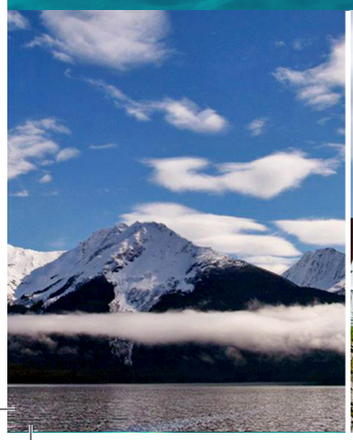
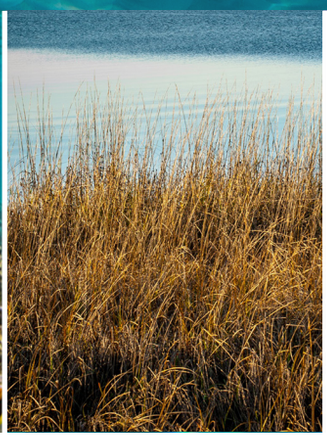
NOAA

IEA

INTEGRATED ECOSYSTEM ASSESSMENT

10 YEARS OF Integrated Ecosystem Assessment





Main cover and foreword photo:
Below the surface of the ocean in Hawai‘i. Photo: Christine Shepard

Bottom cover photos (left to right):
Auke Bay near Juneau, Alaska. Photo: NOAA Alaska Fisheries Science Center, Auke Bay Laboratories/David Csepp
Portland Head Lighthouse in Maine. Photo: NOAA National Weather Service/Alan M. Kolnik
Coral reef fish in West Hawai‘i. Photo: Christine Shepard
Marsh in the Gulf of Mexico. Photo: NOAA/Seann Regan
California coastline. Photo: Monterey Bay National Marine Sanctuary/Steve Lonhart

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Advancing NOAA’s ecosystem science and management enterprise to balance the needs of nature and society for current and future generations, supporting diverse marine resource management objectives in an ecosystem context.

To learn more about IEA efforts, visit:

https://www.integratedecosystemassessment.noaa.gov

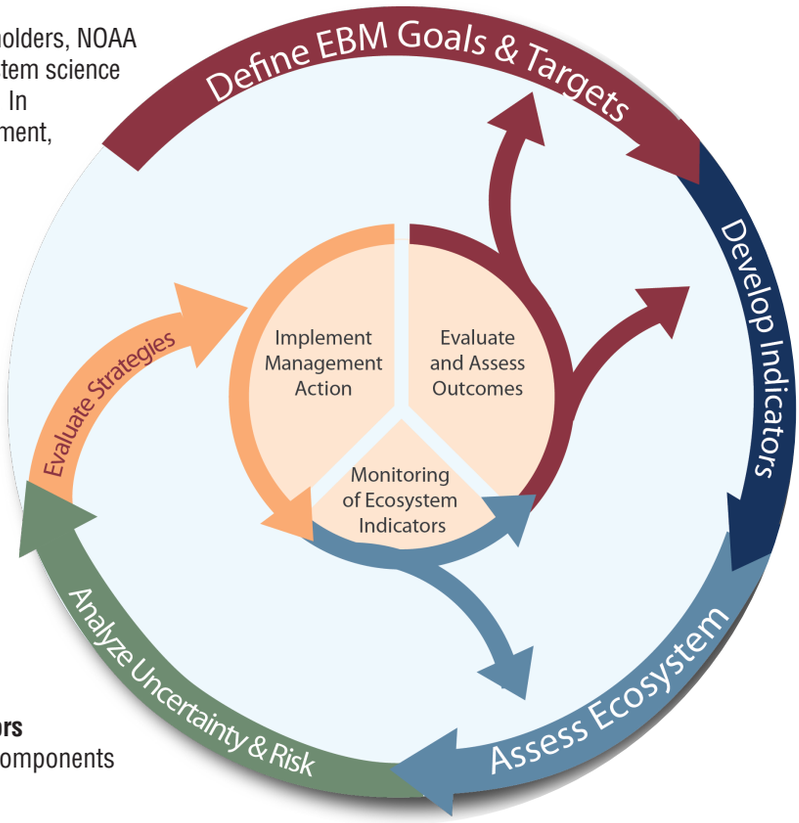
The IEA Approach

What is an Integrated Ecosystem Assessment?

NOAA's Integrated Ecosystem Assessment (IEA) is an approach to Ecosystem-Based Management that integrates all components of an ecosystem, including humans, into the decision-making process so that managers can balance trade-offs and determine what strategy is more likely to achieve their desired goals. This approach is a key part of NOAA's ecosystem science and management enterprise.

In a collaborative effort with researchers, managers, and stakeholders, NOAA scientists are using NOAA's IEA approach to provide the ecosystem science needed to address stressors and prioritize management efforts. In contrast to more conventional approaches to resource management, the IEA approach relies on collaborative, interdisciplinary, and adaptive methods to consider interactions among multiple components of marine ecosystems and recognizes that local communities are an integral part of the ecosystem. As such, the IEA approach recognizes that an understanding of the whole social and ecological system, not simply the individual components, is necessary to manage marine ecosystems.

