NOAA FISHERIES

WESTERN PACIFIC REGIONAL FISHERY MANAGEMENT COUNCIL

Western Pacific Regional Fishery Management Council

Pacific Islands Fisheries Science Center

Pacific Islands Regional Office

Ecosystem-based Fisheries Management Workshop Report

Ala Moana Hotel—Garden Lanai Room
Honolulu, Hawaii
October 4, 2022

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U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Pacific Islands Fisheries Science Center

NOAA Technical Memorandum NMFS-PIFSC-140
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About this report

The Pacific Islands Fisheries Science Center of NOAA's National Marine Fisheries Service uses the NOAA Technical Memorandum NMFS-PIFSC series to disseminate scientific and technical information that has been scientifically reviewed and edited. Documents within this series reflect sound professional work and may be referenced in the formal scientific and technical literature.

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Workshop Purpose

On October 4th, 2022 the Western Pacific Regional Fishery Management Council (WPRFMC or Council) joined the Pacific Islands Fisheries Science Center (PIFSC) and the Pacific Island Regional Office (PIRO) to map out the implementation of Ecosystem-based Fisheries Management (EBFM) in the Pacific Islands. This inclusive approach works towards sustainable management of the breadth of ecosystem components and management unit species, bringing additional elements into play, such as interactions with other species, the effects of environmental changes, or pollution and other stressors on habitat and water quality. EBFM ensures that fishery managers consider these additional elements to more effectively assess the health of any given fishery and determine the best way to maintain it. EBFM cannot succeed without effective, transparent, and frequent communication allowing adaptive management to respond to emerging science. This workshop provided the opportunity to share priorities and capabilities, as well as to listen, talk, and brainstorm activities that can be achieved in the next 5–10 years.

Meeting Objectives

- Improve understanding of the scope of EBFM and develop a shared understanding of the state of EBFM in the region, what changes we want to see in the coming decade, and how we can position ourselves to achieve that goal.
- Foster a shared understanding of the management, science and data challenges and capabilities in the Pacific Islands.
- Learn from a case study (IEA) and discuss how to "scale up" in the PI region.
- Identify common threads (e.g. human dimensions, climate change, socioeconomics, EEJ) that offer opportunities to maximize efforts and prioritize outcomes.
- Develop recommendations on engaging state and territorial stakeholders for future EBFM initiatives.

Welcome and Opening Statements, Expectations and Outcomes

NOAA Fisheries defines EBFM *as a systematic approach to fisheries management in a geographically specified area that contributes to the resilience and sustainability of the ecosystem; recognizes the physical, biological, economic, and social interactions among the affected fishery-related components of the ecosystem, including humans; and seeks to optimize benefits among a diverse set of societal goals.* An ecosystem approach to fisheries management is promoted in the Magnuson-Stevens Fishery Conservation and Management Act (MSA) and requires fishery managers to develop recommendations that expand the application of ecosystem principles in fishery conservation and management activities.

This workshop was a venue to discuss the first steps in collaboration and communication between the Council, PIFSC and PIRO. As an introduction to the presentations and discussions, Kitty Simonds (Council, Executive Director), Sarah Malloy (PIRO, Acting Regional Administrator) and Tia Brown (PIFSC, Deputy Director) provided opening statements that encouraged thoughtful and open communication.

WPRFMC EBFM Priorities

The reauthorization of the MSA calls for expanded attention to ecosystem principles in fishery conservation and management actions. The WPRFMC was one of the first Councils to progressively apply ecosystem principles to management of fisheries under its jurisdiction, specifically through the development of Fishery Ecosystem Plans (FEPs). To successfully implement EBFM in the western Pacific region, the Council operates under the support of three pillars: 1) Science and data to inform policy decisions, 2) the Council process and 3) building community resilience and stakeholder engagement (Figure 1).

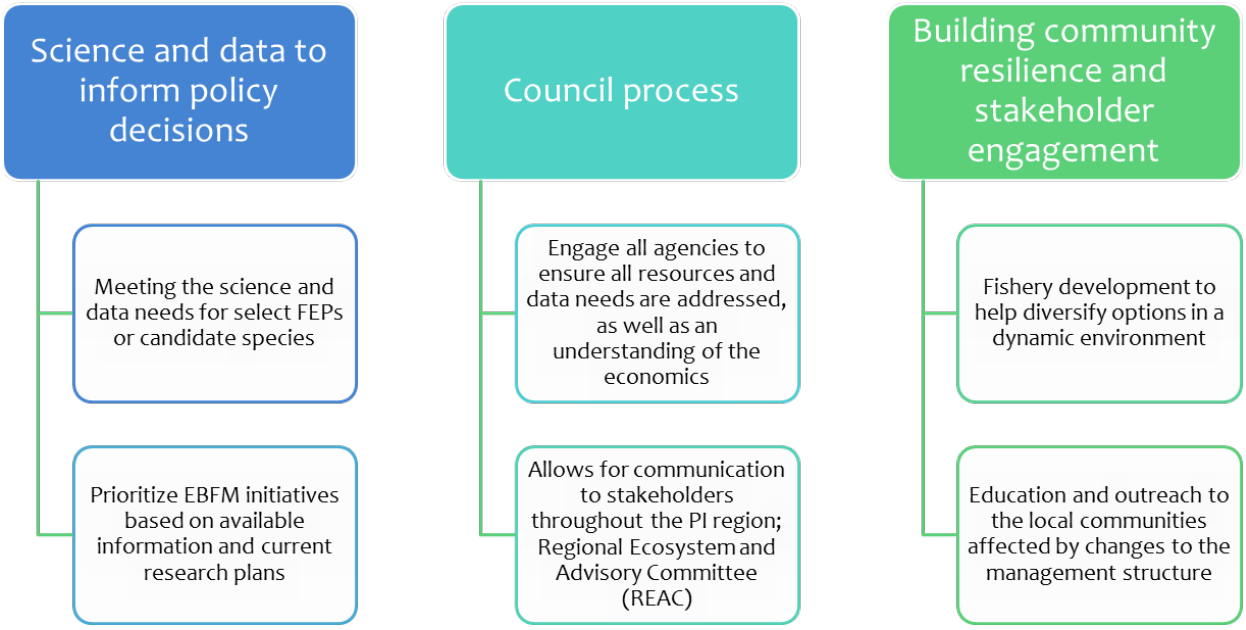

Figure 1. Council pillars which support efforts to implement EBFM.

