimated sensitivity to these changes.

This presentation asked if better coordination and collaboration between these vulnerability assessments and ESRs could be useful to either effort. Specifically, could CVA results be included with ESRs or could ESR results inform CVAs? For the former, information from the CVAs can be used to identify vulnerable resources to track in the ESR. The Mid-Atlantic and New England ESRs (SOEs) include information on priority species and habitats from the CVAs. For the latter, information from an ESR on specific climate factors can be combined with information from the CVAs on how habitats or species are expected to respond to those climate factors. For example, if a habitat or species has a specific temperature range, information on how the temperature is changing can provide insight into how that species or habitat might respond. One challenge is getting the large amount of information resulting from the CVA into the indicator format of ESR. Another challenge is the mismatch in timing between CVAs and ESRs: CVAs are expected to be updated approximately every 5 to 10 years, which is less frequent than ESRs. Finally, the limited inclusion of indicators for habitat status/trends in ESRs can limit their interplay with habitat CVAs, particularly for the nearshore environment.

NEFSC is working to include some information from the habitat vulnerability assessment in their next ESR, linking highly vulnerable habitats to species that depend on those habitats.

Estuarine Submerged Aquatic Vegetation

System: Estuarine

Subsystem: Subtidal & Intertidal

Class: Aquatic Bed

Sub-class: Rooted Vascular

Geographic Area: Entire Area

Overall Vulnerability Rank = High

Habitat Sensitivity = High

Climate Exposure = High

	Estuarine Submerged Aquatic Vegetation	Attribute Mean	Data Quality	Distribution of Expert Scores
Sensitivity Attributes	Habitat condition	3.2	2.6	
	Habitat fragmentation	3.3	2.3	
	Distribution/Range	2.9	2.3	
	Mobility/Ability to spread or disperse	2.9	1.6	
	Resistance	3.2	2.4	
	Resilience	3.4	2.5	
	Sensitivity to changes in abiotic factors	3.3	2.5	
	Sensitivity and intensity of non−climate stressors	3.7	2.6	
	Dependency on critical ecological linkages	2.4	2.1	
	Sensitivity Component Score	High		
Exposure Factors	Sea surface temp	3.7	2.5	
	Bottom temp	n/a	n/a	
	Air temp	n/a	n/a	
	River temp	n/a	n/a	
	Surface salinity	2.8	2.1	
	Bottom salinity	n/a	n/a	
	pH	4	2	
	Sea level rise	2.7	2.2	
	Precipitation	2.7	2.1	
	Floods	n/a	n/a	
	Droughts	n/a	n/a	
	Exposure Component Score	High		
	Overall Vulnerability Rank	**High**		

Low
Moderate
High
Very High

Figure 8. An example summary table from the Habitat Climate Vulnerability Assessment. This is the first page of a longer narrative that provides important habitat-specific takeaways from the assessment.

Relevant Links

- NMFS Climate Vulnerability Assessments
- Morrison et al. 2015 - Marine Fish & Shellfish Vulnerability Assessment Methodology
- Hare et al. 2016 - Northeast Fish Stock Climate Vulnerability Assessment
- Spencer et al. 2019 - Bering Sea Fish Stock Climate Vulnerability Assessment
- Crozier et al. 2019 - Pacific Salmon Vulnerability Assessment
- Lettrich et al. 2019 - Marine Mammal Climate Vulnerability Assessment Methodology
- Lettrich et al. 2020 - Sea Turtle Climate Vulnerability Assessment Methodology

2.6 Presentation 6. Exploring and addressing trade-offs: multi-regional examples

Led by Wendy Morrison (Office of Sustainable Fisheries)

Objectives:

- Learn about multiple examples of where we address trade-offs
- Discuss if ESRs could provide a mechanism/forum for understanding, discussing, or addressing ecosystem trade-offs

Summary of presentation:

One major tenet of EBFM is explicitly addressing trade-offs among species, fisheries, and/or gears. Trade-offs are not new, and can be an important part of single-species management (e.g., higher landings vs decreased probability of overfishing, allocating single species catch between gears where it can be target vs bycatch, higher landings vs stability of landings, maintaining historical small businesses vs improving efficiency) and EBFM (e.g., catch of prey vs predators, balancing catch to ecosystem productivity, interactions between fishing gear and endangered species or habitat). This talk was an aspirational talk working through the question: How can ESRs provide a mechanism or forum for understanding, discussing, or addressing ecosystem trade-offs?

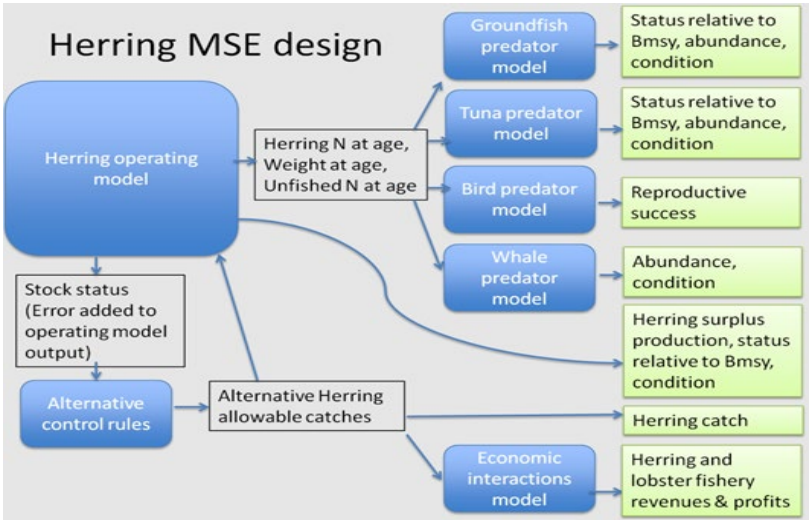

Figure 9. Conceptual diagram of the herring MSE (Sarah Gaichas Personal Communication).

One option is through the use of Management Strategy Evaluations (MSE) (Kaplan et al. 2021). MSE is a simulation approach that compares how a broad range of management strategies behave under uncertainty. The results of MSEs aim to clarify trade-offs across multiple economic, social, and biological objectives. Kaplan et al. (2021) describe four case studies that included ecosystem considerations in an MSE. In another example, the Northeast Fishery Management Council (NEFMC) used an MSE to look at managing herring with sufficient biomass to support its predators (Deroba et al. 2021, Feeney et al. 2021). Simulations were run to determine which management options resulted in objectives being met at 90 percent or more (e.g., tern productivity at 1.0 or higher >90% of the time, fishery yield >90% of MSY, herring biomass >90% of SSB at MSY, etc.). ESRs can inform MSEs: 1) by providing data indicators to be included in the analysis, and 2) identifying where MSEs are needed (e.g., see Tommasi et al. 2021 and Muffley et al. 2020).

A second option linking ESRs to trade-offs could be through the use of an ecosystem cap (a system-level annual total allowable catch limit). There are limits to the amount of biomass that can

be sustainably removed from an ecosystem (Link 2017). Ecosystem caps can identify the appropriate amount of removals and create the need for discussions of trade-offs between fisheries and catch. The North Pacific Fishery Management Council (NPFMC) has mandated catch caps for the Gulf of Alaska and Bering Sea, but only the Bering Sea cap constrains removals (see Presentation 3 above). Most years, NPFMC must discuss catch limits between fisheries to ensure they remain under the cap, with many members in favor of the caps, which they feel lead to more sustainable management. NEFMC is also considering the use of an area cap as a management tool. The ESR could be used to estimate ecosystem productivity and the appropriate level of removals, and provide a forum for discussing trade-offs between fisheries.

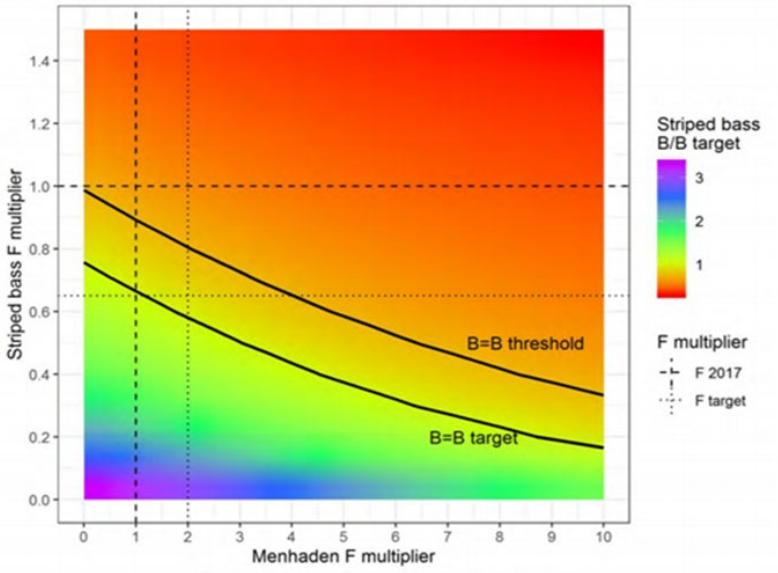

Figure 10. Figure showing the direct trade-off between fishing pressure on menhaden (prey) and striped bass (predator).

The third option is to quantify trade-offs through the use of multi-species assessments. The Atlantic States Marine Fisheries Commission has used multi-species assessments to understand the trade-off between fishing mortality of the prey (menhaden) and predator (striped bass) (Anstead et al. 2021, SEDAR 2020). ESRs can be used to track abundance of key trophic levels, identify relationships that could be included in multi-species stock assessments, and could provide an avenue for analyzing trade-offs between species or fisheries.

Figure 10 shows the direct trade-off between fishing pressure on menhaden (prey) and striped bass (predator). Colors represent striped bass age 6+ biomass ratio (B/BTARGET) in the terminal year of the model projections as a function of fishing mortality on both Atlantic menhaden and striped bass. The solid black lines represent the contours where striped bass B=BTHRESHOLD and B=BTARGET. The dashed lines highlight specific F scenarios where F is equivalent to the F in 2017 or the single-species F target for each species. (SEDAR 2020).

In summary, ESRs provide the context and background necessary for management decisions, which often include decisions about trade-offs, even if not explicitly discussed. ESRs can facilitate the evaluation of trade-offs by informing where MSEs should be prioritized and where multi-species assessments are needed, as well as providing information on changes in primary production. They can provide a framework for looking across fisheries and the ecosystem to identify big changes and interactions that may be affecting certain fisheries (e.g., MAFMC risk assessment from Presentation 4). The question posed is whether ESRs, possibly through the use of conceptual diagrams and stakeholder input, provide a forum to identify where ecosystem components interact and where trade-off discussions would be useful? The discussion following

this presentation echoed the value of using conceptual diagrams to take the information contained in ESRs and visualize how the individual system components are connected.