The IEA approach is a stepwise approach to Ecosystem Based Management (EBM) where each step provides valuable science and builds strong partnerships in the advancement of EBM.



The IEA approach. Image: NOAA IEA

THE STEPS of the IEA Approach

1. **Clearly define goals and the system of interest.**
2. **Identify, select and (when needed) develop indicators** that capture the status and trends of key ecosystem components defined in the first step of the approach.
3. **Assess the ecosystem**, which often results in Ecosystem Status Reports.
4. **Conduct a risk assessment.**
5. **Evaluate management strategies.**

Ecosystem-Based Management
Why use an Integrated Ecosystem Assessment?

For some years, NOAA has recognized the value and importance of moving towards Ecosystem Based Management as an integrated way to meet the Agency's missions and mandates. NOAA's Integrated Ecosystem Assessment (IEA) program is developing and implementing a collaborative, multidisciplinary approach to help advance EBM and to manage our Nation's trust marine resources in an ecosystem context.

The IEA approach provides managers with science regarding all components of an ecosystem, including humans, so managers can make fully informed decisions that are more likely to achieve desired outcomes.

BENEFITS of the IEA Approach

Build consensus and more complete understanding of the ecosystem.

Build a network of interdisciplinary scientists.

Explicitly consider all components of the ecosystem, including humans.

Managers, scientists, and stakeholders work together to achieve marine resource objectives.

Identify trade-offs to make decisions that result in the most desired outcome.

Support transition to ecosystem-based management.

The IEA Program
National Highlights

VISION

Through an integrated science approach, the NOAA Integrated Ecosystem Assessment (IEA) program balances the needs of nature and society for current and future generations, supporting diverse marine resource management objectives in an ecosystem context.

MISSION

The mission of the NOAA IEA Program is to provide a sound interdisciplinary analytical and science-based framework to support effective Ecosystem-Based Management (EBM) of our Nation's marine, coastal, estuarine, and Great Lakes resources.

THE IEA PROGRAM OVERSEES EXECUTION OF THE IEA APPROACH

The NOAA Integrated Ecosystem Assessment (IEA) Program is a NOAA-wide initiative that oversees the direction and execution of Integrated Ecosystem Assessments within the United States ocean and coastal ecosystems. The IEA steering committee consists of representatives from each of the regions, most of NOAA's line offices, and for several specific topics such as climate change and human dimensions. The steering committee, with the program office, leads and advances development and implementation of the program including establishing goals, priorities, and strategies; provides guidance on funding, communication efforts, and agency level initiatives; oversees topical program working groups; and ensures coordination and communication among the regions and across different agency line offices and program partners.

PARTNERS

IEA REGIONAL PROGRAMS

IEA's 5 current regional programs (map is not to scale). Image: NOAA IEA

Alaska Complex
Integrated Ecosystem Assessment

Integrated Ecosystem Assessments carried out in Alaska provide ecosystem science to management, relevant stakeholders, and community members in the Alaska region to support effective Ecosystem-Based Management.

REGIONAL PARTNERS

IEA scientists work in various offices across NOAA and collaborate with a variety of partners; some are listed below.

- **North Pacific Fisheries Management Council**
- **The community of Sitka, Alaska**
- **Kawerak Tribe**
- **The Arctic Council**
- **The Pribilof Islands Community**
- **University of Washington**
- **The University of Alaska Fairbanks**
- **The State of Alaska**
- **Alaska Department of Fish and Game**

Auke Bay near Juneau, Alaska. Photo: NOAA Alaska Fisheries Science Center, Auke Bay Laboratories/David Csepp

REGIONAL GOALS

The primary goals of the Alaska Integrated Ecosystem Assessment program are to:

- Support coordination between ecosystem research activities.
- Facilitate rapid uptake of ecosystem information to management.
- Reinforce partnerships between Alaska Fisheries Science Center researchers, coastal communities, and regional managers.
- Support the co-production of ecosystem knowledge.
- Understand climate risk and build capacity for climate adaptation.

Seagulls in Alaska.
Photo: NOAA

SERVICES FROM AND STRESSORS TO ALASKA MARINE ECOSYSTEMS

Alaska marine ecosystems face increasing stressors, such as fishing, increasing population, oil and mineral extraction, climate change, tourism, shipping, and forestry. Adequately characterizing the impact of these stressors to key ecosystem components, habitats, and species is central to Ecosystem-Based Management (EBM). IEAs in Alaska facilitate the critical science and management advice to support the region's EBM.

The Alaska IEA team of scientists are working on various projects in the four different sub-regions of Alaska: the **Gulf of Alaska (GOA)**, the **Aleutian Islands (AI)**, the **Eastern Bering Sea (EBS)**, and the **Alaskan Arctic** (northern Bering, Beaufort and Chukchi Seas). Alaska sub-regions contain vibrant coupled social-ecological systems that support ecosystem services and resources vitally important to indigenous communities, high-value commercial fisheries, economically important recreation and tourism, multiple marine and terrestrial protected species, and oil and gas development. Each of these regions is distinct in ecosystem structure and function and human activity.