Workshops to implement ecosystem approaches to fisheries management were held as early as 2005 and included managers and scientists from around the world. Three separate workshops focused on advances in ecosystem modeling, data requirements and the policy framework needed to implement an ecosystem approach to management. The first workshop focused on the biophysical data and models to support the transition from single-species-based to ecosystem-based management. The second workshop examined the economic, social, and institutional aspects of the ecosystem approach in the region. The third workshop synthesized the findings from the first two workshops to generate policy options and information needed to effectively implement EBFM in the region.

As a result of these three workshops, the Council initiated the following work: 1) shift from species-based FMPs to place-based FEPs; 2) focus on advances in ecosystem modeling, data requirements and the policy framework; 3) include ecosystem chapters in the Stock Assessment and Fishery Evaluation Reports; 4) use the institutional framework to discuss ecosystem issues through the Regional Ecosystem Advisory Committee 5) include ecosystem considerations in every amendment to the FEPs: habitat, protected species, fishing communities, economic impacts, etc.; 6) provide a proactive EBFM framework to monitor changes in the fisheries as a

function of the ecosystem; and 7) explore the use of EBFM model development for understanding factors driving protected species interaction patterns.

The following management priorities, identified in the Council's program plan, were presented to the workshop participants:

- Streamline the processes for Ecosystem-based Fishery Management;
- Develop ecological fishery indicators and ecosystem level reference points;
- Improve the understanding and incorporate climate considerations into fisheries management;
- Increase understanding of climate change impacts on pelagic and international fisheries management;
- Improve the understanding of overlap between climate change impacts and protected species interactions;
- Account for socioeconomic risks and opportunity loss/gain due to climate change and ecosystem variability;
- Integrate social, ecological and biophysical information into ecosystem-based fisheries management in the region; and
- Improve understanding of the impacts associated with large-scale changes that result in an uncertain future (climate change) on fisheries and fishing communities.

In addition to the management priorities identified in the Council's program plan, Council staff also presented a refined list of priorities recommended by the Western Pacific Scientific and Statistical Committee. This list was developed as a result of the 7th national meeting of the Scientific Coordination Subcommittee in Sitka, Alaska, and ultimately endorsed by the Council as its next steps for implementing EBFM in the western Pacific region:

- Identify reliable ecosystem indicators to incorporate into stock assessments, as well as resources needed to improve and enhance data collection for monitoring the indicators and providing information to understand ecosystem changes and their effects;
- Conduct scenario planning for extreme environmental events to assist with economic and social resilience of fishing communities;
- Collaboration and idea sharing between regions to explore expanded management options;
- Support efforts to build flexibility into stock status, reference point, and rebuilding guidelines when incorporating ecosystem considerations;
- Data-rich pelagic fisheries should consider approaches to link allocations to climate-related changes to abundance; and
- Identify scenarios where quantitative decision making tools could help improve understanding of ecosystem considerations for fisheries in the WP region. Priorities

include interactions between protected species taken in the region's longline fisheries and current management approaches, and considering ways to incorporate ecosystem considerations into bottomfish assessments and reference points.

The final Council-endorsed EBFM priorities were shared with PIRO and PIFSC prior to the workshop to allow for a structured afternoon discussion on the available science/data and additional data needs to ensure forward progress on these priorities. The "Science Challenges and Ways Forward on Council Priorities" session described below highlights the presentations and discussion as they relate to and address the Council priorities.

PIRO-PIFSC EBFM Priorities and Projects

EBFM has been the goal of NMFS for many years, with a policy shared in 2015 and guiding principles established in 2016. Since then, the Pacific Islands region has internally made improvements in our communication and execution of EBFM through quarterly meetings, and has agreed to implementation plans, workshops and working groups. Collectively we have agreed that communication, data accessibility, quality and quantity as well as resource limitations (meaning people and funds) are inhibiting the region's EBFM objectives. However the West Hawai'i IEA has grown to be a stellar example of successful EBFM. West Hawai'i is home to the longest contiguous coral reef track in the State of Hawai'i. The area also supports a spectrum of geographically specific user interest groups. The nexus of these attributes allowed the IEA team to create a mechanism for collaborative, interdisciplinary and adaptive approaches to best management for the unique resources.

Discussion

Question from PIFSC: On a National level, is EBFM recognized as crucial for needed climate work?

Response from Presenter: It is impossible to talk about one without the other but we have not clarified the best way to achieve that goal. There are many Climate and EBFM efforts ongoing. Their needs must be integrated to move forward. We are trying to get the groups to talk openly and move forward together when historically they have done work in parallel.

Question from PIFSC: The structures that we've built in West Hawai'i to achieve EBFM, how resilient will they be when NOAA resources are reallocated to expand the IEA to encompass the State? Will that result in diminished ecosystem services?

Response from Presenter: We never walk away, we transfer capacity, knowledge, capability, technical guidance into the future. We'll never have enough resources to continue direct support, but communities seem to have been open-armed about taking on the capacity to continue the work the program and they started.

PIRO-PIFSC EBFM Workshop Overview

On April 6–7, 2021, PIRO and PIFSC held a joint EBFM Workshop to identify ways to further the implementation of EBFM in the Pacific Islands Region (PIR). The objectives of the workshop were:

- Foster an EBFM understanding and establish communication channels between PIRO and PIFSC.
- Identify ways to better align management (PIRO) and research (PIFSC) activities.
- Identify priority activities needed to fully implement EBFM in the Pacific Islands Region.

The first day of the workshop was intended to develop a more consistent understanding across PIRO and PIFSC staff of what EBFM is, and to provide staff with a more complete picture of the mission and goals of the two offices. This was accomplished through a series of presentations by PIRO and PIFSC staff, with staff from the Regional Office presenting on the primary mandates used to guide the mission of each division, and with Science Center staff presenting on science priorities and objectives.

The focal point of the second day was a number of breakout sessions, where staff elected to participate in one of four discussion groups consisting of Pelagic Fisheries, Coral Reefs and Insular Fisheries, Fishing (Indigenous) Communities, and Protected Species. To guide the discussions in the breakout sessions, facilitators used the following questions:

> *Question 1*: How does the consideration of additional EBFM components change the approach to research/management of your respective theme?
>
> *Question 2*: How will EBFM help to identify and address the unique pressures on your respective theme in the region?
>
> *Question 3*: How can we best address data gaps and analytical challenges to enhance effective research/management of your respective theme at appropriate spatial and temporal scales in the region?