Relevant Links

- Kaplan et al. 2021 - Management Strategy Evaluation case study paper
- Link 2017 - System-level Optimal Yield paper
- Muffley et al. 2020 - There is no I in EAFM paper
- Atlantic Menhaden Ecological Reference Points Stock Assessment Report

2.7 Presentation 7. Maintaining resilient ecosystems: state of the science on ecosystem and community well-being resilience indicators

Led by Chris Harvey (Northwest Fisheries Science Center), Phil Levin (University of Washington, Nature Conservancy), Kirsten Leong, and Jamie Gove (Pacific Islands Fisheries Science Center)

Objectives:

- Start thinking about what resilience means in each region
- Discuss what constitutes good indicators for EBFM Policy Guiding Principle 6
- "What's next?" for regional implementation, ESRs, etc.

Summary of presentations:

Day three of the workshop included a panel discussion on ecosystem and community well-being resilience indicators. Brief presentations covered resilience in the NMFS EBFM Road Map (NMFS 2016; by Chris Harvey), biological resilience indicators (by Jamie Gove), human well-being indicators (by Kirsten Leong), and general thoughts on resilience in general (by Phil Levin). Presentations were followed by a panel discussion (see below).

Chris Harvey provided a brief introduction to the EBFM Policy's Guiding Principle 6, the goal of which is to maintain resilient ecosystems, and to the concept of "resilience," which is of burgeoning interest in fields like natural resource management, ecosystem science, and the study of social-ecological systems. Resilience is being widely studied in the contexts of extreme events as well as long-term change. Resilience can be defined in many ways, and the EBFM Roadmap defines it as "the ability to prepare and plan for, absorb, recover from, and successfully adapt to adverse events." Guiding Principle 6 connects NMFS mandates to achieving and sustaining resilient stocks, habitats, ecosystems, and coastal human communities. Guiding Principle 6 also promotes actions to evaluate measures of ecosystem resilience and human well-being; such actions can be clear linkage points to ESRs.

Jamie Gove based his discussion on resilience indicators they have developed for Hawaii. On coral reefs, herbivorous fish fulfill a key function by controlling fleshy algae and allowing corals to settle and grow. Even though these species fulfill a key role, their abundance does not always result in resilience. Additional factors, including land-based pollution and runoff, can undermine the

functional role of herbivores. They also found that the spatial aggregation of the data has a high impact on results.

Kirsten Leong shared definitions of human well-being, such as "People's ability to live a life they value, a state of being with others and the environment that arises when human needs are met" (Breslow et al. 2016). Breslow identifies four domains of well-being: connections, capabilities, conditions, and the cross-cutting intersection of the other domains. Trying to include indicators from all these domains could quickly overwhelm models. Focusing on the cross-cutting domain, which includes equity, security, sustainability, and resilience could be a way forward. Well-being outcomes are linked to resilience, but resilience requires more than well-being and well-being includes more than resilience. We need to be clear on which social outcome we are striving to achieve, which is usually articulated as well-being. Stakeholders and managers often have different ideas about what is important for human well-being; the way people understand nature is as much based on cultural symbols and norms as the physical attributes of the environment. Therefore, we need to measure more than the physical attributes and activities people engage in to fully understand the benefits they receive from marine ecosystems. Ideally, this work should include an approach based on multiple types of research and sources of evidence. However, this is difficult given the limited number of social scientists available to tackle the issue. In summary, social, cultural, and indigenous sciences need to be elevated to be on par with ecological and physical sciences to fully understand how people experience social-ecological systems and want them managed.

Phil Levin's presentation focused on the bigger picture of resilience. The concept of resilience assumes the current system is the appropriate system (i.e., it is what we want). A common definition of resilience is the ability to prepare and plan for, absorb, recover from, and successfully adapt to adverse events. He notes that there are elements of both resistance to and recovery from perturbations and this can be applied to both biophysical and socio-economic systems in marine ecosystems. The classic view of resilience assumes a stable state and is often depicted as a marble in a bowl. This is not realistic. An alternate view understands there is no stability and climate change is forcing dynamics that we don't understand. This can be depicted as multiple potential mountain valleys (Kareiva & Fuller 2016) where we can try to maintain or direct the ecosystem toward a desirable valley. We need to manage for change, not stability. It would be arrogant to think we can predict what will happen and instead we need to monitor for changes. We should promote a culture of experimentation and dissemination of learning; we need to minimize inertia and be able to adjust or change quickly.

Relevant Links

- Hawaii ESR 2019
- Kareiva & Fuller 2016 - Beyond Resilience paper
- Marvier et al. 2016 - Mark Plummer's legacy paper
- Cinner & Barnes 2019 - Social Dimensions of Resilience paper
- Ingram et al. 2020 - Cultural Ecosystem Services tech memo

Figure 11. Monitoring cultural ecosystem services, benefits, and values through meanings, experiences, and ecosystem components (from Ingram et al. 2020).

2.8 Panel 1. Discussion on maintaining resilient ecosystems: ecosystem and community well-being indicator research

Led by Chris Harvey (Northwest Fisheries Science Center), Jason Link (NMFS Senior Scientist for Ecosystems), Phil Levin (University of Washington, Nature Conservancy), Kirsten Leong and Jamie Gove (Pacific Islands Fisheries Science Center)

Objectives:

- Discuss state of the science, gaps, next steps on resilience indicators

Summary of discussion:

Jason Link started by discussing the thought behind the NMFS EBFM Policy Guiding Principle 6 on maintaining resilient ecosystems. The goal was to integrate ecological and human dimensions. Jason noted that because marine ecosystem management has so many mandates (see below) with different priorities and performance metrics, a catch-all term like resilience can be useful to describe where we want to be in the future, and as an entry point for beginning to achieve some short-term EBFM goals and milestones. Even though there are still definitional debates around resilience, it is important to think about how resilience works, what it means, and how to operationalize it.

Panelists briefly discussed the mandates of NMFS and its partners with respect to ecological and social resilience. The Magnuson-Stevens Fishery Conservation and Management Act (MSA), Endangered Species Act, Marine Mammal Protection Act, Coral Reef Conservation Act, and other laws provide clear mandates to NMFS around biological and ecological resilience. The MSA also requires NMFS to consider fishing communities in management decisions, but many of the factors that influence communities and social well-being are outside the purview of NMFS or the councils and may require cross-agency collaboration for effective management. For example, new offshore wind and aquaculture projects could impact social and economic well-being in fishing communities.

Panelists were asked what characteristics make for effective indicators of resilience, within and across both the ecological and social realms of the system. In general, the panelists reiterated that suites of indicators are preferable to single indicators, which are mostly inadequate for looking at different types of resiliency within complex systems. Further, for social indicators, it is critical that we carefully link the questions we are asking to indicators that are appropriate for those questions, and any social indicators should be identified collaboratively with stakeholders to ensure they resonate with the people they are meant to reach. The ability to frequently update resilience indicators may vary from the ecological realm (as NMFS moves closer and closer to web-based platforms of biophysical indicators updated annually, seasonally, or even in near-real-time) to the social realm (where information gathered through platforms like interviews may be most effective if timed following particular events that affect fishing communities, such as the COVID-19 pandemic). Secondary data used to evaluate adaptive capacity/resilience in coastal communities can underestimate adaptive capacity because the secondary data often have an economic focus. If we do not include communities in the process of measuring and developing resilience, we could

end up inadvertently reducing resilience and well-being if we are responding to different resilience metrics than the ones that matter most to the communities in question.

When asked what our next step should be, Jason Link emphasized the importance of starting to measure resilience indicators, even if we do not have the perfect indicators identified yet; it is better to start now and adapt as we go. As other panelists noted earlier, co-developing and respectfully developing these indicators with people who derive value from the system is key.

2.9 Presentation 8. Use of traditional ecological knowledge in management

Led by Mandy Karnauskas (Southeast Fisheries Science Center), Amy Freitag (National Ocean Service), and Alohi Nakachi (Pacific Islands Fisheries Science Center)

Objectives:

- Learn about the use of citizen science and Traditional Ecological Knowledge (TEK) to track environmental conditions

Summary of presentations:

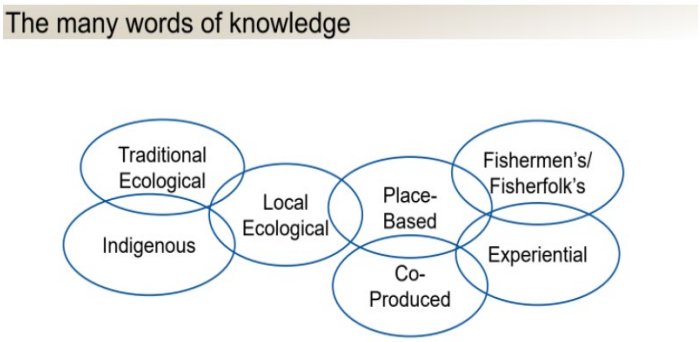

Figure 12. There are many words that can be used to describe knowledge. It is best practice to ask the knowledge holders what term they prefer.

Three experts tag-teamed this presentation. Amy Freitag set the stage by diving a bit into all the terms used for traditional (i.e., non-western scientific) knowledge and noted that stakeholders may have a preferred term. She noted that TEK cannot and should not be lifted out of its cultural context for use elsewhere; instead, researchers should respect and engage with the ways of learning associated with the traditional knowledge holders. Co-production involves integrating different knowledge types. Knowledge is part of people's identities and they have a right to that knowledge. It's best to involve knowledge holders early on in the management process, including during question development. There are a wide variety of social scientific methods available to incorporate TEK into science like ESRs; deciding which one is best involves considering the capacity and skills of the research team and the burden on the knowledge holders.

