NOAA's Integrated Ecosystem Assessment program:
West Hawaii Region 3-Year Work Plan (FY2016-FY2018)

Primary Contact Information: Jamison Gove (NOAA/PIFSC); jamison.gove@noaa.gov; 808.725.5570

IEA Participants: Jeffrey Polovina (PIFSC) and Evan Howell (PIFSC)

Regional IEA Goal/Vision: *What are the primary goal(s) the IEA is trying to accomplish in your region over the next 3-years? What does the region hope to accomplish in the next 3-years to consider themselves successful? How do these goals and objectives fit in with the region's broader IEA vision and the NOAA IEA program goals and objectives?*

The West Hawaii IEA (WH-IEA) aims to provide sound and relevant scientific information that addresses existing and future resource management concerns in West Hawai'i. Over the next 3-years we aim to continue our interactions with existing management entities using IEA products while expanding our scope to engage and produce products for management entities that consider a broader swath of the ecosystem and/or implement place-based ecosystem management. This will allow the WH-IEA to produce products that merge human dimensions with biophysical knowledge to complete a socio-ecological IEA in West Hawaii, while continuing to meet the needs of management customers already using IEA products.

Introduction: *Briefly introduce the IEA region, its goals and its structure, and give an overview of prior IEA activities in the region, highlight the approach being taken, how the IEA hopes to accomplish the goals and vision laid out above, and how the prior and planned activities relate to the IEA loop. This should provide a general understanding of the type of research, development and other activities the region is pursuing over the next three years and why those activities are important.*

The IEA in Hawai'i was formed in 2010 to develop a comprehensive understanding of the marine ecosystem in the Kona coastal region of Hawai'i Island to help support management decisions. The Kona coast, or more commonly referred to as "West Hawaii" by the local community, is home to a diverse group of species including ornamental fish, lush coral reefs, sea turtles, cetaceans and manta rays. West Hawaii also supports a myriad of ecosystem services important to the community, including eco-tourism, an aquaculture industry, and recreational and aquarium fisheries. The balance of these human activities with the natural processes along West Hawai'i is important to sustain ecosystem health in this important region.

Since its inception, the West Hawai'i IEA (WH-IEA) program has focused considerable efforts building relationships with State, Federal and non-governmental agencies and engaging local community organizations to understand management and community needs in this ecosystem. For example, the IEA program has been working closely with each of the Federal programs, including Hawaiian Islands Humpback Whale National Marine Sanctuaries, Habitat Blue Print and Sentinel Site Programs, and more recently, the President's Resilient Lands and Waters Initiative. The region's coral reef ecosystems have also been designated an important

focus area for both the State and NOAA's Coral Reef Conservation Program, and is the focus of the most comprehensive and longest running coral reef monitoring program in the State. These programs and initiatives have served as excellent collaborative and leveraging opportunities as they promote complementary aspects of the IEA program and allow for direct up-take of IEA efforts. With respect to community engagement, the IEA has lead three successful and well-attended science symposia, bringing together researchers, managers and community members to present current scientific findings and discuss relevant resource management issues. Additional community engagement, such as recent workshops focused on gathering place-based knowledge on social-ecological interactions, have provided strong connections in the region and helped establish the IEA program as a key partner in research, conservation, and management of West Hawai'i's marine ecosystems.

To help provide science information to make management decisions, the WH-IEA has focused on researching marine ecosystem dynamics in the region through several outlets. These include collaborating with University of Hawai'i researchers to create conceptual ecosystem models of the West Hawai'i region, downscaling large-scale climate and oceanographic models, hosting three science symposiums, constructing an ecosystem model of the West Hawai'i coastal reef area, and producing the first ecosystem trends and status report for the region. In addition, support from the Pacific Island Fisheries Science Center (PIFSC) has allowed for three separate research cruises aboard the NOAA Ship Oscar Elton Sette to the region, facilitating the collection of a wide range of ecological and oceanographic information that has direct relevance to regional management concerns For example, research focused on cetaceans has provided important information on cetacean habitat preferences that directly inform current management efforts, including the Hawaiian Islands Humpback Whale National Marine Sanctuary management plan review, a growing aquaculture/cage culture initiative in both state and federal waters, active land development issues, as well as State of Hawai'i initiatives to manage shared use areas where commercial and recreational activities converge. With on-going support from PIFSC, the IEA program will continue to lead research efforts in order to gain new insights on local ecological dynamics that supports local-community, State and Federal management planning bodies.