Through the workshop discussions, a number of challenges were identified that will need to be addressed to successfully implement EBFM. While the list of challenges was long, a few of them were mentioned on a recurring basis throughout the workshop and included the following:

> *Climate Change* – We need to better understand how climate change will impact protected species and fish stocks distribution, and how those changes might affect protected species interactions (i.e., by-catch) with the fisheries.
>
> *Communication/Collaboration* – We need to improve both internal and external communications and cooperation. A particular area of emphasis was the need to better engage the local communities, to utilize their expertise, to respect their traditional perspectives, and to better address their concerns.
>
> *Data Gaps* – Successful implementation of EBFM in the Pacific Islands region will require the collection of new data, and access to and innovative synthetic analyses of existing data.

Resource Limitations – Funding and personnel limitations will impede EBFM implementation. To understand the needs in these areas, one of the first priorities should be for PIFSC and PIRO leadership to develop a clear understanding of their objectives and risk tolerance relative to critical management issues in the region.

The EBFM Workshop was the first step to develop a coordinated response to the challenges presented by this new approach. Subject-matter experts from all the divisions within PIFSC and PIRO identified what they perceive as the main obstacles to moving this initiative forward. Based on the breakout group discussions, the following priority strategies were identified:

- Embed the EBFM concept into annual and multi-year project development guidelines and the budget process.
- Establish processes of engagement between PIRO and PIFSC that work to advance EBFM regionally and nationally.
- Develop the capacity to produce climate change scenarios to forecast impacts of environmental change on ecosystems, habitats, and fisheries.
- Develop and implement regional and federal processes that will allow for better community engagement in the management consideration and decision processes.
- Develop and implement the capacity to determine how fishers and protected species will respond to policy and management changes implemented as part of the new EBFM approach.

The final outcome of the workshop was identifying the next steps to begin addressing the priority strategies. One of these was to establish a PIRO EBFM working group. This group has started meeting in the last few months and is currently working towards developing a PIRO EBFM Strategic Plan. Another next step was to develop better EBFM coordination between PIRO, PIFSC, and the Council.

Discussion

Question from Council: As a result of priority strategies, thinking about implementation plan, any thoughts on specific projects to move forward with yet? Council discussions have included a lot of protected species, etc., but what is PIRO's focus?

Response from presenter: We need to move forward with identifying data gaps and how we are going to be able to address the issues of climate change. PIRO is trying to integrate this in a number of place-based projects already. We are already doing this under the consultation framework or monuments work. Going forward we will need to change the management approach to ask how EBFM fits in upfront.

Science Challenges and Ways Forward on Council Priorities

Environmental and Climate Impacts on Pelagic Fisheries—J. Wren

The western Pacific region is the largest (approximately 50% of the U.S. exclusive economic zone) federally managed region in the nation, and a lot of the species studied have habitats that span well beyond the exclusive economic zone and deep into international waters. Within this region, fisheries are managed around Hawaii, Guam, throughout the Commonwealth of the Northern Marianas Islands, American Samoa and the Pacific Remote Island Areas.

The Hawaii-based, deep-set longline fishery footprint represents a prime example of how climate impacts affect pelagic fisheries (e.g., bigeye tuna, swordfish, oceanic white tip shark, leatherback turtle, etc.). This area spans approximately 0–40°N and 125–180°W, which crosses into fishing areas under international jurisdictions. As species continue to move due to oceanographic and climatic events, international agreements and EBFM become more prevalent and necessary. Events such as El Niño Southern Oscillation (ENSO), Pacific Decadal Oscillation (PDO), and North Pacific Gyre Oscillation (NPGO) all affect species distribution patterns and the current and future state of fisheries management. Fluctuations in each of these oscillations are driven by regional and basin-scale variations in wind-driven upwelling and horizontal advection, temperature, currents, etc.—the fundamental processes controlling salinity and nutrient concentrations, and ultimately presence/absence of pelagic fisheries. Climate variabilities cut directly through the region, so pelagic fisheries often experience both positive and negative effects of ENSO, PDO and NPGO. Therefore, scientists and fishery managers have to focus on the mechanisms due to the large area and lack of long-term records.

PIFSC is currently pursuing research to enhance EBFM efforts in the region. The bigeye initiative describes the population and stock structure and seeks to improve understanding of the variability across the North Pacific ecosystem that influences recruitment and the distribution of bigeye tuna and their prey. PIFSC is also working to incorporate the Southern Oscillation Index (SOI) into the Swordfish stock assessment, creating a climate-informed assessment. They are also working to understand how phytoplankton size might be used as a predictor for bigeye tuna recruitment success.

To improve EBFM efforts in the western Pacific region, observational data is necessary to meet objectives. These include, but are not limited to, collection and analyses of observational data to understand ecosystem processes, development and maintenance of long-term time series (fisheries and climate data), improved input into models, and a process to ground truth hypotheses. To meet these objectives, scientists and fishery managers will need to find ways to address challenges specific to the western Pacific, such as the vastness of the region as well as the variable scope and scale of existing oceanographic and climate data.

Moving forward, PIFSC continues to develop innovative approaches to sample the region through satellites, models, floats, etc. Continued international collaborations opens doors to future engagements with colleagues all over the world. Through these collaborations, PIFSC plans to focus on mechanisms rather than empirical relationships to assist in development of a 10-year pelagic sampling plan.

Socio-economic Risk—M. Iwane, D. Kleiber, and H. Chan

There are four basic social-ecological and economic forces within EBFM: environmental (sea and sub-surface temperature, large-scale climate events, chlorophyll, winds, etc.), biological (species abundance, survival, recruitment, size and distribution), human (fishing cost, effort and location, and fish price and profit, as well as social and cultural systems in which fisheries occur), and the external forces (regulations, politics, fuel prices, and foreign competition). The Social-Ecological and Economic Systems (SEES) Program engages in EBFM by monitoring and describing humans, and their fisheries, cultures, societies, and economics as part of the marine ecosystems. They ask questions like, "What's happening in our communities?," "How/why do ecosystem components interact?," and "Why does this matter to management and who participates?" These questions are part of a robust data-collection system that allows us to include social and economic data into fisheries management decision-making. Within this conceptual model, humans are part of the ecosystem rather than external to it.