Mandy Karnauskas then briefly presented participatory modeling she has done with fishery stakeholders in the Gulf of Mexico (figure 13). Participatory system dynamics modeling pulls from the IEA framework (and similar community-based systems) to build conceptual models with stakeholder groups, scientists, and managers and increase information flow in support of stock assessments and ecosystem assessments. The method allows easy identification of factors driving stocks, the diverse set of stakeholder values and objectives, and the risks involved with changes in the system. She noted that currently the time scales for the factors she is tracking with the stakeholders are short and are thus being done outside the ESR. Mandy covered two examples. First, she has worked with snapper-grouper fishermen in the Gulf of Mexico to better understand the extent of and impacts related to red tide. The project led to additional research involving an assessment of local knowledge of current and historical red tides, and collaborative monitoring with fishermen to track anomalous physical conditions. The compilation of information helped the industry adapt by identifying actions that can increase resilience to severe events and integrating the red tide information into stock assessment projections. Second, she worked with stakeholders to document differing perceptions of the dolphin (mahi-mahi) stock across regions coincident with shifts in environmental conditions and region dependence on the resource. The Southeast Fisheries Science Center was then able to provide recommendations to the South Atlantic Fishery Management Council on subregional impacts of various proposed management actions and laid the groundwork for upcoming Management Strategy Evaluation work.

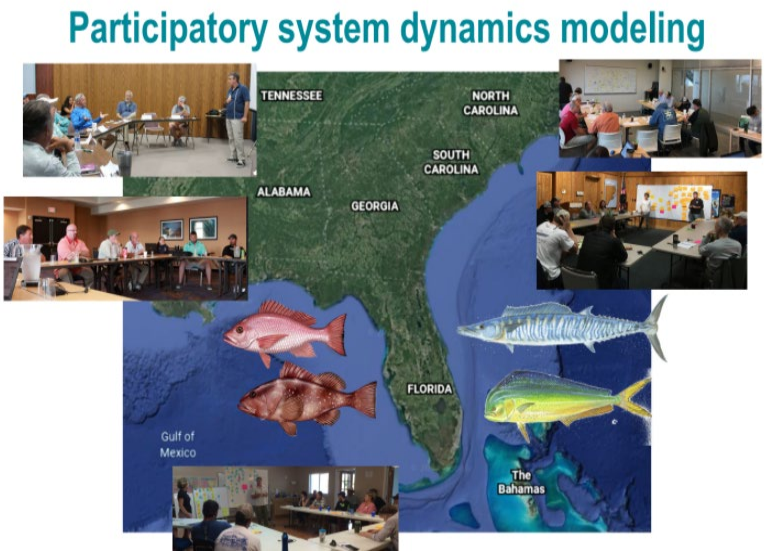

Figure 13. Map shows fisheries associated with the two examples of participatory system dynamics modeling presented by Mandy Karnauskas.

Finally, Alohi Nakachi presented the importance of including the human dimension in EBFM. Ecosystems are social-ecological systems and thus should be managed through a holistic approach that integrates the human system. Cultural ecosystem services is an approach to get at EBFM and to elicit how the environment is important to people. It is important to think about equity and inclusivity in research (e.g., who is most impacted, who is left out), and reciprocity and mutual benefits to create a space for learning and transformation. She described deliberative community workshops the Pacific Islands Fisheries Science Center conducted to better understand cultural ecosystem services for the West Hawai‘i IEA. Some of the lessons learned were:

- Relying on monetary/economic measures can be problematic for indigenous and tribal communities; there is a need for qualitative measures that describe emotional and traditional connections to the resources.

- The current frameworks are not necessarily adequate as they shouldn't separate out tangible and intangible aspects of ecosystem services and human-nature interactions.
- Local information needs to be place-based and scale matters. Who and what is actually being included in the study matters. Nuances of place can be significant.

Each plot segment (Figure 14) represents a single ecosystem service; segment colors represent ecosystem service categories (provisioning, regulating, supporting, and cultural). Effect strength is weaker toward the center and increases outwards. From Ingram et al. 2018.

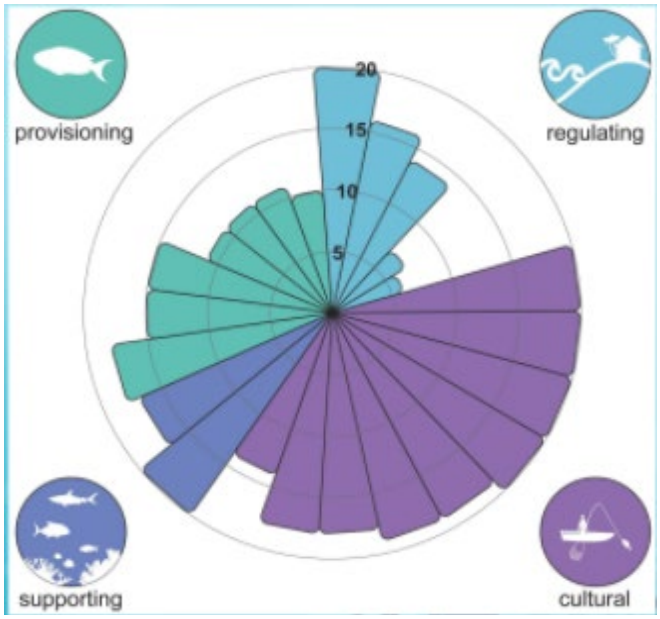

Figure 14. Participant-identified cumulative effect strengths of the overall ecosystem state (comprising four ecosystem components) on individual ecosystem services.

At this point, there is little inclusion of indigenous knowledge or local ecological knowledge in ESRs. However, given the importance of this information, regions could consider ways to increase the collection of and integration of this important information.

Relevant Links

- Ingram et al. 2018 - Hawaii participatory modeling paper
- Freitas et al. 2019 - Co-management of culturally important species paper
- Hill et al. 2020 - Indigenous and local knowledge paper
- SAFMC Dolphin Wahoo Participatory Workshops

2.10 Panel 2. Ecosystem Status Report engagement

Participants: Ebett Siddon (Alaska Fisheries Science Center), Sean Lucey (Northeast Fisheries Science Center), Yvonne de Reynier (West Coast Regional Office), Aaron Mamula (Southwest Fisheries Science Center)

Objectives:

- Learn about report engagement, timing, and lessons learned from each region. Discuss needs and options for better engagement.

Summary of panel discussion:

Question: What's going well with respect to engagement in the ESR process?

We have lots of success stories related to engagement. In the Northeast, they have recently organized a meeting of all the data owners to facilitate discussions on sharing and collaborating. When they release their State of the Ecosystem (SOE) reports (= ESR), they present them to the councils, the council scientific and statistical committees, and the regional office staff. They also release a web story at the same time. They are getting some suggestions on improving the ESRs but expect the relationships to grow and the feedback to improve over time. In the North Pacific, they are also updating their engagement schedule. They have recently added a feedback session in spring to kick off the ESR season and provide initial information on the summer surveys. They are experimenting with multiple forms of communication: briefs, web stories, videos. For the West Coast, they have written down the process they will follow when creating and releasing their ESR. Similar to the other regions, they also present separately to different users and include web stories and coordinated communications outreach events.

Question: How do we apply elements of the ESR to other products?

In the Northeast, they have a system for tracking all the requests they receive related to the SOE (=ESR) to ensure transparency in the process. They currently structure their report around fisheries management objectives that are drawn from legislation. Working with stakeholders to clarify these objectives could make their report more useful and more relevant to other products. During this workshop, we have discussed opportunities for expanding the use of ESRs to other products. The Northeast needs to think a bit more about ways to better incorporate traditional knowledge into their process.

Question: Are there particular groups and audiences that have limited engagement in your region? How to fix this?

For the West Coast, this is the first year the regional office has received a presentation on their ESR. They are thus still building new bridges. Understanding and use of the ESR is not immediate. It takes time to get people to understand what the reports provide. It is a learning process for both the authors and the users.

Question: What formats have resonated most with your audience and why?

In the North Pacific, the short briefs that come out after the ESR are being well received. They are now including a section about how information has been used. They are continually adapting. This year they are working to provide more information on how to use the report. In terms of local and traditional knowledge, their synthesis could be an opportunity to include some local anecdotes. For the Bering Sea Report, they have an integrated seabird section that includes time series, LEK contributions, and citizen science.

Question: What is the role for LEK and TEK in the process?

The presentations from earlier did a great job highlighting how local and traditional knowledge play a role in our understanding of the ecosystem. However, the best "role" of the local and traditional knowledge is still being determined. In the Southwest, it is clear that local knowledge is already an important input to their ESR, but we need to continue to find places for them in our products. Aaron's main experience with this is with the Klamath Dam Removal project. For this project, the tribes played a huge role and there is an obvious place where TEK informs the process. A formal role in the ESR is less clear.

Yvonne noted that one benefit of EBM is that we can better connect to TEK and LEK and the perception of our place in the ecosystem. This is invaluable for educating the council and for giving people a venue for seeing the bigger picture.

3.0 SUMMARIES OF REGIONAL BREAKOUT GROUPS

3.1 Northeast

The Northeast Fisheries Science Center has been producing annual State of the Ecosystem (SOE) reports for both the New England and Mid-Atlantic Councils since 2016.

Key Takeaways:

- These reports are focused ESRs for the regional fishery management councils and are valued by managers. However, the extent to which they are used within the management process differs. Currently, both the New England and Mid-Atlantic Councils are seeking ways to enhance the use of the SOEs and other ecosystem information.
- The Mid-Atlantic Council's Scientific and Statistical Committee is exploring ways to improve the incorporation of ecosystem information, such as that contained within the SOE, into the management process.
- The New England Council has also expressed some interest in revisiting their Risk Policy and exploring ways to operationalize ecosystem information in the management system.
- Both Councils, along with the South Atlantic Council, are engaged in the East Coast Climate Change Scenario Planning process, which is investigating the challenges with fisheries governance associated with the changing climate.
- The primary challenge for the region is supporting two different approaches with limited resources. The Mid-Atlantic Council has adopted an Ecosystem Approach to Fisheries Management (EAFM). This has led to a series of policy documents linking together their various FMPs. The New England Council is exploring a place-based Ecosystem-based Fisheries Management (EBFM) approach, whereas they are prototyping a Fisheries Ecosystem Plan (FEP) for the Georges Bank region. Each approach has its pros and cons with each requiring significant staff support from the Science Center and Regional Office.

Next Steps:

- Continue to work with the New England and Mid-Atlantic Councils, and their Scientific and Statistical Committees, to operationalize the use of ecosystem-level information in management decisions. This includes the development of stock-specific ecological and socio-economic profiles (ESP) which build off similar indicators as the SOE.
- The Science Center and Regional Office will also work with the New England Council on possible revision of their risk policy to more explicitly incorporate information from the SOE.
- Tangential to working with the Councils, the Northeast region will need to engage in assessing the impacts of offshore wind energy development on fishery resources. Offshore wind energy development is slated to become a major human use of the oceans along the East Coast and will likely have an impact on fisheries.