This research foundation has led to the creation of the first Ecosystem Trends and Status report for the WH-IEA, and will provide a solid base for upcoming IEA activities over the next three years. Activities planned include the completion of the IEA-loop for coral reef ecosystems in the region, expanding human dimensions and climate change work, broadening local community engagement, and strengthening our existing connections with resource managers to better facilitate management uptake of IEA-related efforts.

REGIONAL GOALS, OBJECTIVES, ACTIVITIES, AND DELIVERABLES (Fill out as many priority goals as appropriate and indicate whether they will be accomplished with core funding or supplemental):

PRIORITY GOAL #1: **Fully implement an Integrated Ecosystem Assessment for coral reef ecosystems in West Hawai‘i.**

We have been working towards the implementation of an IEA for coral reef ecosystems in West Hawai‘i since 2014. This has resulted in important scoping of the IEA and IEA-related activities and vetting ecosystem indicators with the local community and researchers from the State of Hawai‘i’s Department of Aquatic Resources (DAR). The recent mass coral bleaching event of 2015 has motivated the State of Hawai‘i to start the process of developing a comprehensive Coral Reef Management Plan. The researchers and resource managers within this study area (DAR and the Hawaiian Islands Humpback Whale National Marine Sanctuary) are supportive of working with the West Hawai‘i IEA and using the IEA framework to help transfer scientific information in support of the Coral Reef Management Plan.

Objective #1: Select consistent indicators for use throughout the region that assess the full socio-ecological system and respond to goals of the varying place-based management entities.

Deliverables:

- Conceptual models for coral reef ecosystem state.
- West Hawai‘i Ecosystem Trends and Status Report
  - Identify information gaps and determine if the indicator suite can address all focal ecosystem components identified in the EBM-DPSER models for this region.
- Create information products (e.g., maps, web visualizations) for managers that display the trends and status data in relevant, user-friendly ways.

Objective #2: Conduct ecosystem modelling of West Hawai‘i’s coral reef ecosystem.

Deliverables:

- Ecosystem model estimates of coral reef ecosystem state changes in response to variations in key ecosystem pressures and drivers, as identified via EBM-DIPSER and recent published work on recreational fishing pressure.
- Estimate changes to ecosystem services and human well-being based on changes to ecosystem state from above output.

Objective #3: Conduct risk assessments of coral reef ecosystem state.

Deliverables:

- Conduct a risk assessment of coral reef ecosystem state (corals and reef-fishes) based on key pressures and drivers as identified in Objective #1.
- Assess risk to coral reef ecosystem state based on changes in fishing pressure using output from ecological modelling (Objective #2).

Objective #4: Evaluate Management Scenarios based on the State of Hawai‘i’s pending coral reef management plan.

Deliverables:

- Conduct a formal trade-off analysis based on the recommendations of the coral reef management plan to be developed by the State of Hawai‘i.

- Model changes to ecosystem state (via Objective #2) based on scenarios/recommendations of the coral reef management plan developed by the State of Hawai‘i.
- Examine the impact of these scenarios/recommendations on ecosystem

Priority Goal #1 Workplan

Deliverable (from above)	Task/Activity	Expected Completion Date	Responsible LO/ Partner (or Person)	Progress Reporting
Conceptual Ecosystem Models	*Scoping/Indicator Selection*	*FY16 Q2*	*NMFS/Jamison Gove and UH/Kirsten Oleson*	
Ecosystem Trends and Status Report	*Indicator Selection and Ecosystem Assessment*	*FY16 Q2*	*NMFS/Jamison Gove*	
Risk Assessment of Coral Reefs to Key Pressures and Drivers	*Risk Assessment*	*FY17Q3*	*NMFS/Jamison Gove*	
Ecopath Ecosystem Modelling of Reef-Fish	*Risk Assessment/MSE*	*FY17 Q3*	*NMFS/Jamison Gove and Jeffrey Polovina*	
Trade-Off Analysis of Coral Reef Management Scenarios	*MSE*	*FY18 Q4*	*NMFS/Jamison Gove*	