Across this process, there are strengths and weaknesses. For example, we currently lack established management frameworks to systematically incorporate human dimensions into management decisions, and we lack trusted relationships with diverse sectors of the fishing population. We have little experience in ecosystem service valuation (non-market and cultural values), and are challenged to effectively model the complex relationships between human decisions, biological factors, environmental characteristics, and external factors. However, we have a strong capacity to analyze large quantitative and qualitative data sets and a framework to collect primary economic data from many regionally important fisheries. Within EBFM socioeconomic data enable consideration of trade-offs among human well-being, fisheries, aquaculture, protected species, biodiversity, and habitats. There is growing support for the use of traditional and ecological knowledge (TEK) in research and within management. Advancements in computing capacity, modeling, and analytical techniques, in addition to large high-resolution data sets of human activity will allow improved exploration of complex relationships and responses that human behavior introduces to marine ecosystems, ultimately making EBFM a reality.

Protected Species—E. Oleson, S. Martin, M. Barbieri

The Council outlined two EBFM priorities related to protected species: 1) improve understanding of the overlap between climate change impacts and protected species interactions, and 2) integrate social, ecological and biophysical information into ecosystem-based fisheries management in the region. The nexus of these priorities and the activities of the Marine Turtle Biology, Hawaiian Monk Seal Research and Cetacean Research Programs (MTBP, HMSRP, and CRP respectively) was the core of this session.

The major threats for marine turtles within this changing climate are twofold: habitat loss and temperature impacts on their sex ratios and nesting success. The remote nature of their habitats and nests make monitoring their abundance, trends, and distribution logistically challenging. To overcome these challenges, the Program implemented partnerships with international and local entities to monitor movements, gather data, monitor nests as well as implement technological improvements using satellite tags, data loggers, and remote sensing. Improving ecological understanding of marine turtles facilitates the EBFM approach to their management and long-term conservation.

Threats to monk seals also include habitat loss and fragmentation, but these concerns are exacerbated by fishery interactions and marine debris entanglements, among other anthropogenic threats in the main Hawaiian Islands. The HMSRP gathers high-quality, but resource-intensive, data from across the Northwestern Hawaiian Islands (NWHI) using seasonal field camps and surveys paired with research cruises; data about seals in the main Hawaiian Islands comes from public reporting and partner organizations who monitor seal haul-out activities. As conducting field research in the NWHI is resource intensive, the HMSRP is examining ways that unmanned systems (aerial and other uninhabited vehicle platforms) can augment traditional sampling methods. Together, these crucial data streams from the NWHI and MHI feed into the long-term population assessment database, and range-wide population estimates. Fortunately, the terrestrial and marine habitat use and ecology of monk seals is well described with established critical habitat. While in the field, staff are able to directly mitigate real time threats to monk seals, such as from debris, predation, and food limitation. These basic understandings and mitigations readily allow PIFSC to meet many conservation and management goals. However this endangered species continues to be challenged by a changing climate; continued monitoring will allow us to detect and report on changes in survival and reproductive trends that stem from climate change and habitat loss.

There are more than 25 species and 120 stocks of cetaceans in the Pacific Islands. Understanding the social, ecological and biophysical characteristics of such a large group of animals is an enormous undertaking, and, as a result, most of the stocks range from data poor to data moderate. Critical for EBFM are those stocks that interact with fisheries, either through prey removal or climate-induced shifts in prey. The CRP conducts periodic assessment surveys and targeted studies to provide updated abundance, range, and demographic information for as many as possible, but it is challenging. Such assessments are infrequent, expensive, and cover only a portion of pelagic species stock range. Equally important, but also poorly understood, are the distribution, abundance and biology of their prey. The CRP is working on new approaches to fill these gaps, using occupancy modeling to examine climate-induced range shifts, integrating passive acoustic detection to increase assessment precision, and integrating ecosystem measures during cetacean surveys. The synthesis of the data can start to provide mechanistic linkages and better understanding of these stocks in a changing environment.

Large-scale Changes (Climate) on Fisher and Fishing Communities— J. Ruzicka

An end-to-end (E2E) “physics-to-fisheries” ecosystem model can be a powerful tool to estimate ecosystem-scale and socioeconomic consequences of alternate management actions within a changing climate setting. E2E models are a necessary proxy for ecosystem-scale experiments. They are constructed as a chain of linked models: an oceanographic model, a biological model (typically a multi-species food web), a fleet model, and a socioeconomic model. They provide a platform to evaluate the consequences of “what if” scenarios that force changes along any link in this chain (e.g., changes in physical environment, changes in food web structure or processes, or changes in fleet dynamics).

The development of a biological model for EBFM must thoughtfully consider processes relevant to the science and management issues important to a particular ecosystem. For example, a biological model for the changing central North Pacific region must incorporate behavior (diel vertical migration, foraging excursions, seasonal and ontogenetic migration) and physiological

stressors (temperature, oxygen limitation, ocean acidification, potential deep-sea mining plumes, and the life-histories of individual living groups). These relevant processes highlight data gaps that must be filled. Often such data cannot be collected or inferred from remote satellite observation alone. To accurately define community composition and trophic relationships, physical samples must be collected for taxonomic identification and diet analysis. To accurately incorporate diel vertical migration and foraging behaviors, acoustic surveys and archival tagging data are necessary.

Once developed, meaningful application of an E2E model requires consideration of best practices for scenario design and choice of model-derived metrics appropriate for the science and management questions asked. In the context of EBFM, a specific management action scenario should consider changes in stock productivity as well as tradeoffs among different fishing sectors, commercial and non-commercial species. Evaluation of climate change and management impacts to fishers and communities requires a well-designed framework of socioeconomic objectives that may each be mapped to specific model-derived metrics that can range from estimates of landed revenue to indices of ecosystem diversity (Weijerman et al. 2020).

Next steps: Approaches for EBFM

Indicators for Stock Assessments—M. Sabater

Several provisions in the Magnuson-Stevens Act (MSA) require information provided by stock assessments, e.g., maximum sustainable yield, status determination criteria, annual catch limits, acceptable biological catches, domestic overfishing and stock rebuilding. The National Standard 2 provisions within MSA also ensure assessments include the best scientific information available and fishery evaluation reports. All these requirements can currently be derived from assessments generated by the PIFSC Stock Assessment Program.