3.2 Southeast

The Southeast region covers three distinct marine ecosystems: the Gulf of Mexico, the U.S. South Atlantic, and the Caribbean. An Ecosystem Status report (ESR) for the Gulf was completed in 2013 and updated in 2017. The first ESR for the South Atlantic has recently been completed and will be available by the end of 2021, while the Caribbean ESR is currently in progress.

Key takeaways:

- Given that ESRs have only recently been developed for the marine ecosystems in the Southeast region, it was helpful for Gulf of Mexico, South Atlantic, and Caribbean Fishery Management Council staff who participated in the workshop to learn: (1) about the process and content of ESRs (or State of the Ecosystem Report) from other regions, (2) how often and in what format information from ESRs and SOEs are communicated to councils and other management bodies in other regions, and (3) how this information is utilized in other regions to inform management decisions. The group recognized the value in framing the ESR currently being developed within the South Atlantic within the context of what is being done in response to stressors such as oil spills (e.g., Deepwater Horizon) and hurricanes that are having significant impacts on the system. These effects influence heterogeneous, mixed species and multi-sector (i.e., commercial/recreational) fisheries that are themselves challenging to monitor. The ESRs need to identify these ecosystem changes and develop indicators to effectively monitor and communicate them to managers in a timely fashion. This is currently a challenge for the region given the lack of dedicated personnel time and standardization in data reporting and management.
- There is a need in the Southeast region to align information from ESRs with high-priority management needs of coastal and fisheries managers. While fisheries managers have been a focal point in the Southeast as in other regions, there are also a number of restoration activities, particularly in the Gulf, that could benefit from well-designed indicators to measure progress toward restoration goals. Progress in this area requires additional stakeholder engagement to identify what kind of information available in ESRs is most important to regional managers. This might involve scoping activities, surveys/workshops, or requests from councils to formalize what type of information and in what form would be most useful. Participatory workshops centered around direct interactions with fishermen, recent formation of ecosystem subcommittees to the SSC,

and increasing frequency of presentations directly to the council or SSC are positive signs of progress toward increased stakeholder engagement and familiarity with ecosystem information. The workshop provided an opportunity for scientists and council staff to draw on the experiences accrued in other regions and could help clarify how ESRs might be used in the Southeast.

- It is increasingly clear that there are persistent (press) changes occurring in many Southeast ecosystems, such as rising temperatures and increasing frequency and severity of hypoxia and harmful algal blooms (HABs), as well as event-scale (pulse).
- Ecosystem reporting activities in the Southeast need to be better aligned with the current assessment and management process. Most ecosystem reporting to date has occurred in an ad hoc manner rather than as a routine and regular activity aligned with assessment, SSC, and council schedules. This is a challenge given the limited time available on SSC and council schedules and current staff workloads.

Next steps / Needs for the Southeast/Caribbean/Gulf of Mexico region:

- Finalize the South Atlantic and Caribbean ESRs and make them available (via full reports, presentations, summary documents) to council and other coastal management bodies.
- Develop a strategic approach to engage councils and other managers on the type of ecosystem reporting that would be most useful.
- Develop an approach to continue the development and updating of ESRs given current resource constraints. This might involve increased collaboration with partners on relevant data, coordination with other regions (e.g., the Northeast) to co-develop indicators relevant to both regions, and updating of key subsets of indicators rather than full indicator suites.

3.3 West Coast

West Coast regional breakout groups identified several takeaways from the workshop in relation to the annual California Current ESR. Some of those were:

- There are major ecosystem issues that are known or emerging (climate change, extreme events, offshore renewable energy planning, etc.) that will affect fisheries on the West Coast. The ESR needs to provide indicators and interpretation of these issues in a manner that supports future risk assessments, trade-off analyses, planning, and adaptation.
- Many products created within or in parallel to ESRs in other regions may be valuable additions to our efforts, such as 2-page graphical summaries, the risk tables from Alaska, and the automation and conceptual model approaches from the Northeast.
- One challenge we discussed is that the ESR has multiple audiences within the Pacific Fishery Management Council (PFMC) and that they view the report differently. Council members want the big picture; advisory bodies, such as the SSC, often focus on fine detail; and fishery participants may associate ecosystem issues with either increased regulation or with a sense of hopelessness, as with climate-driven threats to salmon.
- Developing a strategic approach to interacting with the diverse audiences within the PFMC could help us to address their needs while reducing the workload of developing the report. Successes from other regions that were described during the workshop (e.g., NEFSC and MAFMC; AFSC and NPFMC) could inform this approach.

- One opportunity is that in a post-COVID world, virtual or hybrid meetings may enable us to reach more PFMC advisory bodies and require fewer presentations to do so.

Some key next steps for the West Coast are:

- Improve the efficiency of ESR production, accessibility via the CCIEA website, and readability and clarity through effective and relatable narratives and visualizations.
- Eliminate steps that are costly in time and effort relative to the management support they provide (for example, converting each ESR into a subsequent tech memo).
- Because the PFMC prioritizes decisions for specific FMPs at different meetings, develop complementary short-form ESRs for those meetings that focus on those FMPs.
- Build focus on climate change, including mechanisms and understanding of shifting baselines, reference points, and the flexibility, adaptability, and resilience of communities.
- Develop some trial risk tables, similar to those generated by the AFSC for the NPFMC, to elicit PFMC interest and possibly facilitate use of ESRs in tactical decision-making.

3.4 Alaska

The Alaska breakout groups identified the following takeaways:

- A habitat compression index as applied in the West Coast Region or other indicators may help inform how we address cumulative impacts to Essential Fish Habitat (EFH) in our region.
- Labeling of multiple EBFM products causes confusion (e.g. EBM, EBFM, ESR, SOE, etc.).
- Having a central place for a lot of indicators is good because they can be used for different EBFM products. Scientists have to communicate why they're using the indicators they're using.
- Defining priority areas by ecosystem would be helpful.
- The PROCESS of developing the ESRs seems to be the glue that is important for the science centers and the regional offices and not necessarily the ESR products themselves. It's important to get the engagement between the science center and the regional office during the development of the ESRs.
- Make time to have the right conversations between the science center and regional office after the ESRs are presented (e.g., discussing the meaning of the information for management needs to address EBFM that may not come up in directed presentations for Plan Teams and SSC). The idea is to include ESR authors at quarterly Alaska EBFM Working Group member EBFM Regional Outlook meetings.
- Consider how to best include social science information in our region—through ESR or another avenue.

Challenges:

- Communication is both an opportunity and a challenge—transparency is important in order to track how we're learning. It's also important for credibility.

- The Council is looking for ways to incorporate climate information more broadly across Council actions.
- Climate and fisheries initiative: data could be coming out of this that could help to inform NOAA (both a challenge and an opportunity).
- Outside of NOAA, there are hurdles that are hard to address (e.g., USCG vessel traffic data that they can't distribute. That information has to be purchased).
- Finding the right way/best way to communicate to managers—tailoring information to user groups.
- Understanding that creating flexibility and responding to environmental changes identified in a report may be easier for managers than for individual stakeholders where changes impact their livelihoods. Shifting baselines and change are not impacting ecosystem components equally. We need to be measuring the right things and have metrics in place to identify change and quantify resilience.
- A challenge for ESRs is separating tactical and strategic items. This is the reason for evolving the "health report card" idea through the Bering Sea FEP process. It's hard to know what to do with respect to resilience and other larger topics; we need to identify goals.
- We need more resources brought to all challenge questions.

Opportunities:

- Increasing AFSC/AKR/NPFMC communication.
- The more clearly we can define management questions with the Council, the more specific and effective we can design the indicators.
- Presentations at Plan Team meetings, Council meetings, and other venues are opportunities for communication, both for getting the information out and for taking in information to refine our process and information.
- We should be asking communities and industry what they are doing to be resilient or how they know that they are resilient. ESRs can provide a full picture of what is changing.

Next steps:

- Many things are in the pipeline to make improvements but they don't exist yet so the ESR is the placeholder for those. Continuing to work on those additional products and delineating between the ESR and those other products will be important.
- The timescale of the ESR products—are we addressing current status and how we address long-term climate change projections.
- Addressing how to include social science indicators: Are ESRs the right mold for social science and local knowledge/traditional knowledge information/indicators? If local knowledge/traditional knowledge information is included, it will be important to include it in the appropriate place and context to be useful.

3.5 Pacific Islands

The Pacific Islands Region encompasses a massive geographic area (as large as all the other U.S. EEZs combined), an astonishing diversity of habitats, and unique human communities that have

relationships with the marine environment that are distinct from other communities in the region and from those in the mainland United States. In many ways, these conditions have shaped the evolution of ESRs in the PI Region with an initial emphasis on engagement with communities and conditions in a specific region before gradually expanding the efforts to reflect larger geographic areas and broader human communities.

Key takeaways:

- ESRs developed differently in various regions and currently play a limited role in management in the PI region.
- Current ESRs, while involving extensive stakeholder engagement, are of limited use for multiple management needs because they target specific geographies. The future of ESRs in the region will depend on regional interest, broad agency and partner engagement, and EBFM implementation requirements.
- The Council's SAFE report is the most prominent use of ESR-like information but is limited to informing the SEEM (social, economic, ecological, monitoring) process.
- EBFM implementation will require working across divisions, but reluctance to new processes (i.e., risk assessment and trade-off analyses) or because they are contradictory to the mandates will hinder acceptance.
- The PI Region must consider a broad range of scales in ecosystem resilience including not only geographic area, but also the intensity and frequency of events that affect ecosystems.
- Focus on better states for ecosystems under future conditions (not steady-state based on conditions now) that vary by community and engage at those scales to ensure development of clear management questions and proper ecosystem change metrics that are relevant to stakeholders and applicable to management decisions.
- Human dimensions data remain largely missing from current PI Region ESRs due to lack of data, difficulty incorporating socio-economic data into reports, and uncertainty in how management would use the information.
- Successful community engagement should be completed early and often to frame the problem, done with cultural sensitivity using existing community systems, and focused on identifying all the stakeholders that need to be involved in management decisions.

<u>Opportunities</u>

- Collaboration between the Council, Science Center, and Regional Office on the development of ESRs that support, complement, and potentially expand existing efforts within the SAFE report for the Hawaiian Islands.
- Possibility of working within the SEEM (social, economic, ecological, monitoring considerations) process.
- Incorporation of risk tables into the PI reports.
- Implementation of EBFM approaches could result in increased community engagement.
- Resilience based on a"better state" under likely climate change conditions rather than a "steady-state."
- Development of ESRs that have local and indigenous engagement from the beginning.
- Partnerships with other agencies and organizations (e.g., non-profits) that have shared needs.