PRIORITY GOAL #2: Expand Human Dimensions within the West Hawai‘i IEA

Effective marine governance requires ecologically meaningful information that is coupled with diverse human uses and practices at operationally relevant spatial and temporal scales. The WH-IEA has conducted a number of workshops focused on gathering place-based knowledge and expert-opinion on human uses to help better understand some of the key social-ecological interactions in the region. During these workshops, community members, scientists and resource managers came together and developed a consensus of the primary pressures and drivers of coral reef ecosystem state. Informed by the outputs of the collaborative workshop and with current scientific understanding of sub-tropical marine ecosystems, an initial suite of social indicators were derived to help track the status and trends in West Hawai‘i’s marine ecosystem. These efforts have helped engage the local-community and increased our understanding of important social-ecological interactions. However, additional work is required that broadens human dimensions information and better captures critical ecosystem services (e.g., cultural practices, aesthetics, community perception and sense of place) important to support marine governance in the region.

Objective #1: Broaden scope of the IEA to include human interactions with additional ecosystem states (beyond coral reefs) in the region.

Deliverables:

- Development of Conceptual Ecosystem Models for additional ecosystem states (beyond coral reefs).
- Driver-Pressure-State-Impact-Response (DPSIR) models to quantify the connections and interaction strengths and examine the relationships that exist between social and ecological components of the ecosystem.
- Expanded list of additional ecosystem services in the region.

Objective #2: Build-upon recent participatory mapping efforts and better assess spatial variability in human uses and the delivery of ecosystem services.

Deliverables:

- Synthesize ecosystem services and social drivers and add a spatial component to these data sets within the region.

Objective #3: Analyze uncertainty and risk to essential ecosystem services identified in Objectives #1 and #2

Deliverables:

- Risk assessment of essential ecosystem services. Those associated with coral reef ecosystems will be linked to Priority Goal #1 Objective #2.

Priority Goal #2 Workplan

Deliverable (from above)	Task/Activity	Expected Completion Date	Responsible LO/ Partner (or Person)	Progress Reporting
CEM's and DPSIR Models for expanded ecosystem states	*Scoping/Indicator Development*	*FY17 Q1*	*NMFS/Jamison Gove*	
Spatially explicit information on social drivers and ecosystem services	*Indicator Development*	*FY18 Q2*	*NMFS/Jamison Gove*	
Risk Assessment for Essential Ecosystem Services	*Risk Assessment*	*FY18 Q4*	*NMFS/Jamison Gove*	

PRIORITY GOAL #3: Expand Scientific Research in West Hawai‘i to Support Community-Based and State Management Efforts

Recent IEA research on cetaceans has provided important information on habitat preferences that will help inform the NOS management plan review among other relevant management activities, including a growing aquaculture/cage culture initiative in both state and federal waters, active land development issues, as well as State of Hawai‘i initiatives to manage shared use areas where commercial and recreational activities converge. Over the next three years, the IEA program will broaden this scope of this work to focus on additional aspects of the region's dynamic ecosystem that will aid existing and future management decisions. For example, upcoming work will investigate the following: surface slicks as important physical oceanographic phenomena for larval retention and recruitment; spatial and temporal changes in local phytoplankton production as it relates to the Island Mass Effect; the mesopelagic boundary layer community and the associated importance for supporting higher trophic groups. The Pacific Islands Fisheries Science Center has agreed to provide ship time on a biennial basis (subject to budget availability) aboard the NOAA Ship Oscar Elton Sette. The availability of ship time allows the IEA to offer collaborative research opportunities to partners working in the region.

Objective #1: Conduct scientific research on management-relevant aspects of marine ecosystem dynamics in West Hawai‘i.

Deliverables:

- Research findings on the ecological and physical oceanographic properties of surface slicks, their importance for fish (and other marine animals) recruitment

and development, and overall relevance for local ecosystem dynamics in the region.
- Increased understanding of the mesopelagic boundary layer community and the associated importance of this community in supporting higher trophic groups (including cetaceans) in the region.
- Quantifying coral mortality in the region associated with the 2015 coral bleaching event.