However, EBFM asks that stock assessments be informed by ecosystem data. In domestic assessments like the main Hawaiian Islands Deep 7 bottomfish, uku, Kona crab, and the territorial bottomfish management unit species complex, ecosystem information like wind speed and direction, sea surface temperature (SST), fishing location (for spatial effects), calendar days (for seasonal effects) and fisherman's fishing ability (for fisher effects) are used to standardize the CPUE so the only remaining effect is the change in abundance over time. These data do not go into the modeling and are considered a retrospective view on the effects on these variables from the start to the end of the time series used in the assessment. This is in contrast with the western central Pacific swordfish assessment (Sculley et al. 2018) that used SST and swordfish recruitment as indicators for the CPUE standardization and the future biomass projection by incorporating it in the surplus production model. It is both a retrospective and a forward-facing approach to incorporating ecosystem information. However, the forecasting of fish abundance was based on assumed future fishing scenarios and not future climate projections. To incorporate ecosystem variables in forecasting biomass based on future climate scenarios, then we must also upgrade the management strategies and the data to be used in the assessment. There is a need to monitor ecosystem indicators at the proper scale, for in-situ environmental data especially those at-depth and also to establish a near-real-time management response in the application of the accountability measures.

PIFSC is analytically capable to incorporate ecosystem indicators in stock assessments, conduct forecasting, as well as analyze a range of management strategies that can support EBFM. The region can also utilize the existing P* and SEEM (Social, Economic, and Ecological Management) frameworks to incorporate ecosystem considerations in the annual catch limit (ACL) specification. However, the P* and SEEM processes could be further improved from the current semi-quantitative scoring approach. There are several weak points. The Pacific Island region small boat fisheries are in a data-poor situation. The noise in the fishery dependent data needs to be addressed to ensure that the signal over time is due to a real change or effect of the changing environment and not just fluctuations due to the data collection. The scale of the oceanographic data also does not match that of the scale of the fishery. These large-scale data sets need to be downscaled and calibrated with in-situ measurements. The current management framework is rigid. It needs to transition to a strategic approach and infuse a level of flexibility. There is also a lack of basic biological data pertaining to responses to changing environmental conditions.

The single-species assessments being conducted allow for narrowing the ecosystem change effect to a specific life history. Each species does not respond similarly to environmental changes

by its unique biology and ecological characteristics. PIFSC is also embarking on the improvements to the fishery dependent data collection systems that would reduce the noise in these data sets.

Quantitative Decision Tools for Interactions and Ecosystem Considerations—K. Tanaka

Quantitative decision tools facilitate the delivery of a successful EBFM approach to managing living marine resources. EBFM practitioners need tools to (1) construct a clearer picture of ecosystem interactions and considerations to determine the best management approaches and (2) synthesize and integrate a wide range of information for EBFM objectives. Such tools can help us develop sufficient modeling capacity to analyze trade-offs of different management decisions and facilitate stakeholder involvement in planning processes.

Environmental Data Summary (EDS) is an R-based programming package developed by Tanaka and Oliver (2022a) that can "enhance" any field observations with spatiotemporally matching satellite data that are available from NOAA OceanWatch and CoastWatch databases. EDS has been proven successful when applied to many research projects, including PIRO-funded Essential Fish Habitat (EFH) and NCMRP-funded "Enhancing Reef Resilience through Process Investigation." By its use, PIFSC is able to derive model-based spatiotemporal inference on EFH for more than 400 reef fish species. Tanaka has also developed a statistical EFH level-2 (density & biomass; Tanaka et al. 2022) modeling framework employing a combination of in-situ reef fish density data enhanced by various gridded satellite products via EDS. This framework uses a large, fishery-independent database as a source of data for analysis and prediction of the habitat distribution of EBFM-relevant species along the nearshore coastal area across the central Pacific region.

Tanaka and Oliver (2022b) recently developed a generalized simulation-based framework to examine alternative statistical Living Marine Resources (LMR) survey designs at different levels of sampling effort within a data-poor environment. Specifically, PIFSC can now incorporate varying sampling efforts to analyze the sensitivity of estimated biomass to the different strategies. This simulation framework contributes to PIFSC's effort to promote resilience-based Management Strategy Evaluation in an era of uncertain support for field surveys.

Finally, Tanaka introduced the "local extreme heat index" (LEHI), a novel climate index originally developed by Tanaka and Van Houtan (2022) that can be used as a metric for the normalization of historical marine heat extreme events. LEHI can quantify the magnitude and frequency of extreme marine heat events by summarizing the number of time units exceeding a fixed threshold at a given location. Tanaka demonstrated that increases in the extent of extreme marine events over the 50 years resulted in many local climates to have shifted out of their historical SST bounds across many economically and ecologically important marine regions (e.g., Mariana and Samoa). Tanaka's LEHI metric provides an alternative framework that may better contextualize the dramatic changes currently occurring in marine systems. This suite of new tools allows PIFSC to more effectively meet management needs within the confines of data and fiscal limitations that are not abating.

Climate Change Scenario Planning—K. Leong

Scenario planning is a structured process that helps participants explore and describe multiple plausible futures and plan for how best to adapt and respond to them. In the face of climate change, this novel-futures planning is a necessity, and differs from current planning which uses historical baselines to set management objectives. The RAD (Resist-Accept-Direct) strategy, used by the National Park Service and others, helps us think through strategies we might use in the face of differing uncertain futures. Such efforts allow us to be prepared and have a plan of action; share current practices which are likely or unlikely to succeed in the future; identify critical uncertainties around which monitoring or new science could be developed; update goals or actions in the face of uncertainty; and encourage stakeholder participation helping to build relationships and collaboration opportunities. The Office of Sustainable Fisheries has developed guidance for fishery managers and is currently supporting efforts in multiple regions. Scenario planning allows for critical conceptual thinking but can potentially not receive the necessary follow-through to applied management. It brings people together to highlight, understand, discuss and evaluate trade-offs in an open and transparent manner but can be vulnerable to politics and be resource intensive. Scenario planning helps us prepare for changing climates and ecosystems that we have not experienced in the past. A scenario planning training and workshop are included as action items in the EBFM and PIRAP 2.0 Action Plans.

Discussion

Question from Council: I am curious about the next steps to use EDS to implement EBFM.

Response from presenter: The next step is running EDS on a full data system. We will also be using 30-50 satellite data sets on a cloud computing system. We can do more data intensive processes, like large public data sets for environmental drivers. We hope this work will lead to more research applications. Current test study is seeing if we can forecast species distributions due to changes in environmental conditions. Do we have any strong recommendations on what to use when you forecast species distribution? For example, uku. The model says that uku does not respond to temperature but rather surface wind variability over the last 70 days. This could be due to changes in fishing effort. Regardless, it opens more doors to test more hypotheses.