Alaska Complex IEA
In Action

Sitka Harbor.
Photo: NOAA Fisheries/Ellen Spooner

An example of how NOAA's IEA approach is supporting ***STAKEHOLDER*** *needs.*

In Sitka, Alaska, NOAA's IEA approach was used to identify ecological components of local fisheries and linkages between Sitka residents' well-being and local fisheries. Information from this process will be used to assess impacts on the ecosystem from stressors and can lead to more sustainable, improved fisheries management.

SITKA SOUND MARINE ECOSYSTEM and the Community

Sitka, Alaska, is a relatively small fishing community located on the west coast of Baranof Island in the Gulf of Alaska. This coastal community is nestled in the Tongass National Forest along Sitka Sound containing the Saint Lazaria Wilderness area and the Alaska Maritime National Wildlife Refuge. Sitka is the 6th largest port in terms of the value of seafood landings nationwide. With a population of just under 9,000, 18% of Sitka's population earns their income from fishing or by the broader seafood industry. Sitka residents participate in commercial, sport and subsistence fishing.

The integration of intrinsically linked social, economic, physical, and biological components of the Sitka Sound marine ecosystem into scientific, stakeholder, and management decision-making is essential to ensure sustainability of this important marine ecosystem and the well-being and sustainability of the local community.

AN APPROACH to Link Human Well-Being and the Ecological Components

In a collaborative effort with scientists, managers, and community members, NOAA scientists are using NOAA's Integrated Ecosystem Assessment (IEA) approach to provide the community of Sitka with ecosystem science that connects key social and ecological components of important fisheries and eventually to evaluate ecosystem impacts from stressors and management actions. In contrast to managing single ecosystem components, the IEA relies on collaborative, interdisciplinary, and adaptive methods to consider interactions among multiple components of coastal and marine ecosystems and recognizes that local communities are an integral part of these systems. NOAA's IEA approach recognizes that an understanding of the whole social and ecological system, not simply the individual components, is necessary to conserve marine ecosystems and the benefits and services they provide.

The first step of the IEA approach is to clearly define goals and the components of the socio-ecological system of interest. Conceptual models are useful IEA tools to identify these

relevant components and linkages in marine ecosystems. Conceptual models also improve communication between stakeholders, interdisciplinary scientists, and managers, allowing the incorporation of diverse types of knowledge. Developing and maintaining relationships with stakeholders, managers, and community members as equal partners is foundational to the IEA process.

In Sitka, NOAA scientists and university partners began the process of developing socio-ecological conceptual models of the most important local fisheries. They first synthesized available scientific publications on important parts of the ecosystem that affect the halibut, herring, salmon, and sablefish fisheries. They identified key components within and linkages among physical, social, economic and biological components. Locally-relevant information on the links between fisheries including subsistence, commercial, and recreational uses and human community well-being are not well-understood for Sitka. Therefore, NOAA social scientists sought to address these information gaps by engaging with Sitka residents to determine these linkages. All of these components and linkages were used to build initial conceptual models of the ecosystem around these fisheries.

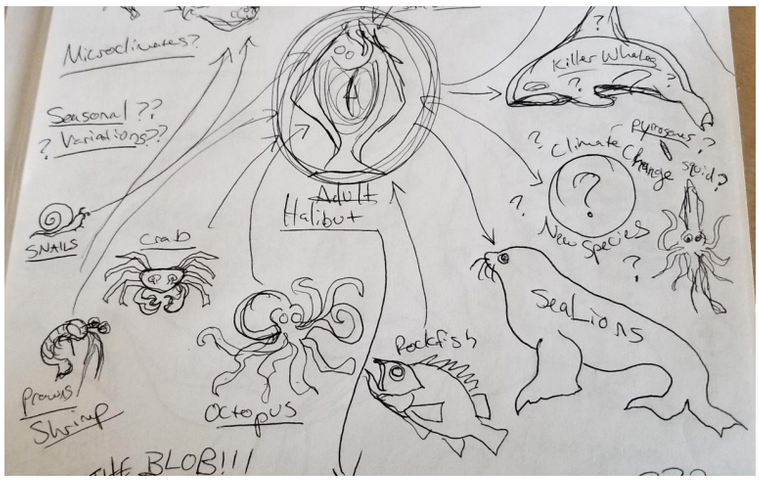
INTEGRATING LOCAL ECOLOGICAL KNOWLEDGE and Traditional Western Ecosystem Science

Workshops were held in April and November 2018 with Sitka community members to get direct input on these conceptual models and better understand their connection to the marine environment. With the assistance of partners in the community, researchers identified and worked with key participants for these workshops who have in-depth knowledge of the community's interactions with their local fisheries.

The goal of this co-production of knowledge is to integrate Local Ecological Knowledge (LEK) and traditional western science to understand the local ecosystem and to ensure a holistic, integrated and effective management of marine resources through an active partnership with the Sitka community.

To understand the human dimensions, the workshops identified linkages between local fisheries and Sitka residents' well-being, expanding beyond conventional understanding of livelihood benefits to include family connections, cultural values and traditions, and connection to the ecosystem, among others. Information gathered was based on personal experiences, knowledge, and observations of Sitka stakeholders. Workshop participants also identified how these well-being components are affected by changing marine ecosystem conditions and how such effects may be tracked with indicators that can provide critical information on how changing environmental and biological conditions reverberate through human communities.