Challenges

- Data limitations to meet the needs for ESRs/EBFM due to the massive size of the region, and the life history and management structures of many of the most valuable commercial fisheries.
- The large expanse of the Pacific Islands domain makes it extremely difficult to produce an ESR for each portion of the region.
- Lack of fishery-independent information for most species of interest.
- Getting involvement from PIFSC and PIRO protected species divisions.
- The ability to assess thresholds in a data-poor environment with a limited number of stock assessments for many of the species of interest.
- Properly identifying who, when, and at what scale to engage the local communities in ways that they feel included. A history of a lack of engagement on past issues will complicate the effort, as will mandate-driven timelines.
- Recognition of the magnitude of the challenge, yet limited commitment of resources.
- The necessity for productive engagement with the international fisheries community through regional fishery management organizations and scientific collaborations to collect data and apply policies that promote resilience of many of the highly migratory pelagic stocks.
- Limitations on the capacity in data and expertise in the region to seek community engagement.

Next Steps

- Further engagement across divisions and between Science Center, Regional Office and partners to further ESR development.
- Expand the West Hawaii ESR to include a broader state-wide scale in the next ESR update.

4.0 NATIONAL LEVEL OBSERVATIONS AND NEXT STEPS

The workshop successfully brought together science center, regional office, headquarters, and council staff to learn about examples of ESR and ESR-related projects from around the United States. Additionally, participants learned about approaches to getting more ecosystem information, including economics and human dimension, into the fisheries management decision processes. Break-out groups provided a forum for introducing or re-familiarizing regional staff to each other and allowed for region-specific discussions about priorities and needs. The cross-regional plenary and regional breakout discussions highlighted the need to continue the momentum of the workshop with further regional and national dialog. Below are some reflections from the National EBFM Working Group.

National Level Takeaways:

- Current ESRs are mostly meeting expectations of surveyed council and regional office staff and are recognized as great reference, education, and communication tools.

- Ecosystem information contained in ESRs can be used in other products that may serve as on-ramps into the management process. Information from other products (i.e., climate vulnerability assessments) could also be integrated into ESRs to help identify high-priority or emerging indicators for timely assessment of risk, and to provide a more complete description of ecosystem conditions.
- Council staff and/or regional office engagement is critical to clarifying fishery management priorities that could benefit from the incorporation of more ecosystem information. Two-way communication between managers and scientists is key to identifying products that meet management needs and are scientifically feasible. In addition, regular ongoing conversations on expectations are crucial as management needs, ecosystem conditions, and staffing resources change.
- Interactions across science centers, regional offices, and council staff led to insights on the development and use of ESRs and connection to EBFM milestones that will inform the continued evolution of ESRs.
- Because each region has a slightly different focus for EBFM, there is high value in regions learning from each other.
- Fisheries management is facing many challenges, including climate change impacts on productivity and distribution. ESRs are a potential avenue for tracking and documenting these changes. It is unclear if ESRs can also offer a forum for identifying options for addressing these changes.
- Trying to make ESRs do too much could result in them not doing anything well. Increasing staff workload associated with ESRs may leave less staff time to work on other things
- There can be several ways to address resource constraints such as prioritizing and focusing the scope of ESRs to align tightly with management objectives and partnering with others to expand data sources.

Regional focus areas for advancing ESRs:

- Northeast and Mid-Atlantic: Work with the New England and Mid-Atlantic Councils, and their Scientific and Statistical Committees, to operationalize the use of ESRs in management decisions; work with New England on the possible revision on their risk policy to more explicitly incorporate ESR information; continue to pursue Ecosystem Socio-economic Profiles and incorporation of socio-economic and ecosystem information.
- Southeast/Caribbean/Gulf of Mexico: Finalize the South Atlantic and Caribbean ESRs and socialize to determine what the councils are most interested in; coordinate with the Northeast region on emerging issues and relevant, overlapping indicators; connect with partners on relevant data; work toward more regular updates to ESRs recognizing resource constraints.
- West Coast: Streamline ESR production effort and improve tailoring, presentation, and data visualization for different partners; continue development of social-economic indicators, e.g. related to National Standard 8; link indicators to risk assessments and ecosystem thresholds.
- Alaska: Hold quarterly Alaska EBFM Outlook meetings to discuss regional office/science center EBFM strategic priorities and timely actions, including as related to the development of the ESRs. Address how to include social science indicators. Are

ESRs the right mold for social science and local knowledge/traditional knowledge information/indicators? If local knowledge/traditional knowledge/social science information is included, it is important to include it in the appropriate place and context to be useful.

- Pacific Islands: Improve the understanding of climate change on species habitats and spatial distribution and develop forecast models of potential impacts on Pacific fishing communities; explore the use of risk assessment models and trade-off analyses to consider future fishing areas and interactions with protected species by integrating ecosystem science and management; explore alternatives for the collection of future data needs (e.g., eDNA, autonomous systems, satellite data, numerical modeling, and socio-economic data); establish a Council, PIFSC, PIRO EBFM working group to liaise with leadership and the Scientific and Statistical Committee.

EBFM Working Group Next Steps Include:

- Sharing this report widely, including with ESR authors as well as regional office and council staff who were unable to participate in some or all of the workshop.
- Leveraging the outcomes of regional roundtable discussions to
    - Improve coordination among fishery management council staff, regional office staff, and science center ESR authors to prioritize data needs in alignment with regionally specific management priorities.
    - Improve managers' understanding of possible approaches to address their regional management needs (ESRs, multispecies models).
    - Explore partnerships to improve data quantity and quality and incorporate other ecosystem information (e.g., resiliency, traditional knowledge, habitat).
    - Strengthen inclusion of social science in EBFM planning and implementation.
    - Strengthen coordination with habitat and protected species management needs and data streams used in ecosystem status reports.
- Organizing a future workshop to focus on technical aspects of ESRs, such as how to move toward data automation, process for adding and removing indicators through time, and best practices for communication and dissemination.
- Increasing social science expertise on the EBFM Working Group and exploring ways to further integrate socio-economic considerations into assessments and models.
- Providing regional and HQ quarterly updates on any activities made in response to this workshop as part of the EBFM Working Group meetings to learn from successes and discuss challenges.
- Considering further investigations of ecological and social resilience indicators.
- Developing additional products from the workshop; assisting in identifying resources that can contribute to ESR products and applications; and exploring leveraging Council Coordination Committee[1] to strengthen council engagement.

[1] The Council Coordination Committee consists of the chairs, vice chairs, and executive directors from each of the eight regional fishery management councils.

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6.0 REFERENCES

Anstead, K. A., Drew, K., Chagaris, D., Schueller, A. M., McNamee, J. E., Buchheister, A., Nesslage, G., Uphoff Jr., J. H., Wilberg, M. J., Sharov, A., Dean, M. J., Brust, J., Celestino, M., Madsen, S., Murray, S., Appelman, M., Ballenger, J. C., Brito, J., Cosby, E., Craig, C., Flora, C., Gottschall, K., Latour, R. J., Leonard, L., Mroch, R., Newhard, J., Orner, D., Swanson, C., Tinsman, J., Houde, E. D., Miller, T. J., and Townsend, H. 2021. The Path to an Ecosystem Approach for Forage Fish Management: A Case Study of Atlantic Menhaden. Frontiers in Marine Science 8. https://doi.org/10.3389/fmars.2021.607657

Bastille, K., Hardison, S., deWitt, L., Brown, J., Samhouri, J., Gaichas, S., Lucey, S., Kearney, K., Best, B., Cross, S., Large, S., and Spooner, E. 2021. Improving the IEA Approach Using Principles of Open Data Science, Coastal Management, 49:1, 72-89. https://doi.org/10.1080/08920753.2021.1846155

Breslow, S. J., Sojka, B., Barnea, R., Basurto, X., Carothers, C., Charnley, S., Coulthard, S., Dolsak, N., Donatuto, J., Garcia-Quijano, C., Hicks, C. C., Levine, A., Mascia, M. B., Norman, K., Poe, M., Satterfield, T., St. Martin, K., and Levin, P. S. 2016. Conceptualizing and operationalizing human wellbeing for ecosystem assessment and management. Environ. Sci. Policy 66: 250–259. https://doi.org/10.1016/j.envsci.2016.06.023

Cinner, J.E. and Barnes, M. L. 2019. Social Dimensions of Resilience in Social-Ecological Systems. One Earth, 1(1): 51-56. https://doi.org/10.1016/j.oneear.2019.08.003

Craig, J.K., Kellison, G.T., Binion-Rock, S.M., Regan, S.D., Karnauskas, M., Lee, S.-K., He, R., Allen, M., Bacheler, N.M., Blondin, H., Buckel, J.A., Burton, M.L., Cross, S.L., Freitag, A., Groves, S.H., Hayes, C.A., Kimball, M.E., Morley, J.W., Muñoz, R.C., Murray, G.D., Reimer, J.J., Shertzer, K.W., Shropshire, T.A., Siegfried, K.I., Taylor, J.C., and Volkov, D.L. 2021.Ecosystem Status Report for the U.S. South Atlantic Region. NOAA Technical MemorandumNMFS-SEFSC-753, 145 p. https://doi.org/10.25923/qmgr-pr03

Crozier, L. G., McClure, M. M., Beechie, T., Bograd, S. J., Boughton, D. A., Carr, M., Cooney, T. D., Dunham, J. B., Greene, C. M., Haltuch, M. A., Hazen, E. L., Holzer, D. M., Huff, D. D., Johnson, R. C., Jordan, C. E., Kaplan, I. C., Lindley, S. T., Mantua, N. J., Moyle, P. B., Myers, J. M., Nelson, M. W., Spence, B. C., Weitkamp, L. A., Williams, T. H., and Willis-Norton, E. 2019. Climate vulnerability assessment for Pacific salmon and steelhead in the California Current Large Marine Ecosystem. PLoS ONE 14(7): e0217711. https://doi.org/10.1371/journal.pone.0217711

DePiper, G., Gaichas, S., Muffley, B., Ardini, G., Brust, J., Coakley, J., Dancy, K., Elliott, G. W., Leaning, D. C., Lipton, D., McNamee, J., Perretti,C.,Rootes-Murdy, K., and Wilberg, M. J. 2021. Learning by doing: collaborative conceptual modelling as a path forward in ecosystem-based manage-ment. ICES Journal of Marine Science 78(4): 1217–1228. https://doi.org/10.1093/icesjms/fsab054

Deroba, J. J., Gaichas, S. K., Lee, M.-Y., Feeney, R. G., Boelke, D., and Irwin, B. J. 2019. The dream and the Reality: Meeting Decision-Making time frames while incorporating Ecosystem and

Economic Models into Management Strategy Evaluation. Canadian Journal of Fisheries and Aquatic Sciences 76. https://doi.org/10.1139/cjfas-2018-0128

Dorn, M. W. and Zador, S. G. 2020. A risk table to address concerns external to stock assessments when developing fisheries harvest recommendations, Ecosystem Health and Sustainability 6:1. https://doi.org/10.1080/20964129.2020.1813634

Feeney, R. G., Boelke, D. V., Deroba, J. J., Gaichas, S., Irwin, B. J., and Lee, M.-Y. 2019. Integrating Management Strategy Evaluation into Fisheries Management: Advancing Best Practices for Stakeholder Inclusion Based on an MSE for Northeast US Atlantic Herring. Canadian Journal of Fisheries and Aquatic Sciences 76. https://doi.org/10.1139/cjfas-2018-0125

Ferriss, B.E. and S. Zador 2021. Ecosystem Status Report for the Gulf of Alaska, Stock Assessment and Fishery Evaluation Report. North Pacific Fishery Management Council, 1007 West Third, Suite 400, Anchorage, AK 99501.