EBFM Case Study: Integrated Ecosystem Assessment (IEA)

The Integrated Ecosystem Assessment (IEA) program is a process designed to inform EBFM. It is a NOAA cross line-office effort engaging NOAA's National Marine Fisheries Service (NMFS), NOAA's National Ocean Service (NOS), NOAA's Ocean and Atmospheric Research Service (OAR), NOAA's National Environmental Satellite, Data and Information Service (NESDIS) and NOAA's National Weather Service (NWS) to varying levels depending on the area. In the Pacific Islands, the west coast of the Big Island, also known as Hawai'i Island, provided an area with a unique biogeographic and oceanographic setting, protected species in residence, existing marine managed areas, commercial and non-commercial fisheries and a highly engaged community. This nexus allowed the West Hawaii (WHI) IEA team to learn about the area, develop relevant scientific information to address existing and future resource management concerns, and transparently offer advice to managers on a variety of challenging and contentious questions. They conducted a massive data gathering exercise to allow them to examine ecosystem trends through time resulting in 30 indicators spanning social, ecological, climate, and oceanographic variables. Community workshops provided input on the indicators and allowed opportunities for community members, researchers and managers to substantively engage. They developed a conceptual ecosystem model with hundreds of connections, drivers, pressures and components influencing ecosystem services. They monitored drivers of reef ecosystem change and the impacts of local (e.g., septic systems) and global (e.g., marine heat wave) variables and analyzed the impact of the independent and combined variables. They were also able to examine the ecosystem's ability to recover and persist in the face of these stressors. Subsequently, these pieces allowed State managers to maximize their impact in achieving their conservation and management mission.

There is a desire to scale up the WHI-IEA to the entire State, using it as a template for EBFM success. IEAs are data-hungry enterprises and the needs for such a scale up would be large, but not impossible. It would require updated ocean driver and human use data layers; greater emphasis on offshore fisheries and ecosystems; and improved understanding of ancillary pelagics (e.g., mahimahi, ono), non-longline fisheries, and climate change and strong sociocultural research and indicator development spanning the State. The "about to be released" Ecosystem Status Report for Hawaii 2022 makes a first step at that expansion. The document examines drivers of ecosystem status and trends across the main Hawaiian Islands but also evaluates the goods, services, values and meanings stakeholders derive from the ecosystem. The strengths of using EBFM as a template are the collaborative nature of the work, involving contributions from a spectrum of academics, non-governmental organizations (NGOs), managers, and community members. The process is iterative and allows for feedback and refinement of science-based efforts and products as well as being flexible in its ability to address targets, goals, and questions based on acute disturbances, changes in geographic scope, and shifts in fisheries, ecosystem, or habitat focus.

It is not a perfect model for several reasons. As stated, the extreme data needs are expensive to construct, maintain and analyze. The level of community engagement in building and maintaining relationships as well as trust requires a not yet realized workforce. But the opportunities in moving from an IEA to EBFM model would meet the high priority articulated by the Council, PIRO, PIFSC as well as NMFS and NOAA. It would expand the science and management improvements realized in West Hawaii around cultural service, human well-being,

improved understanding of offshore and deep-water fisheries, as well as larval fish nursery habitat and protected species. Reoccurring and extensive funding cuts, undermine the strengths and opportunities and exacerbate the weaknesses. An increase in turnover from reduced funding weakens relationships, and requires shifting priorities and resources to the next important task for which there are often insufficient funds.

Discussion

PIFSC: If we are expanding to the main Hawaiian islands, are there areas of priority within the State?

Response from presenter: No, there are some key projects. Holomua and land-based stressor data have been produced in the past but those will be updated with respect to 30 × 30, which also supports the National Coral Reef Monitoring Program. We can dig into past and new discussions about the key questions to answer with the in-depth indicator analyses. But it really depends on what management needs.

PIFSC: Are we considering expanding an IEA program into the territories?

Response from presenter: The topic has come up. Identifying the right personnel and building the relationships to do this process is possible, but we are short on human and fiscal capital.

Council: We are looking forward to the ecosystem status report and using it to inform Council discussions here and in other regions. My question is around how you think this fits in with what we have been doing in our Stock Assessment and Fishery Evaluation (SAFE) report over the last five years. That report includes ecosystem sections with a lot of indicators. Will it be possible to point to the Ecosystem Status Report instead? Will it be coming out on an annual basis?

Response from presenter: I am aware of how other IEA's support Council process and others have more resources to dedicate to their annual process which we don't. There is a lot of potential for one to inform the other – ecosystem status report and SAFE reports. We can get together to see how to inform the SAFE report and ensure they are not duplicate efforts. Finally, the ecosystem status report annually is out of our capabilities at this point. As an example, the California Current IEA has more than ten people per year working on their ESR, with two as their full-time job. If we want to do that here, there needs to be greater dedication of resources to that product.

EBFM Collaborative Goal Setting

The goal of this session was to create a shared understanding of EBFM priorities, needs, and capabilities between the three offices. The desired outcome from these sessions was to have identified priority activities that could be achieved over the next 5–10 years with respect to EBFM. NMFS provided a facilitator to lead the discussion and work towards the workshop goals.

Prior to the workshop, the workshop committee shared their respective priority activities to fully implement EBFM in the PIR (see sections "WPRFMC EBFM Priorities and PIRO-PIFSC EBFM Priorities). These activities were placed on a board and all participants were asked to vote for the priority activities that they considered most important, either by placing a sticky dot next to them, or, if virtual, a checkmark next to them on the JamBoard. The activities that garnered the most votes from each office were:

Council EBFM Priorities:

- Identify reliable ecosystem indicators;
- Enhance data collection from monitoring; and
- Build flexibility when incorporating ecosystem considerations, and account for uncertainty to ecosystem drivers for management advice.

PIRO EBFM Priorities:

- Identify processes to adopt informed management;
- Improve partnerships with indigenous communities; and
- Identify issues that can be addressed with EBFM.