Priority Goal #3 Workplan

Deliverable (from above)	Key Tasks/Activity	Expected Completion Date	Responsible LO/ Partner (or Person)	Progress Reporting
Research Cruise and Associated Scientific Findings	*Building Capacity/Assess Ecosystem*	*FY16 Q3*	*NMFS/Jamison Gove*	

PRIORITY GOAL #4: **Increase Community Involvement and Collaborative Activities with the West Hawai‘i IEA program**

Identifying the focal ecosystem components necessary to consider for EMB in West Hawai‘i’s has largely been informed by local community input and collaborative activities. Recent workshops focused on gathering place-based knowledge and expert opinion has helped identify and better understand some of the key social-ecological interactions in the region. Similarly, the Science Symposia have been well received and garnered high praise for the IEA, as the event is unique to the region and brings together community members, scientists and resource managers all focused on West Hawai‘i. Over the next three years, the Program will build upon these successes and continue expanding community engagement and collaborative activities.

Objective #1: Broaden community input focusing on additional ecosystem states (beyond coral reefs) in the region.

Deliverables:
- Hold participatory workshop(s) in the region to develop the following:
  - Conceptual Ecosystem Models
  - Driver-Pressure-State-Impact-Response (DPSIR) models
  - List of ecosystem services in the region.

Objective #2: Broaden community and management interest and showcase IEA-related and collaborative ecosystem research in the region

Deliverables:
- The 4th Science Symposium on West Hawai‘i’s Marine Ecosystem
  - A 2-day event encompassing 40+ presenters and 200 attendees

Objective #3: Outreach and science-based communications of Priority Goal#3/Objective #1 so as to maximize community input and management uptake.

Deliverables:

- Web-based visuals and community involvement of research operations and outcomes
  - Scientific summary and info-graphic development
  - Updates of operations while underway via 'blogs' and 'ask a scientist'

Priority Goal #4 Workplan

Deliverable (from above)	Key Tasks/Activity	Expected Completion Date	Responsible LO/ Partner (or Person)	Progress Reporting
Participatory Workshop to Broaden Ecosystem States Captured	*Scoping*	*FY17Q1*	*NMFS/Jamison Gove*	
4th Science Symposium on West Hawai'i's Marine Ecosystem	*Scoping/Community Outreach/Collaboration*	*FY16Q4*	*NMFS/Jamison Gove*	

PRIORITY GOAL #5: Estimating the Impact of Climate Change

During the summer of 2015, water temperatures reached their warmest level in at least the last 35 years and resulted in the worst coral bleaching event ever recorded in the region. Although climate change is expected to increase coral bleaching in the future, much remains unknown with respect to the severity and frequency of future bleaching events in the region. Estimating the impacts of climate change, such as coral bleaching, is a priority for the West Hawai'i IEA and through collaborative partnerships we are now making inroads towards better understanding climate in the region. For example, the WH-IEA has recently funded the downscaling of global climate model output in order to estimate the spatial and temporal patterns of future warming. The outcomes of this work will provide resource managers the information necessary to build a comprehensive coral reef management plan that bolsters resiliency to future coral bleaching events. Over the next three years, the Program will expand on this initial effort and investigate the additional effects of climate on local ecosystem dynamics in the region.

Objective #1: Downscaled global climate model output of SST from the recent IPCC AR5 climate assessment (i.e. CMIP5)

Deliverables:

- 4 km monthly SST data from 2005 – 2100 for the region
  - Estimate the timing of the onset of annual severe coral bleaching

Objective #2: Assess the effects of future warming to marine ecosystem dynamics.

Deliverables:

- Assess the vulnerability of future coral bleaching for reef-fishes owing to the loss of essential fish habitat.