Freitas, C. J., Lopes, P. F. M., Campos-Silva, J. V., Noble, M. M., Dyball, R., and Peres, C. A. 2019. Co-management of culturally important species: A tool to promote biodiversity conservation and human well-being. People and Nature 2(1): 61-81. https://doi.org/10.1002/pan3.10064

Gaichas, S. K., DePiper, G. S., Seagraves, R. J., Muffley, B. W., Sabo, M. G., Colburn, L. L., and Loftus, A. J. 2018. Implementing ecosystem approaches to fisheries management: risk assessment in the US Mid-Atlantic. Frontiers in Marine Science 5. https://doi.org/10.3389/fmars.2018.00442

Gaichas, S. K., Seagraves, R. J., Coakley, J. M., DePiper, G.S., Guida, V. G., Hare, J. A., Rago, P. J., and Wilberg, M. J. 2016. A framework for incorporating species, fleet, habitat and climate interactions into fisheries management. Frontiers in Marine Science 3. https://doi.org/10.3389/fmars.2016.00105

Gove, J. M., Lecky, J., Walsh, W. J., Ingram, R. J., Leong, K., Williams, I. D., Polovina, J. J., Maynard, J. A., Whittier, R., Kramer, L., Schemmel, E., Hospital, J., Wongbusarakum, S., Conklin, E., Wiggins, C., and Williams, G. J. 2019. West Hawai‘i integrated ecosystem assessment ecosystem status report. Pacific Islands Fisheries Science Center, PIFSC Special Publication, SP-19-001, 46 p. https://doi.org/10.25923/t3cc-2361

Hare, J. A., Morrison, W. E., Nelson, M. W., Stachura, M. M., Teeters, E. J., Griffis, R. B., Alexander, M. A., Scott, J. D., Alade, L., Bell, R. J., Chute, A. S., Curti, K. L., Curtis, T. H., Kircheis, D., Kocik, J. F., Lucey, S. M., McCandless, C. T., Milke, L. M., Richardson, D. E., Robillard, E., Walsh, H. J., McManus, M. C., Marancik, K. E., and Griswold, C. A. 2016. A Vulnerability Assessment of Fish and Invertebrates to Climate Change on the Northeast U.S. Continental Shelf. PLoS ONE 11(2): e0146756. doi:10.1371/journal.pone.0146756

Harvey, C. J., N. Garfield, G. D. Williams, and N. Tolimieri, editors. 2021. Ecosystem Status Report of the California Current for 2020–21: A Summary of Ecosystem Indicators compiled by the California Current Integrated Ecosystem Assessment Team (CCIEA). U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-170.

Hausner, A., Samhouri, J. F., Hazen, E. L., Delgerjargal, D., and Abrahms, B. 2021. Dynamic strategies offer potential to reduce lethal ship collisions with large whales under changing climate conditions. Marine Policy 130. https://doi.org/10.1016/j.marpol.2021.104565

Hill, R., Adem, Ç., Alangui, W.V., Molnár, Z., Aumeeruddy-Thomas, Y., Bridgewater, P., Tengö, M., Thaman, R., Adou Yao, C.Y., Berkes, F., Carino, J., Carneiro da Cunha, M., Diaw, M.C., Díaz, S., Figueroa, V.E., Fisher, J., Hardison, P., Ichikawa, K., Kariuki, P., Karki, M., Lyver, P.O., Malmer, P., Masardule, O., Oteng Yeboah, A.A., Pacheco, D., Pataridze, T., Perez, E., Roué, M.-M., Roba, H., Rubis, J., Saito, O., and Xue, D. 2020. Working with Indigenous, local and scientific knowledge in assessments of nature and nature's linkages with people. Curr. Opin. Environ. Sustain., Indigenous Conceptualizations of 'Sustainability' 43, 8–20. https://doi.org/10.1016/j.cosust.2019.12.006

Ingram, R. J., Leong, K. M., Gove, J., and Wongbusarakum, S. 2020. Including human well-being in resource management with cultural ecosystem services. U.S. Dept. of Commerce, NOAA Technical Memorandum NOAA-TM-NMFS-PIFSC-112, 94 p. https://doi.org/10.25923/q8ya-8t22

Ingram, R. J., Oleson, K. L. L., and Gove, J. M. 2018. Revealing complex social-ecological interactions through participatory modeling to support ecosystem-based management in Hawai'i. Marine Policy 94: 180-188. https://doi.org/10.1016/j.marpol.2018.05.002

Kaplan, I. C., Gaichas, S. K. ,Stawitz, C. C., Lynch, P. D., Marshall, K. N., Deroba, J. J., Masi, M., Brodziak, J. K. T., Aydin, K. Y., Holsman, K., Townsend, H,,Tommasi, D., Smith, J. A., Koenigstein, S.,Weijerman, M., and Link, J. 2021. Management Strategy Evaluation: Allowing the Light on the Hill to Illuminate More Than One Species. Frontiers in Marine Science 8:624355. https://doi.org/10.3389/fmars.2021.624355

Kareiva, P. and Fuller, E. 2016. Beyond Resilience: How to Better Prepare for the Profound Disruption of the Anthropocene. Global Policy 7: Suppl. 1. https://doi.org/10.1111/1758-5899.12330

Karnauskas, M., Kelble, C. R., Regan, S., Quenée, C., Allee, R., Jepson, M., Freitag, A., Craig, J. K., Carollo, C., Barbero, L., Trifonova, N., Hanisko, D., and Zapfe, G. 2017. 2017 Ecosystem status report update for the Gulf of Mexico. NOAA Technical Memorandum NMFS-SEFSC-706, 51 p.

Large, S. L, Fay, G., Friedland, K. D., and Link, J.S. 2013. Defining trends and thresholds in responses of ecological indicators to fishing and environmental pressures. ICES Journal of Marine Science 70(4): 755-767. https://doi.org/10.1093/icesjms/fst067

Lettrich, M. D., Asaro, M. J., Borggaard, D. L., Dick, D. M., Griffis, R. B., Litz, J. A., Orphanides, C. D., Palka, D. L., Pendleton, D. E., and Soldevilla, M. S. 2019. A Method for Assessing the Vulnerability of Marine Mammals to a Changing Climate. NOAA Tech. Memo. NMFS-F/SPO-196, 73 p.

Lettrich, M. D., Dick, D. M., Fahy, C. C., Griffis, R. B., Haas, H. L., Jones, T. T., Kelly, I. K., Klemm, D., Lauritsen, A. M., Sasso, C. R., Schroeder, B., Seminoff, J. A., and Upite, C. M. 2020. A Method for Assessing the Vulnerability of Sea Turtlesto a Changing Climate. NOAA Tech. Memo. NMFS-F/SPO-211, 84p.

Levin, P. S., Breslow, S. J., Harvey, C. J., Norman, K. C., Poe, M. R., Williams, G. D., and Plummer, M. L. 2016. Conceptualization of Social-Ecological Systems of the California Current: An Examination of Interdisciplinary Science Supporting Ecosystem-Based Management, Coastal Management, 44:5, 397-408, DOI: 10.1080/08920753.2016.1208036

Link, J. S. 2017. System-level optimal yield: increased value, less risk, improved stability, and better fisheries. Canadian Journal of Fisheries and Aquatic Sciences 75(1): 1-16. http://dx.doi.org/10.1139/cjfas-2017-0250

Link, J. and Brodziak, J. (eds.). 2002. Report on the Status of the NE US Continental Shelf Ecosystem. NEFSC Ecosystem Status Working Group. Northeast Fisheries Science Center Ref. Doc. 02-11, 245 pp.

Link, J. S., Griffis, R., and Busch, S. (eds.). 2015. NOAA Fisheries Climate Science Strategy. U.S. Dept. of Commerce, NOAA Technical Memorandum NMFS-F/SPO-155, 70p.
Muffley et al. 2020. There is no I in EAFM. Adapting Integrated Ecosystem Assessment for Mid-Atlantic Fisheries Management. Coastal Management 49:1, 90-106, https://doi.org/10.1080/08920753.2021.1846156

Marvier, M., Kareiva, P., and Fuller, E. 2016. Mark Plummer'sLegacy: Leave No Orthodoxy Unquestioned, Coastal Management, 44:5, 380-396. https://doi.org/10.1080/08920753.2016.1208035

Morrison, W.E., Nelson, M. W., Howard, J. F., Teeters, E. J., Hare, J. A., Griffis, R. B., Scott, J.D., and Alexander, M.A. 2015. Methodology for Assessing the Vulnerability of Marine Fish and Shellfish Species to a Changing Climate. U.S. Dept. of Commer., NOAA. NOAA Technical Memorandum NMFS-OSF-3, 48 p. http://dx.doi.org/10.7289/V54X55TC

Muffley, B., Gaichas, S., DePiper, G., Seagraves, R., and Lucey, S. 2021. There Is no I in EAFM Adapting Integrated Ecosystem Assessment for Mid-Atlantic Fisheries Management, Coastal Management, 49:1, 90-106. https://doi.org/10.1080/08920753.2021.1846156

NMFS. 2016a. Ecosystem-Based Fisheries Management Policy of the National Marine Fisheries Service, National Oceanic and Atmospheric Administration.