Integrating LEK with western science is crucial to achieve sustainable, effective, and equitable management of fisheries. Stakeholder participation in the scientific process leads to a more informed and empowered community in relation to their local ecosystem and resources. NOAA's IEA approach thus inherently leads to a more holistic view of fisheries management.



A halibut conceptual model developed during the Ecological Connections section of the workshop. Photo: NOAA IEA

SUSTAINABLE, EFFECTIVE, AND EQUITABLE Management of Fisheries

These co-produced conceptual models have strengthened the shared holistic understanding of the social and ecological ecosystem components and linkages. They also identify knowledge gaps in the biology, food web interactions, and important economic and social outcomes of local fisheries and to inform ecosystem research needs.

Information gathered from this process will be used to evaluate the robustness of the system when different stressors are applied. This way managers and community members will have a more holistic understanding of how stressors impact the ecosystem, including differential impacts on human well-being.

California Current
Integrated Ecosystem Assessment

The California Current Integrated Ecosystem Assessment (CCIEA) is an interdisciplinary research effort led by NOAA scientists along the U.S. West Coast. The goal is to provide science support for ecosystem-based management of the California Current — a complex ecosystem in which natural and human systems are inextricably linked.

REGIONAL PARTNERS

IEA scientists work in various offices across NOAA and collaborate with a variety of partners; some are listed below.

- **Pacific Fishery Management Council**
- **National Marine Sanctuaries**
  - Olympic Coast
  - Cordell Bank
  - Greater Farallones
  - Monterey Bay
  - Channel Islands
- **NOAA Fisheries West Coast Region, Protected Resources Division**
- **State of Washington, Marine Spatial Plan**
- **Farallon Institute for Advanced Ecosystem Research**
- **Washington Sea Grant**
- **State of California**

California coastline. Photo: Monterey Bay National Marine Sanctuary/Steve Lonhart

Ecosystem Components of the California Current Marine Ecosystem

The following are key components of the California Current Ecosystem.

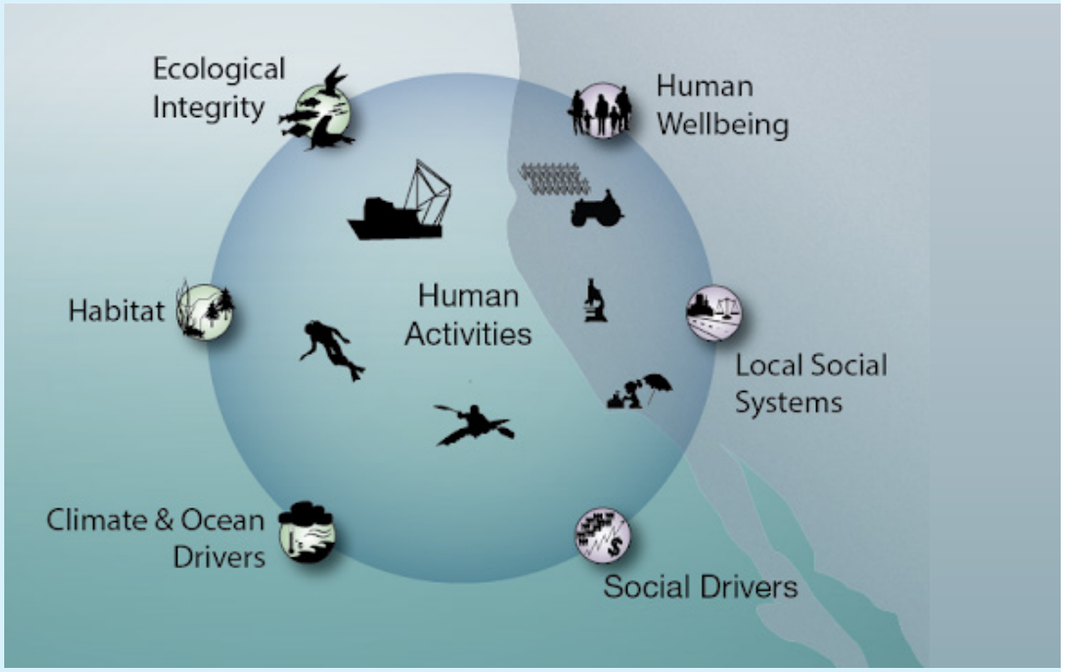
Ecosystem Integrity – The structure and function of marine and coastal ecosystems and ecological communities.

Resilient and Economically Viable Coastal Communities – Social, economic and cultural well-being and human health as it is tied to the marine environment.

Wild Fisheries – Condition of fishery stocks included in Pacific Fishery Management Plans: Coastal Pelagic Species, Highly Migratory Species, Groundfish, and Pacific Salmon.

Protected Species – Species with special protection as designated by the Endangered Species Act, Marine Mammal Protection Act, Migratory Bird Act, etc.

Habitat – Biogenic and abiotic habitats both on the seafloor and in the water column.