Objective #3: Evaluate management scenarios that aim to increase the resiliency of the ecosystem its associated services under likely climate change scenarios

Deliverables:

- Evaluate mitigation scenarios to mitigate climate change on coral reef ecosystems and improve ecosystem states and services

Deliverable (from above)	Key Tasks/Activity	Expected Completion Date	Responsible LO/ Partner (or Person)	Progress Reporting
Downscaled Climate Model Projections of Future Warming	*Climate/Risk Assessment*	*FY16 Q4*	*NMFS/Jamison Gove in collaboration with Jeffrey Maynard (MARC)*	
Estimate Future Coral Bleaching in West Hawai‘i	*Climate/Risk Assessment*	*FY17 Q2*	*NMFS/Jamison Gove in collaboration with Jeffrey Maynard (MARC)*	
Effects of Bleaching-Induced Habitat Loss on Coral Reef Fishes in West Hawai‘i	*Climate/Risk Assessment*	*FY18 Q1*	*NMFS/Jamison Gove*	
Management Strategy Evaluation to Mitigate Climate Change on Coral Reef Ecosystems	*Climate/MSE*	*FY18 Q4*	*NMFS/Jamison Gove and Jeffrey Polovina*	

Additional Methodological Information

1. *How will these outcomes result in a complete iteration of the IEA loop and/or advance IEA activities?*

As stated in Priority Goal # 1, we plan on completing a full iteration of the IEA loop for coral reef ecosystems in the region. Coral reef ecosystems have the highest likelihood for management uptake of IEA efforts and are consistently the one of the most important ecosystems in the region among local community members. Lessons learned from the completion of the IEA for reef ecosystems in the region combined with efforts outlined in the above work plan (i.e. Priority Goals #2 – 3) will advance the WH-IEA towards broadening our efforts into pelagic and other priority ecosystems in the region.

2. *What scientific advancements are anticipated from this work plan that are likely transferrable to other regions?*

The WH-IEA has principally learned from other IEAs across the Nation with respect to methodological approaches owing to the historical distribution of funds and the associated advances the regions have made through the IEA loop. However, the work plan above outlines activities that could be of use to other regions. For example, the GoM IEA may utilize the downscaled climate model information to assess future bleaching scenarios for the region's coral reefs. Similarly, our proposed efforts to spatially map ecosystem services through participatory mapping efforts could serve as a model for other regions to incorporate.

3. *How will human dimensions and climate change be incorporated into the work?*

With the release of the Ecosystem Trends and Status Report in FY16 Q2, the WH-IEA will provide a suite of initial social indicators for the region. The WH-IEA will build upon this initial work and consider and incorporate social drivers and ecosystem services in all aspects of the Program. In addition, Priority Goal #1 *Expand Human Dimensions within the West Hawai‘i IEA* outlines work planned over the next three years to increase the role of human dimension information in the WH-IEA program.

The WH-IEA has initiated work to downscale global comate models in order to assess future thermal stress on corals in Hawai‘i. This work will provide the first ever estimate of the temporal onset and spatial distribution of severe coral bleaching under differnet climate change scenarios for the region. As outlined in Priority Goal #5, the WH-IEA plans on building on this initial work to assess the vulnerability of reef-fishes to the loss of essential fish habitat induced by future coral bleaching and conduct a MSE that investigates potential mitigation strategies to increase the resiliency of ecosystem services under different climate change scenarios.

4. *Will this research transition into or inform actionable management decisions?*

The State Department of Land and Natural Resources is in the initial phase of developing the first Coral Reef Management Plan for the State's coral reef ecosystems. The WH-IEA will serve an integral role in this process. J.Gove of the IEA is serving on the scientific steering committee for developing Plan while outputs from priority #1 and #5 as well the soon to be completed Ecosystem Trends and Status Report will directly inform the management planning process.

5. *What management entities are engaged or will be engaged by this effort? How do you envision the work informing management decisions in your region? Are there specific pending management decisions that you aim to inform with this work?*

The following management entities will be engaged in IEA-related activities outlined above: Hawaiian Islands Humpback Whale National Marine Sanctuary, Department of Land and Natural sources/Department of Aquatic Resources, West Hawai'i Fisheries Management Council, West Pacific Regional Fishery Management Council

6. *What steps will be taken to increase the probability that relevant management agencies make decisions informed by IEA products?*

The WH-IEA is actively involved in the development of a Coral Reef Management Plan by the State. In addition, the Hawaiian Islands Humpback Whale National Marine Sanctuary is transitioning into an Ecosystem Sanctuary, in which IEA-activities and specifically Priority Goal #1 will directly support and inform this new management paradigm for the agency.