NMFS. 2016b. NOAA Fisheries Ecosystem-Based Fisheries Management Roadmap, National Oceanic and Atmospheric Administration.

NPFMC. 1994. Ecosystem Considerations for 1995. Stock Assessment and Fishery Evaluation (SAFE) Report for the Bering Sea, Aleutian Islands, and Gulf of Alaska. North Pacific Fisheries Management Council. Box 103136, Anchorage, AK 99510.

NPFMC. 2019. Bering Sea, Aleutian Islands and Gulf of Alaska SAFE. Appendix 3C. Ecosystem and Socioeconomic Profile of the Sablefish stock in Alaska, November

Ortiz, I. and Zador, S., 2021. Ecosystem Status Report 2021: Aleutian Islands, Stock Assessment and Fishery Evaluation Report. North Pacific Fishery Management Council,
1007 West Third, Suite 400, Anchorage, AK 99501.

Sagarese, S. R., Vaughan, N. R., Walter III, J. F., and Karnauskas, M. 2021. Enhancing single-species stock assessments with diverse ecosystem perspectives: a case study for Gulf of Mexico red grouper (*Epinephelus morio*) and red tides. Canadian Journal of Fisheries and Aquatic Sciences 78(8). https://doi.org/10.1139/cjfas-2020-0257

Samhouri, J. F., Andrews, K. S., Fay, G., Harvey, C. J., Hazen, E. L., Hennessey, S. M., Holsman, K., Hunsicker, M. E., Large, S. I., Marshall, K. N., Stier, A. C., Tam, J. C., and Zador, S. G. 2017. Defining ecosystem thresholds for human activities and environmental pressures in the California Current. Ecosphere 8(6). https://doi.org/10.1002/ecs2.1860

Santora, J.A., Mantua, N.J., Schroeder, I.D., Field, J. C., Hazen, E. L., Bogard, S. J., Sydeman, W. J., Wells, B. K., Calambokidis, J., Saez, L., Lawson, D., and Forney, K. A. 2020. Habitat compression and ecosystem shifts as potential links between marine heatwave and record whale entanglements. Nat Commun 11, 536. https://doi.org/10.1038/s41467-019-14215-w

SEDAR. 2020. SEDAR 69 – Atlantic Menhaden Ecological Reference Points Stock Assessment Report. SEDAR, North Charleston SC. 560 pp. available online at: http://sedarweb.org/sedar-69

Siddon, E. 2021. Ecosystem Status Report for the Eastern Bering Sea, Stock Assessment and Fishery Evaluation Report. North Pacific Fishery Management Council, 1007 West Third, Suite 400, Anchorage, AK 99501.

Slater, W. L., DePiper, G., Gove, J. M., Harvey, C. J., Hazen, E. L., Lucey, S. M., Karnauskas, M., Regan, S. D., Siddon, E. C., Yasumiishi, E. M., Zador, S. G., Brady, M. M., Ford, M. D., Griffis, R. B., Shuford, R. L., Townsend, H. M., O'Brien, T. D., Peterson, J. O., Osgood, K. E. and Link, J. S. 2017. Challenges, Opportunities and Future Directions to Advance NMFS Ecosystem Status Reports (ESRs): Report of the National ESR Workshop. NOAA Technical Memorandum NMFS-F/SPO-174, 66 p.

Snowden, D. J. and Boone, M. E. 2007. A leader's framework for decision making. Harvard Business Review 85: 68-75.

Spencer, P. D., Hollowed, A. B., Sigler, M. F., Hermann, A. J., Nelson, M. W. 2019. Trait-based climate vulnerability assessments in data-rich systems: An application to eastern Bering Sea fish and invertebrate stocks. Glob Change Biol. 25:3954–3971. https://doi.org/10.1111/gcb.14763

Tam, J. C., Link, J. S., Large, S. I., Andrews, K., Friedland, K. D., Gove, J., Hazen, E., Holsman, K., Karnauskas, M., Samhouri, J. F., Shuford, R., Tomilieri, N., and Zador, S. 2017. Comparing Apples to Oranges: Common Trends and Thresholds in Anthropogenic and Environmental Pressures across Multiple Marine Ecosystems. Frontiers in Marine Science 4: 282.https://doi.org/10.3389/fmars.2017.00282

Tommasi, D., deReynier, Y., Townsend, H., Harvey, C. J., Satterthwaite, W. H., Marshall, K. N., Kaplan, I. C., Brodie, S., Field, J. C., Hazen, E. L., Koenigstein, S., Lindsay, J., Moore, K., Muhling, B., Pfeiffer, L., Smith, J. A., Sweeney, J., Wells, B., and Jacox, M. G. 2021. A Case Study in Connecting Fisheries Management Challenges with Models and Analysis to Support EBFM in the California Current Ecosystem. Frontiers 8. https://doi.org/10.3389/fmars.2021.624161

United States. National Marine Fisheries Service.;Northeast Fisheries Science Center. 2021. State of the Ecosystem 2021: Mid-Atlantic Revised. DOI : https://doi.org/10.25923/jd1w-dc26

United States. National Marine Fisheries Service.;Northeast Fisheries Science Center. 2021. State of the Ecosystem 2021: New England Revised. DOI : https://doi.org/10.25923/6pww-mw45

Welch, H., Hazen, E. L., Briscoe, D. K., Bograd, S. J., Jacox, M. G., Eguchi, T., Benson, S. R., Fahy, C. C., Garfield, T., Robinson, D., Seminoff, J. A., and Bailey, H. 2019. Environmental indicators to reduce loggerhead turtle bycatch offshore of Southern California. Ecological Indicators 98: 657-664. https://doi.org/10.1016/j.ecolind.2018.11.001

APPENDIX A – WORKSHOP AGENDA

Ecosystem Status Report (ESR) Workshop Agenda

August 3, 2021:
Examples from current ESRs

TIME (pm)	DISCUSSION ITEM (LEADS)
2:00 - 2:10	Welcome and Ground Rules (Kenric Osgood and Karen Abrams)
2:10 - 2:20	Discuss 2017 ESR workshop vs. current workshop goals (Kenric Osgood)
2:20 - 2:50	Discuss current state of existing ESRs and pre-meeting feedback from Regional Office and Council staff (Tauna Rankin)
2:50 - 3:20	Ecosystem considerations in management: West Coast region example (Toby Garfield)
3:20 - 3:50	Ecosystem considerations in management: NPFMC example (Stephani Zador)
3:50-4:00	BREAK
4:00 - 4:40	Regional Breakout Groups (AK - Jodi Pirtle, NE - Emily Keiley, PI - Richard Hall, SE - Todd Kellison, WC - Wendy Morrison)
4:40 - 5:00	Plenary

August 4, 2021
Cumulative impacts, cumulative risks and trade-offs. Theme: focus on existing uses MAFMC, AK ecosystem caps, begin to transition to other uses? Focus is less on the ESR but towards ESR derivative or other products that address EBFM RM.

TIME (pm)	DISCUSSION ITEM (LEADS)
2:00 - 2:05	Ground Rules, Recap (Sean Lucey)
2:05 - 2:15	Introduce need to continue to make ESRs more effective for management (Sean Lucey)
2:15 - 2:45	Prioritize vulnerabilities and risks: MAFMC Example (Sarah Gaichas)
2:45 - 3:15	Prioritize vulnerabilities and risks: OPR or OHC example or needs (Emily Farr and Matt Lettrich)
3:15 - 3:45	Explore and address tradeoffs: Multi-regional Examples (Wendy Morrison)
3:45 - 4:00	BREAK
4:00 - 4:40	Regional breakouts (AK - Megan Mackey, NE - Sean Lucey, PI - Kenric Osgood, SE - Tauna Rankin, WC - Kristin Marshall)
4:40 - 5:00	Plenary

August 26, 2021
Ecosystem Resilience, Community wellness and resilience. Theme: focus is on resilience indicators.

TIME (pm)	DISCUSSION ITEM (LEADS)
2:00 - 2:20	Ground Rules, recap, briefly discuss meeting products, review of Guiding Principle 6 and objectives for the day (Chris Harvey and Tauna Rankin)
2:20 - 2:50	Maintain resilient ecosystems: State of the Science on ecosystem & community well-being resilience indicators (Jamie Gove, Kirsten Leong, and Phil Levin)
2:50 - 3:30	Panel Discussion on Maintain resilient ecosystems: ecosystem & community well-being indicator research (Phil Levin, Jason Link, Jamie Gove, and Kirsten Leong)
3:30-3:40	BREAK
3:40 - 4:20	Regional breakouts (AK - Stephani Zador, NE - Sean Lucey, PI - Ryan Rykaczewski, SE - Rusty Swafford, WC - Kristin Marshall)
4:20 - 5:00	Plenary report out of breakouts and wrap up

August 27, 2021
Engaging communities through traditional ecological knowledge (TEK), engagement strategies and moving forward - next steps. Theme: Focus here is a very interactive day to bring all the ideas together and put pen to paper.