To better support the interdisciplinary dialogue necessary for a successful IEA process, the California Current ecosystem was conceptualized as a social-ecological system which explicitly acknowledges linkages and feedbacks between human and biophysical systems at multiple scales. Image: NOAA IEA

California Current IEA
In Action

California Halibut.
Photo: Ed Bierman

An example of how NOAA's IEA approach is supporting ***STATE MANAGEMENT*** *needs.*

In collaboration with California's Department of Fish and Wildlife and stakeholders, NOAA's IEA approach was used to pilot an evaluation of potential fishing impacts on target species, bycatch species, and habitats. This new approach has the potential to be a more efficient, objective, and transparent way to prioritize fishery management efforts.

POTENTIAL CHALLENGES to Managing California's Productive Fisheries

The waters off of California's coast supports some of the most productive fisheries in the world. Millions of dollars are paid directly to fishermen from commercial fishery landings, and over 100,000 jobs on and off the water are supported by California's seafood industry. Fisheries are an important part of California's economy, culture, and history and provide a wide variety of sustainable and local seafood.

These fisheries have the potential to impact many parts of the marine ecosystem. Intensive fishing can cause fish populations to decline, threatening the availability of seafood and the structure of the ecosystem. Some types of fishing gear may damage important habitat for marine life. Bycatch from fishing can also lead to possible declines in other species' populations.

Addressing all of these potential impacts requires a more holistic approach to management. The complexities of holistic ecosystem management make it difficult to implement. Viable approaches to evaluate ecosystem-wide effects of fishing are still developing. Real-world examples of ecosystem-wide management are even less common. In addition, fisheries managers often have limited resources and capacity to address all these issues.

AN APPROACH to Evaluating Fisheries' Impacts on the Ecosystem

In order to help understand and address fisheries' potential impacts on target species, bycatch species, and marine and estuarine habitats, NOAA scientists used NOAA's Integrated Ecosystem Assessment (IEA) approach to collaborate with the California Ocean Science Trust, fishery managers at the California Department of Fish and Wildlife (CDFW), and stakeholders to pilot an ecological risk assessment for California state managed fisheries.

In contrast to managing single ecosystem components, the IEA approach relies on collaborative, interdisciplinary, and adaptive methods to consider interactions among multiple components of marine ecosystems and recognizes that people are an integral part of the ecosystem. As such, the IEA approach recognizes that an understanding of the whole

social and ecological system, not simply the individual components, is necessary to conserve marine ecosystems and the benefits and services they provide. According to Paul Reilly, a CDFW lead scientist, "This ecological risk assessment can be customized to suit the needs of the management agency".

This pilot ecological risk assessment was done in conjunction with the revision of CDFW's Master Plan which guides their implementation of California's Marine Life Management Act (MLMA). The MLMA ensures the conservation, restoration, and sustainable use of California's marine living resources. The 2001 Master Plan focused on the vulnerability of specific stocks to fishing, the process of developing Fishery Management Plans, the public involvement in that process, and on data collection needs. However, other objectives related to socio-economics and potential impacts of fisheries to habitat and bycatch were not fully addressed.

NOAA's IEA approach has the potential to give CDFW the ability to assess fisheries impacts on habitat and bycatch. This is expected to make the prioritization of fisheries management more objective.

SCIENTISTS, MANAGERS, AND STAKEHOLDERS Work Together

A crucial part of NOAA's IEA approach is engaging stakeholders and managers early and often. CDFW also requires strong engagement and transparency with stakeholders in its management processes.

In order to ensure transparency, in 2018 workshops were conducted to examine the draft ecological risk assessment and solicit feedback for futher improvement. Stakeholders including fishermen, environmental non-governmental organizations and other federal fisheries experts were present. Using a single fishery as an example, this process fostered the inclusion of multiple perspectives and interpretations of existing data, setting the stage for broad buy-in. A modified ecological risk assessment was agreed upon and is being piloted by CDFW to help prioritize its fisheries management attention.

A More Holistic MANAGEMENT STRATEGY

Using NOAA's IEA approach to conduct this pilot ecological risk assessment, CDFW's updated Master Plan now includes a scaled and step-wise approach to consider and address the various potential impacts fisheries have on the ecosystem. In June 2018 the California Fish and Game Commission voted unanimously to adopt this updated Master Plan.

NOAA scientists will continue to use NOAA's IEA approach to work collaboratively with California state managers, scientists, and stakeholders to consider interactions among multiple components of California's coastal and marine ecosystem and recognize that people are an integral part of the ecosystem.

National Marine Sanctuaries

*An example of how NOAA's IEA approach is supporting **SANCTUARY** needs.*

West Coast NATIONAL MARINE SANCTUARIES

NOAA's IEA approach provided a more objective way for West Coast Sanctuaries to track the health of the Sanctuaries' marine ecosystems. The updated 2016 Channel Islands National Marine Sanctuary Condition Report used NOAA's IEA approach to identify indicators for key components of an ecosystem. Status and trend assessments of the indicators were based on the interpretation of quantitative assessments and the observations of scientists, managers, and sanctuary users, providing a more objective decision model. According to the Channel Islands Research Coordinator, Chris Caldow, "This report is such a massive improvement from the 2009 report and much of the improvement was due to this great collaboration and application of IEA products, processes, and expertise". Use of NOAA's IEA approach is also implemented in the Monterey Bay and Olympic Coast National Marine Sanctuaries.