PIFSC EBFM Priorities:

- Improve Data accessibility/quality; and
- Identify economic/societal/cultural indicators

Summary Comments

PIFSC

The processes used by PIFSC allow for assessment of risk and uncertainty in fisheries, but there are unknowns around the ecological importance of species. Those unknowns may be able to be addressed in the future, but that may require data that is not currently available. The most complete data currently available is fishery dependent data, but there is still a large gap in the biological data associated with species' response to climate change. While the fishery dependent data is good, there is limited fishery independent data. The fishery dependent data provides information on where the fishermen are fishing and the fish in those areas, but we do not know about the fish (abundance, size, species etc.) in areas where fishermen are not fishing. Habitat data is also limited. Understanding where fish species shelter, spawn, breed, feed, or grow to maturity. Possible solutions to overcome the lack of habitat data might be through the use of EDS or through the clarity on what management goals are and the issues being addressed will

help focus the types, scope and scale of data needed. For instance, with regards to the "human well-being," there are a lot of ways to operationalize questions to address this issue. Understanding what is important to the communities facilitates understanding what data is needed. Identifying the data gap may only be the first step. There may be a problem with filling those gaps because of data availability or quality. We may need to look at mechanisms to overcome these gaps (e.g., modeling), but there are some gaps that we may not be able to overcome.

Finally, it is not clear where science fits into the management decisions process, is it one place or many? Getting clear guidance on where PIFSC could engage in the management decision process would be helpful.

PIRO

The current process for addressing management needs with PIFSC science products needs to be adapted so that management input is provided at the beginning of the process. Additionally, there could be greater focus on habitat. Generally, habitat data is not being included where it could provide a greater understanding of ecosystem dynamics. In order to do that, it is necessary to incorporate various stakeholders.

While identifying gaps in data is important, funding limitations may prevent us from getting the data we want and need. There is already a lot of good data, so we should focus energy on how we can apply the data we have to meet our needs now and work towards data improvements in the longer term.

Council

For the time being, the focus should be on the mechanisms we already have in place. Other methods mentioned or not currently being used may be "data hungry" and there may not be the right amount or type of data to use them. It would be better to adapt the mechanisms we have on a case-by-case basis. Consideration also needs to be given to the limitations of the mechanisms we use. For instance, in fishery stock assessments accounting for uncertainty (often due to a lack of data) usually means allowing less mortality. Relying on fishery-dependent data can also be problematic. The data collected by the fishermen concentrates on target species, while non-target species may be underreported, this may appear to indicate a decline in those species, but may actually just be an issue with how the data is reported and collected.

EBFM Coordination

To enhance the coordination of regional EBFM efforts between the Council, PIRO, and PIFSC, participants of the Workshop agreed that a collaborative working group should be convened to continue progressing on the potential projects, processes, and plans that are needed to actualize EBFM in the U.S. Pacific Islands. Further, the collaborative working group would aim to identify details for necessary priorities and communication protocols by which fishery managers in the western Pacific region can implement EBFM. Each agency has an internal EBFM working group. The proposed collaborative working group would be a joint team of a few (~3) staff from each of the three agencies. Communication is especially important because the working group membership is mid-level staff that would need to relay relevant information to leadership. The

collaborative working group would meet quarterly to start, but meeting frequency could be adjusted as needed over time.

Workshop participants agreed that the proposed collaborative working group should examine specific examples of implementing EBFM that can be applied to the western Pacific region, potentially across a range of different fishery considerations (e.g., pelagic, protected species, coral reef, etc.). Each consideration would likely have varying levels of data availability, which would impact the extent to which EBFM could be applied to the fishery, generally speaking. Ultimately, the collaborative working group should develop a regional "template" that would help guide future efforts to effectively implement EBFM. Workshop participants generally voiced that the collaborative working group needs an objective goal, but it may be the case that the group will be able to establish more concrete objectives after they convene to discuss examples proposed by workshop participants.

Engaging stakeholders was identified as a possible challenge in implementing EBFM. Public participation would be fostered primarily through the Council process. The collaborative working group would come together to decide when sufficient progress had been made to warrant reporting to the Council during one of its regular meetings. These meetings are open to the public and would provide the first opportunity for members of relevant communities to give input on implementing EBFM. Secondly, the products that working groups would be expected to develop would likely encourage stakeholder engagement on the implementation of EFBM. Their purpose is to provide a focused venue for members of the public and other stakeholders to provide feedback on the processes to utilize an ecosystem approach to fisheries management.

Potential Projects

Over the course of the workshop, participants identified case studies that the collaborative working group could examine in the pursuit of generating a standardized process for applying EBFM to regional fisheries. Participants wanted to note several examples since the nature of problems encountered would differ (e.g., depending on scale, constituents, relevancy in the long-term, etc.). The current perspective is regarding system mechanisms, but there also could be a species-based perspective; the collaborative working group should discuss which of the two is more feasible. Additionally, because EBFM will be an iterative process, it is not necessary to "reinvent the wheel," and working group members should utilize data products and models that already exist when possible.

Identified projects that the working groups could examine include:

- Managing protected species interactions in the longline fisheries and understanding socio-economic impacts and trade-offs from management strategies in these fisheries.
    - Ties three main workshop themes together (flexibility in management by the Council, identification of indicators, and clear management priorities from PIRO).
    - Working groups would need to communicate with PIFSC to understand what modeling work has already been done, with data requirements and limitations.
    - Management Strategy Evaluation could be used to bolster this process, as is already being done by Rob Ahrens for giant manta ray and oceanic whitetip shark

interactions in the longline fishery. The team that collaborated on that project is looking to explore improving TurtleWatch next.
    - Data concerns, particularly around fishery independent data, exist for pelagic species.
    - Longline fisheries are managed, in part, under RFMOs. Questions arose about how EBFM could be examined at a smaller scale when many drivers push from a larger scale (i.e., internationally).

- Holistically managing the Hawaii bottomfish and/or uku fishery
    - The fishery has a wealth of data (e.g., forthcoming single-species stock assessments, BFISH fishery-independent surveys, etc.) that may have fewer gaps than other regional fisheries.
        - However, the fishery is still "commercial data-rich, but fishery-independent data-poor."
    - This could be generalized to Hawaii small boat fisheries, including those that target pelagics since many bottomfish fishers also harvest pelagics. The same group of people may be fishing differently at specific times of the year and managers may be able to inform fishers when it is appropriate to diversify their fishing methods to optimize yield.
        - Market dynamics (in relation to the longline fisheries) are an important consideration in fishers' decision making in small boat fisheries.
    - The management system for Hawaii small boat fisheries needs to incorporate ecosystem considerations. The discussion should be about how to better include available information for stock assessment and management decision-making purposes.
    - A point of emphasis could be identifying fishery ecosystem relationships between fishery-dependent data and environmental parameters.
    - There are upcoming efforts by PIFSC to holistically synthesize all available datasets for bottomfish, including calibrating disparate datasets to extend spatiotemporal scales.
    - It is critical to consider the joint management between the State of Hawaii and the federal agencies for Hawaii Deep 7 bottomfish and uku.
        - Last year, the Council recommended an MSE be conducted for the uku fishery because of incongruent management strategies for the non-commercial fishery sector (i.e., the State did not want catch limits or closures, but wanted bag limits and minimum sizes for the non-commercial sector).