7. *Identify and describe external drivers related to EBM and IEA in your region. How are you proposing to work with these external drivers to benefit the IEA?*

With J.Gove serving as a scientific adviser, the IEA is directly involved with the development of a State-wide Coral Reef Management Plan, of which IEA-products and future activities will directly inform and support.

End-Users (e.g. recipients/ beneficiaries of regional IEA work and impact): Identify the management entities you are working with in the IEA project. In addition, if possible, please provide letters of request, support, endorsement, evaluation from pertinent management agencies that are likely to use the IEA products being developed from this regional IEA. Alternatively, provide meeting records that reference and state the need for or request IEA products.

The IEA program is actively working with each of the relevant management entities including the following:

- State of Hawai'i's Department of Land and Natural Resources (DLNR)
  - In response to the 2015 mass coral bleaching event, DLNR will put together the State's first Coral Reef Management Plan. J.Gove of the IEA is serving on the scientific steering committee for the Plan and IEA products (e.g. Ecosystem Trends and Status Report) will directly inform the management planning process.
- Hawaiian Islands Humpback Whale National Marine Sanctuaries

    - IEA products and information are contributing directly to the Hawaiian Islnds Humpback Whale National Marine Sanctuary's is management plan review.
    - The IEA leading efforts in the creation of an Ocean Health Index for the region, which has been requested by NMS.
  - West Hawai'i Fisheries Management Council
  - Western Pacific Regional Fishery Management Council

Long-term Outcome(s): How will this work contribute to the broader IEA vision in your region and beyond?

This proposed work plan demonstrates how all steps of the IEA loop will support decision-making while including social and ecological components as well as their interaction. The work will also identify and move toward filling research and data gaps, furthering our ability to complete the West Hawai'i IEA for coral reefs and additional ecosystem states.

Success: How will you know and evaluate/ determine that your objectives and activities have been successful at achieving your priority goals? What is the ultimate outcome you are trying to achieve? What are the anticipated impacts and benefits of the IEA work in your region?

The overarching goal for the WH-IEA is for IEA-related activities and products to directly inform existing and future resources management policies in the region. By carrying out the full IEA loop for coral reefs, we will be better positioned to advance a process for using the IEA framework to evaluate management actions in other aspects of West Hawai'i. Additionally, providing information products to managers with immediate challenges and needs and following through with the application IEA-related information, we will provide solid examples of the benefits of the IEA process for adaptive management.

COMMUNICATION AND OUTREACH *(e.g. dissemination of project outputs and lessons learned; sharing of knowledge gained from the project):*

The program disseminates information to partners and stakeholders through:

- Organizing and holding Science Symposia that is free and open to the public.
- Presentations and ongoing engagement at workshops and meetings (e.g. fisheries management council, advisory groups, local community workshops)
- Reports including Ecosystem Status and Trends Reports.
- Models and other management tools (e.g. conceptual models, ecosystem models, risk assessments) .
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The program uses feedback from partners and stakeholders to:

- Identify the greatest management issues for which supporting information is needed.
- Shape the management and climate scenarios for which assessments are conducted.
- Formulate relevant results and products for managers.

APPENDIX A: PAST ACCOMPLISHMENTS/PROGRESS

Past Accomplishments: *Describe the past accomplishments of your IEA program.*

The WH-IEA held a recent workshop focused on gathering place-based knowledge and expert opinion to help better understand some of the key social-ecological interactions in the region. Community members, scientists and resource managers came together and developed a consensus of the primary pressures and drivers of coral reef ecosystem state. Informed by the outputs of the collaborative workshop and with current scientific understanding of sub-tropical marine ecosystems, we formulated a series of ecosystem indicators useful for tracking the status and trends in West Hawaiʻi's marine ecosystem.

The past three science symposia have been extremely successful, providing a one-of-a-kind avenue to present and discuss science advances and resource management needs in the region. With over 40 presenters and nearly 200 attendees during the 2014 Symposium, the WH-IEA Science Symposium is now widely recognized for the quality and management relevance of the work presented.

Research focused on cetaceans has provided important information on cetacean habitat preferences that directly inform current management efforts, including the National Marine Sanctuary management plan review, a growing aquaculture/cage culture initiative in both state and federal waters, active land development issues, as well as State of Hawaiʻi initiatives to manage shared use areas where commercial and recreational activities converge.