Gulf of Mexico
Integrated Ecosystem Assessment

In collaboration with researchers, managers and local community, NOAA scientists lead the use of the Gulf of Mexico Integrated Ecosystem Assessment (IEA). The approach balances the needs of nature and society. It brings integrated ecosystem science and management advice to natural resource managers, supporting ecosystem-based management for current and future generations.

REGIONAL PARTNERS

IEA scientists work in various offices across NOAA and collaborate with a variety of partners; some are listed below.

- **NOAA Office of Habitat Conservation**
- **Southeast Regional Office**
- **Louisiana Trustee Implementation Group**
- **The state of Louisiana (Coastal Protection and Restoration Authority)**
- **Gulf of Mexico Fisheries Management Council**
- **Florida Keys National Marine Sanctuary**
- **Local Fishermen**

Marsh in Gulf of Mexico. Photo: NOAA/Seann Regan

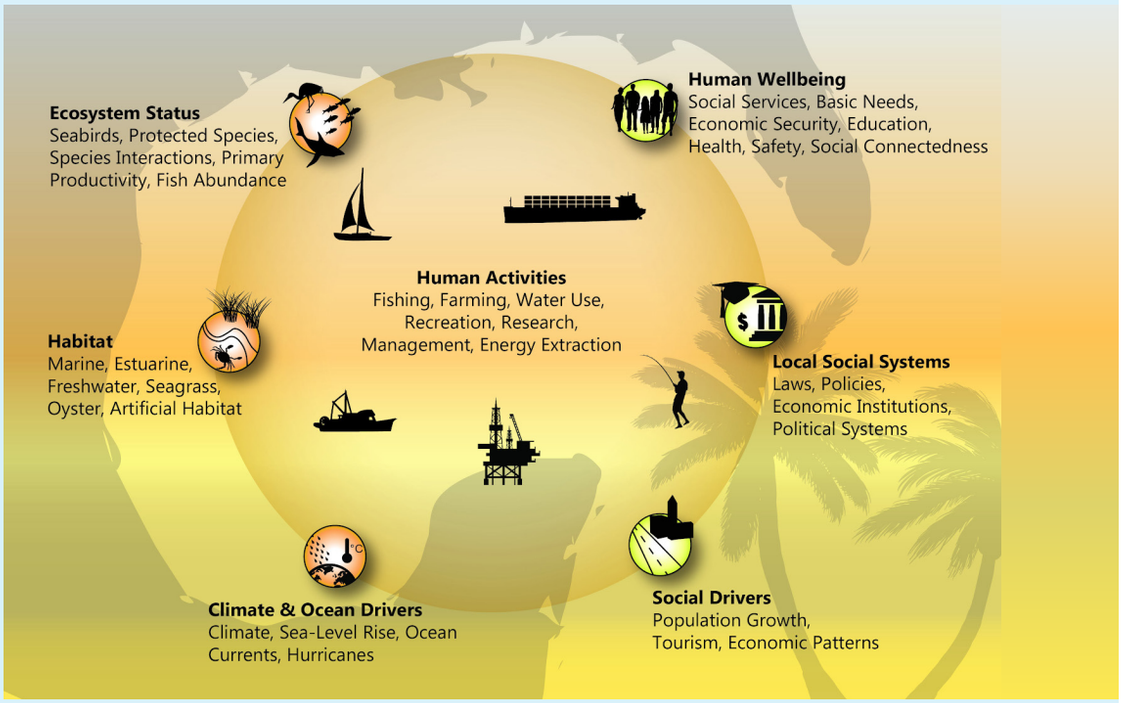
REGIONAL GOALS

The goal of the Gulf of Mexico IEA is an ecosystem that is sustainable and capable of delivering societally desired levels of ecosystem services.

A SHARED UNDERSTANDING of the Gulf of Mexico marine ecosystem:

A team of NOAA scientists used the IEA approach to gather expert opinion and engage stakeholders to develop a shared understanding of integrated systems in the Gulf of Mexico. In framing this conceptual model, it has been vital to understand the connections between the humans, coastal environments, and species that inhabit these places.

These team efforts have resulted in an integrated socio-ecological conceptual model (pictured), which shows various ecosystem sectors and connections to human processes. This model is used to guide all other work done in the Gulf of Mexico IEA.



Integrated socio-ecological conceptual model of the Gulf of Mexico. Image: NOAA IEA

Gulf of Mexico IEA In Action

Homes along the Gulf of Mexico Coast.
Photo: NOAA National Centers for Coastal Ocean Science/Seann Regan

An example of how NOAA's IEA approach is supporting ***STAKEHOLDER*** *needs.*

Although the effects of red tides along the West Florida Shelf are included in stock assessments, no framework was in place to address broader impacts on communities. NOAA's IEA approach provided scientists with that structure to engage communities and address the complex impacts from red tides. Already, the IEA team identified several easy, inexpensive approaches to help fishermen.

RED TIDES Impact More than Just Fish

Massive fish die-offs along the west coast of Florida were just one of many concerns fishermen raised with NOAA scientists. Fishermen described how the spread of the brevetoxin-producing dinoflagellate (*Karenia brevis*), also known as "red tide," was impacting many parts of their lives. Many species were dying, including important commercial species, forage fish, dolphins, manatees, and sea turtles, leading to losses in consumer confidence of local seafood and drops in tourism. There were also health ramifications due to the brevetoxins causing respiratory illnesses, and reports of mental health issues and bacterial infections. Many fishermen described impacts from the 2018 event as more severe than any previous event, because of the number and type of species killed, and impacts to businesses.