TIME (pm)	DISCUSSION ITEM (LEADS)
2:00 - 2:10	Ground Rules plus importance of engagement with Councils and stakeholders (Wendy Morrison and Chris Harvey)
2:10 - 2:40	Use of TEK in management (Amy Freitag, Mandy Karnauskas, and Alohi Nakachi)
2:40 - 3:10	Panel Discussion of Regional Office Staff and ESR lead authors (Ebett Siddon, Sean Lucey, Yvonne de Reynier, Aaron Mamula)
3:10 - 3:20	BREAK
3:20 - 4:15	Regional breakouts (AK - Jodi Pirtle, NE - Emily Keiley, PI -Michael Parke, SE - Karen Abrams, WC - Chris Harvey)
4:15 - 5:00	Plenary discussion. Wrap up -- Review decisions and actions

APPENDIX B – WORKSHOP PARTICIPANTS

Karen Abrams (NMFS OSF)
Max Appelman (NMFS OSF)
Andrew Applegate (NEFMC)
Kerim Aydin (NMFS AFSC)
Cheryl Barnes (Affiliate NMFS AFSC)
Kimberly Bastille (Affiliate NMFS NEFSC)
Suzana Blake (Affiliate SEFSC)
Steven Bograd (NMFS SWFSC)
Peg Brady (NMFS OST)
Mandy Bromilow (Affiliate NMFS OHC)
John Carmichael (SAFMC)
Kevin Craig (NMFS SEFSC)
Marina Cucuzza (Affiliate NMFS OST)
Jennifer Cudney (NMFS SERO)
Kit Dahl (PFMC)
Yvonne deReynier (NMFS WCRO)
Dori Dick (NMFS OPR)
Dan Dorfman (NOS)
Kate Draa (Affiliate NMFS NEFSC)
Anne Marie Eich (NMFS AKRO)
Diana Evans (NPFMC)
Jack Eynon (Affiliate NOS)
Emily Farr (NMFS OHC)
Bridget Ferriss (NMFS AFSC)
Amy Freitag (NOS)
Kathryn Frens (NMFS OSF)
Sarah Gaichas (NMFS NEFSC)
Graciela Garcia-Moliner (CFMC)
Toby Garfield (NMFS SWFSC)
Steve Gittings (NOS)
Jamison Gove (NMFS PIFSC)
Correigh Greene (NMFS NWFSC)
Richard Hall (NMFS PIRO)
Chris Harvey (NMFS NWFSC)
Elliott Hazen (NMFS SWFSC)
Rebecca Ingram (Affiliate NMFS PIFSC)
Mandy Karnauskas (NMFS SEFSC)
Melissa Karp (Affiliate NMFS OST)
Emily Keiley (NMFS GARFO)
Todd Kellison (NMFS SEFSC)
Willem Klajbor (Affiliate NMFS OST & NOS)
Scott Large (NMFS NEFSC)
Andrew Leising (NMFS SWFSC)
Kirsten Leong (NMFS PIFSC)
Matthew Lettrich (Affiliate NMFS OST)
Phil Levin (University of Washington)
Joshua Lindsay (NMFS WCRO)
Jason Link (NMFS Senior Scientist)
Maria Lopez (NMFS SERO)
Sean Lucey (NMFS NEFSC)
Megan Mackey (NMFS AKRO)
Aaron Mamula (NMFS SWFSC)
Tony Marshak (Affiliate NOS)
Kristin Marshall (NMFS NWFSC)
Matthew McPherson (NMFS NEFSC)
Kara Meckley (NMFS OHC)
Natasha Mendez-Ferrer (GMFMC)
Kelley Montenero (Affiliate OAR)
Wendy Morrison (NMFS OSF)
Brandon Muffley (MAFMC)
Alohi Nakachi (Affiliate NMFS PIFSC)
Stephanie Oakes (NMFS OST)
Patrick Opay (NMFS SERO)
Ivonne Ortiz (Affiliate NMFS AFSC)
Kenric Osgood (NMFS OST)
Michael Parke (NMFS PIFSC)
Lansing Perng (Affiliate NMFS PIFSC)
Jay Peterson (NMFS OST)
Wendy Piniak (NMFS OPR)
Jodi Pirtle (NMFS AKRO)
Leila Kaaekuahiwi Pousima (NMFS PIRO)
Roger Pugliese (SAFMC)
Tauna Rankin (NMFS OHC)
Seann Regan (Affiliate NOS)
Liajay Rivera (CFMC)
Ryan Rykaczewski (NMFS PIFSC)
Marlowe Sabater (WPFMC)
Giselle Samonte (NOS)
Danielle Schwarzmann (NOS)
Elizabeth Siddon (NMFS AFSC)
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Rusty Swafford (NMFS SERO)
Abigail Tyrell (Affiliate NMFS NEFSC)
Bruce Vogt (NMFS CBO)
Jillian Wiener (University of Michigan)
Greg Williams (Affiliate NMFS NWFSC)
Stephani Zador (NMFS AFS)

APPENDIX C – ACRONYMS

ABC - Acceptable Biological Catch
AFSC - Alaska Fisheries Science Center
CBO - Chesapeake Bay Office
CFMC - Caribbean Fishery Management Council
CVA - Climate Vulnerability Assessment
EBFM - Ecosystem-Based Fisheries Management
EFH - Essential Fish Habitat
ESP - Ecosystem and Socioeconomic Profile
ESR - Ecosystem Status Report
FEP - Fishery Ecosystem Plan
GARFO - Greater Atlantic Regional Fisheries Office
GMFMC - Gulf of Mexico Fishery Management Council
IEA - Integrated Ecosystem Assessment
LEK - Local Ecological Knowledge
MSE - Management Strategy Evaluation
NEFSC - Northeast Fishery Management Council
NMFS - National Marine Fisheries Service
NOS - National Ocean Service
NPFMC - North Pacific Fishery Management Council
NWFSC - Northwest Fisheries Science Center
OHC - Office of Habitat Conservation
OSF - Office of Sustainable Fisheries
OST - Office of Science and Technology
PIFSC - Pacific Islands Fisheries Science Center
PFMC - Pacific Fisheries Management Council
SAFE - Stock Assessment and Fishery Evaluation
SAFMC - South Atlantic Fisheries Science Center
SEFSC - Southeast Fisheries Science Center
SOE - State of the Ecosystem Report
SERO - Southeast Regional Office
SSC - Scientific and Statistical Committee
SWFSC - Southwest Fisheries Science Center
TAC - Total Allowable Catch
TEK - Traditional Ecological Knowledge
WCRO - West Coast Regional Office
WPFMC - Western Pacific Fishery Management Council

APPENDIX D – SUMMARY OF PRE-WORKSHOP SURVEY RESPONSES BY REGION

Pacific Islands:

- Respondents noted that there is not currently an ESR for WPFMC. One respondent discussed how the annual SAFE report provides the ecosystem information for their region (however, it does not integrate ecosystem parameters with fishery performance).
- All respondents picked 5 of the listed ecosystem challenges as important for the region- and agreed that changes in distribution, changes in productivity, and socio-economic or community impacts were important.
- Respondents focused on EFH as an area of management that could benefit from ecosystem information.
- The biggest challenge is the integration of the ecosystem indicators with fishery management measures.
- Better use of MSE and regulatory frameworks was suggested
- EBFM application for some fisheries could require a higher level of regulatory coordination between jurisdictions (state, territories, federal).

West Coast

- Respondents indicated that the ESR is meeting their expectations. They note that all parts of the reports are useful, but one noted the climate and ocean drivers, as well as components of ecological integrity, were especially useful.
- One respondent feels strongly that the ESR is useful without needing to be directly tied to management as it increases the stakeholder and managers' understanding about what is happening in the ecosystem. The other respondent felt that tailoring indicators to match management decisions and timing of decisions would be useful.
- For the most part, respondents thought the region had many challenges related to EBFM (checked that 7 or 9 of the 9 challenges were present in the region)
- The biggest challenge moving forward is climate change- either in general or on a highly vulnerable species (salmon).
- More information is needed on diets and on how oceanographic phenomena impact managed species.

Alaska

- Respondents listed multiple sections of the report as being useful: report card, in brief report, hot topics, indicators, habitat information, fishing effects analysis, and details in the environmental and biological parts.
- Sections on social-economic indicators are harder to use as the connections to fisheries are not as clear.
- There was a large difference between respondents on the number of current and expected challenges for their region. For example, one respondent listed only changes in fish

distribution and interactions between fisheries and gear as important, while another respondent picked 7 of the 9 challenges as important for the region, leaving out interactions between fisheries or gear and interactions with other sectors (i.e. energy).

- Respondents listed communication about climate and ecosystems (and the associated uncertainty) as one of the region's future challenges. Another future challenge is creating appropriately nimble policies.

Northeast

- Multiple respondents listed "risks to meeting fishery management objectives" as one of the more useful sections of the report. There was also a shout-out to the two-page overview.
- Three of the five noted the ESR was meeting expectations. Two respondents noted the difficulty in using the information in management decisions.
- The recommendations on improving the report varied between respondents. Multiple responses noted a need to better connect the report to management decisions. Two responses noted the need to better connect how the ecosystem changes could impact managed species- either through improvements in analyses (to demonstrate direct connections) or in telling the story (identifying possible connections). One response highlighted that information about trade-offs associated with ecosystem information and management decisions would be useful. It was also noted that a pause in updating the report to focus on implementation might be useful.
- All respondents checked 5-8 of the listed challenges as relevant to the region, and all challenges had at least 3 checks. Three challenges were identified by all respondents: changes in fish productivity, changes in fish distribution, and the need for socio-economic information, and one challenge was identified by the majority of the respondents: interactions with other ocean uses.
- Quite a few challenges were listed by the respondents when asked for the biggest EBFM challenge:
    - Understanding and anticipating the effects of predation and prey availability on the productivity of managed stocks, their biological reference points, and on rebuilding expectations.
    - General lack of use and application of ecosystem information within the stock assessment process.
    - The lack of clear examples of how/where used in management makes it difficult to point to something to show how it can work. Taking a step back and/or piloting how this information and approach could be used for one or two species or fisheries could be very beneficial instead of trying to do it all for all species – highlight those benefits at a single species level and see how it helped.
    - Institutional/regulatory overhauls necessary to implement EBFM
    - Overfished stocks are not responding to reduced fishery-dependent mortality.
    - Shifting stocks and resulting allocation issues.

- Multiple council decisions that could benefit from more ecosystem information were listed including allocation decisions, catch limits, rebuilding plans, stock definitions, management and research priorities, etc.

Southeast

- Currently, there is an ESR for the Gulf of Mexico. ESRs for the South Atlantic and Caribbean are in development. For the respondents who had read the GOM ESR, the following information was listed as being helpful: commercial and recreational fishing, impacts to habitat from land-use changes, and how changes in ocean conditions impact migratory patterns in managed species.
- One respondent noted that the ESR is helpful in clarifying causal relationships (red tide impacts and the need for harvest reductions).
- Recommendations for the ESR included increasing its use by the Council and establishing a framework for how to incorporate the information from the ESR into the management process. Content-wise, information on the relationship between climate change and socio-economics could be useful.
- All respondents checked 5-9 of the listed challenges as relevant to the region, and all challenges had between 3-5 checks. Two challenges were identified by all respondents: changes in fish productivity, and changes in fish distribution.
- Quite a few challenges were listed by the respondents when asked for the biggest EBFM challenge:
    - Interactions among various industries
    - Shifting stocks
    - Capacity building – preparing future scientists and managers to better utilize climate and ecosystem information
    - Integration of variable stakeholder views
    - Communicating the link between lack of enforcement and catch limits
    - Understanding cumulative impacts and risks
- Multiple council decisions that could benefit from more ecosystem information were listed including sustainable management of ecosystem (preventing overfishing), better compatibility between federal and state regulations, allocation of catch, essential fish habitat, etc.