Summary Comments

PIFSC

The mechanism by which PIFSC can contribute science for each of the different potential projects may differ depending on the management goal and identified item. Managers should work to identify where science can best inform their processes. For example, in the longline fishery, science can be incorporated for protected species interactions, but management advice needs to be generated to guide data usage and acquisition for other valued ecosystem

components. To aid in this decision making process, a forthcoming scenario planning training could employ the identified projects and offer insights to incorporate climate change.

The teams will not be able to accomplish everything and will work towards identifying one or two items that can be supported, to facilitate progress. As focus is geared towards specific projects, there will be a need to examine different scales, either looking at management unit species or protected species individually, or at the system/mechanism approach. The scale needs to be chosen at a level for which managers identify what they need to know and what is actionable. A priority shared by all offices is related to identifying data streams and associated ecosystem indicators. For EFH, PIFSC is working on species-specific eDNA assays for Deep-7 bottomfish and uku in Hawaii to see what areas fish are in at different times separate from fishery-dependent metrics of abundance. PIFSC is exploring how to apply these new data, perhaps in stock assessments.

The first step is understanding the question: What is the management outcome each office is trying to achieve and what are the roles of each agency in reaching that outcome (e.g., PIFSC is science, the Council is community engagement, etc.)? As these working groups move forward, managers need to identify where to focus specific resources. This effort is about establishing the process. Ask "what is the next step to get to…" and figure out how each office can collaborate to achieve it.

PIRO

From the management perspective, the three offices need to agree on a question to narrow the broad topics that often seem overwhelming. Pulling in only a couple of pieces is still progress, for example the collaborative working group could simply identify science gaps and brainstorm solutions to provide for a desired management outcome. However, the collaborative working group will not be solving the EBFM problem, but will make a template for EBFM efforts in the region. Currently, there is ongoing work that can be built upon to help broaden the opportunity to push this initiative forward. Ultimately, the collaborative working group's goal is to define the process and make recommendations on projects based on data availability, funding and capacity.

Council

The Council process is very well defined and incorporates all necessary agencies, stakeholders and members of the public. As any fishery action or initiative is developed, all notices for public meetings are first published in the federal register. The process begins with input from advisory panels and community members, an action team, the plan teams, the Scientific and Statistical Committee, and finally the Council. All actions are vetted through this process and often cycled through multiple times to ensure adequate progress is made with input from all stakeholders. As a result of this workshop, the Council, PIFSC and PIRO need to define a method that incorporates the priorities and needs of three offices to implement EBFM action items, which is likely to be completed through progress by the collaborative working group. Ultimately, the working group does not have to simply focus on one potential project. They should also focus on an action plan, "road map," and priorities that can be vetted through the Council process detailed above. Eventually, these products can be aggregated to make an action plan that covers all three offices.

Recommendations

The following recommended members are tasked to participate in the collaborative working group. These members will work to implement the EBFM initiatives discussed above. The team will meet quarterly and report out at the quarterly coordination meeting. The Council representative will be invited to participate in that portion of the coordination meeting. Leadership will be invited periodically (potentially semi-annually) to keep them informed.

Council	PIFSC	PIRO
Matthew Seeley	Beth Lumsden	Richard Hall
Asuka Ishizaki	Kisei Tanaka	Savannah Lewis
Mark Fitchett	Jamie Gove	Elena Duke
Josh DeMello	Marlow Sabater	Malia Chow

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Appendix A Agenda

9:00 Welcome and Opening Statements, Expectations and Outcomes
Kitty Simonds (Council), Sarah Malloy (PIRO), Tia Brown (PIFSC),
Steering Committee: Beth Lumsden (PIFSC), Richard Hall (PIRO), Matthew Seeley (Council)

9:15 WPFMC EBFM Priorities (Matthew Seeley and Asuka Ishizaki)
Articulate Council EBFM priorities and why they are important to fisheries management in the PI.

9:40 PIRO-PIFSC EBFM Priorities and Projects (Frank Parrish and Gerry Davis)
Frank- EBFM guiding principles and waypoints to implementation.
Gerry- Points of collaborative progress and a specific example of West Hawaii (HFA and IEA)

10:05 PIRO-PIFSC EBFM Workshop Overview (Richard Hall)
Provide an overview of the April 2021 EBFM workshop objectives, issues, priority outcomes and next steps.

10:15 Break

10:30 Council identified priorities (Science challenges and ways forward tailored to council priorities)
- Environmental and climate impacts on Pelagic Fisheries (J.Wren)
- Socio - Economic Risk (D. Kleiber, H. Chan, M. Iwane)
- Protected Species (E. Oleson, S. Martin, M. Barbieri)
- Large Scale changes (Climate) on fisher and fishing communities (J. Ruzicka)
- Panel Q&A

11:15 Council identified Next steps (Approaches for EBFM)
- Indicators for stock assessment - M. Sabater (5-7)
- Quantitative decision tools for interactions and ecosystem considerations – K.Tanaka (5-7)
- Climate Change Scenario Planning – K.Leong (5-7)
- Panel Q&A

12:00 Lunch

13:00 Welcome: Mike Seki, PIFSC

13:05 EBFM Case Study: IEA (J. Gove)
Scaling the IEA up to State and basin scale

13:35 EBFM Collaborative Goal setting (Facilitated discussion)

Intersections of Council, PIRO and PIFSC activities

- Pre-mortem activity: What do we want to have achieved in 10 years and what do we (each organization) need to do/ achieve/ learn to get there

14:35 Break

14:50 EBFM Collaborative Goal setting (Facilitated discussion continued)

15:35 EBFM Coordination (Facilitated report out)

- *Agreeing to next steps - future EBFM workshop engaging stakeholders*

16:20 Workshop end/ Pau Hana