THE CHALLENGES of Addressing Ecosystem Impacts

Scientists, managers, and community members are challenged with addressing all of these impacts. While research to incorporate red tide impacts on commercially important species into management has been successfully operationalized for many years, NOAA scientists' engagement with fishermen in 2018 brought to light a need to consider additional ecosystem components. **Community members highlighted the need to address additional impacts of the red tide events, including habitat loss, reductions in forage species, decreases in demand for local seafood, drops in tourism, and human health issues.** There was no framework in place to understand and address many of these impacts.

AN APPROACH to Understand and Address Ecosystem Impacts

NOAA scientists are using NOAA's Integrated Ecosystem Assessment (IEA) approach, in collaboration with community members, to address these red tide ecosystem impacts. In contrast to managing each component separately, the IEA considers multiple ecosystem components and their interactions. IEA also motivates the formation of highly interdisciplinary teams to address critical issues affecting

human well-being. The IEA approach supports trusted relationships between scientists, managers, and stakeholders.

The first step of an IEA is to define the system of interest. An interdisciplinary team of NOAA scientists started defining the west Florida shelf marine ecosystem and engaging stakeholders by holding several workshops in the summer of 2018 to "increase information flow between scientists, managers, and stakeholders, in support of improved stock assessment and ecosystem assessment in the Gulf of Mexico". Local fishermen identified key ecosystem components and linkages in the ecosystem.

Conceptual models that connected key physical, ecological, social, and economic components of the west Florida shelf marine ecosystem were developed in a highly collaborative and iterative, consensus-based process that integrated information from diverse stakeholders and interdisciplinary scientists. Conceptual models are useful tools of the IEA approach to define the system of interest.

A RESPONSE PLAN

NOAA scientists and fishermen are using information gathered from these workshops to develop an adaptive response plan to 1) document the immediate impacts of the red tide on fish, marine mammals, sea turtles, habitat, and fishing communities, 2) understand how red tides develop and the response of marine species, and 3) detect and monitor future bloom events. **This includes continued collaboration between scientists and stakeholders to increase understanding of red tide impacts and develop strategies to manage these severe events.**

INCORPORATING LOCAL COMMUNITIES' Ecological Knowledge into Science

It became clear that the full impacts of historical red tide events to biological and human communities could not be determined because of a lack of available data. NOAA scientists began to collect oral histories from fishermen to document historical red tide locations, frequency, and severity over time and space, impacts to different fish populations and habitats, and fishermen's adaptations to fishing during red tides. These oral histories are still ongoing; however, it is becoming increasingly apparent that **fishermen are struggling to adapt their operations to red tide events, and many have lost their businesses or suffered severe losses.**

LOCAL COMMUNITY Takes Action

Scientists have long been collecting water quality data in this area, but are poorly equipped to rapidly respond to emerging events. Most data collection has taken place after red tides are well established. But fishermen are constantly on the water and able to rapidly identify unusual conditions.

Casey Streeter, a fisherman, took initiative to work with NOAA scientists to collect water quality data often. Casey and other fishermen have registered their own non-profit organization, bought their own water profiling units and are working with scientists to develop a sampling protocol and define monitoring sites. Casey stated ,"Scientists and fishermen are the same thing, out there fishing for facts, information and data. We all want strong fisheries and a healthy ecosystem, very like-minded". This process has not only engaged the local community with scientists but empowered them to take action. Already, the IEA team identified several easy and inexpensive approaches for helping fishermen become more resilient.

National Marine Sanctuaries

*An example of how NOAA's IEA approach is supporting **SANCTUARY** needs.*

Gulf of Mexico IEA and FLORIDA KEYS NATIONAL MARINE SANCTUARY

The IEA approach is helping the Florida Keys National Marine Sanctuary set management targets. In May of 2018, the Gulf of Mexico Integrated Ecosystem Assessment team met with Florida Keys National Marine Sanctuary staff to understand their science and management priorities and initiate the IEA process. Sanctuary scientists and managers expressed a need to set management targets that better address issues in the sanctuary. Ecological, social, and economic indicators were selected by regional experts to quantify thresholds of ecosystem change to the system. These thresholds will be used to help set management targets.

Northeast Shelf
Integrated Ecosystem Assessment

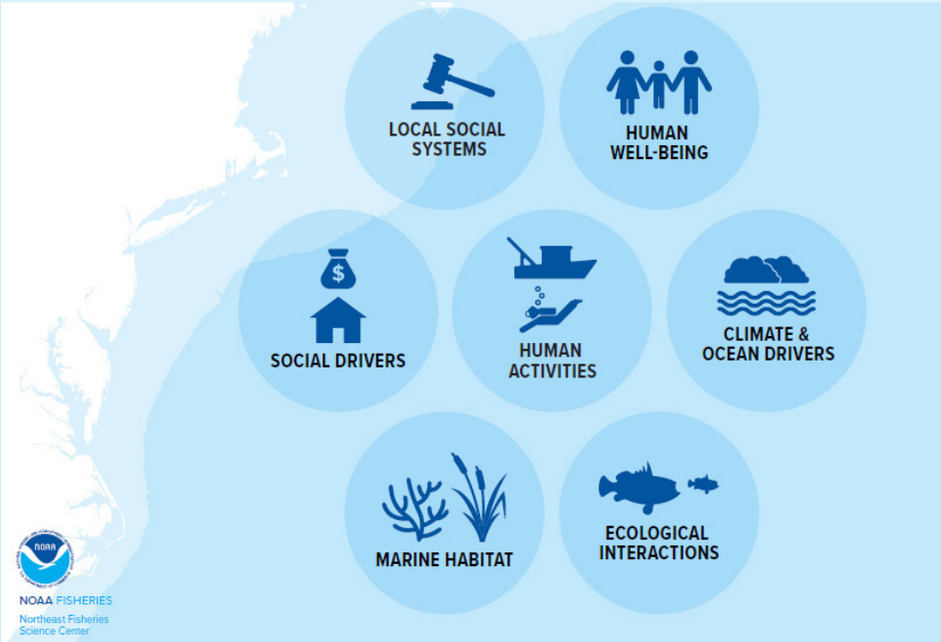
The Northeast Shelf Integrated Ecosystem Assessment (IEA) provides a framework that brings social and ecological science and management advice to managers in a manner that is useful under current governance structures while supporting the adoption of Ecosystem-Based Management.

REGIONAL PARTNERS

IEA scientists work in various offices across NOAA and collaborate with a variety of partners; some are listed below.

- **New England Fishery Management Council**
- **Mid-Atlantic Fishery Management Council**
- **International Council for the Exploration of the Sea (ICES)**
  Working Group on the Northwest Atlantic Regional Sea
- **Stellwagen Bank National Marine Sanctuary**

Portland Head Lighthouse in Maine. Photo: NOAA National Weather Service/Alan M. Kolnik



Coupled social-ecological conceptual model of the Northeast U.S. continental shelf. Image: NOAA Northeast Fisheries Science Center

MANAGEMENT OBJECTIVES

- Optimize revenue
- Optimize seafood production
- Optimize recreation
- Optimize stability
- Understand and support stable cultural and spiritual services
- Maintain biomass within acceptable limits
- Maintain trophic structure within acceptable limits
- Maintain habitat productivity and diversity

NORTHEAST MARINE ECOSYSTEM

This highly productive ecosystem supports a diverse array of invertebrates, pelagic fish, groundfish, anadromous fish, seabirds and marine mammals. This ecosystem has supported productive fisheries for centuries; in the past half-century, high fishing pressure and changing oceanographic conditions have resulted in the depletion of some fish stocks. Despite this, the value of the fisheries remains an important feature of the region, both economically and socially.

Other stressors on this ecosystem include coastal development and shoreline alteration, nutrient runoff, industrial pollution runoff, and high vessel traffic. A high proportion of the U.S. population live in the Northeast and use the ocean; ocean activities include recreational and commercial fishing, eco-tourism (whale watching), shipping, recreational boating, and many others.

Northeast Shelf IEA In Action

Fishing vessels in Point Judith, Rhode Island.
Photo: NOAA Fisheries/Ariele Baker

Regional Fisheries Management Councils

An example of how NOAA's IEA approach is supporting ***COUNCIL*** *needs.*

In collaboration with Mid-Atlantic Fishery Management Council and stakeholders, NOAA's IEA approach helped incorporate key ecosystem components into management decision making. In August 2016, the Council approved the Ecosystem Approach to Fisheries Management Guidance Document, which formally adopted consideration of the IEA approach.

STRESSORS on the Northeast Marine Ecosystem

From New York to North Carolina, marine ecosystems along the Mid-Atlantic coast are experiencing increasingly complex stressors. Fishermen noticed shifting fish distributions. Demand for recreational fishing opportunities and other ocean uses has increased. Water quality and temperature changes are impacting species habitats. Demand for seafood is increasing. Regulations to protect marine mammals and other at-risk species are impacting fisheries.

The Mid-Atlantic Fishery Management Council manages fishery resources in the US waters from North Carolina to New York and is responsible for trying to address all of these issues.

Yet, managers have few processes in place to assess the interactions of these complex issues. Current management approaches do not directly address climate, habitat, or species interactions, and they address fleet interactions only to the extent that multiple fleets catch similar species. Social and economic interactions are only partially accounted for in the current fishery management process but are critical drivers of both fisheries dynamics and the benefits generated from our marine system, and they can connect species that may otherwise not be connected. This creates a need for a science and management approach that can help managers address ecosystem interactions.

AN APPROACH to Address Complex Ecosystem Interactions

In June 2015 the council convened a series of workshops to develop an Ecosystem Approach to Fisheries Management Plan. Scientists, managers, and stakeholders discussed potential strategies to consider species interactions and climate drivers in the stock assessment and management process. One workshop reviewed existing single species approaches as well as information and analytical tools available to address key species interactions. NOAA's Integrated Ecosystem Assessment (IEA) approach was adopted to help develop ecosystem science products for management.

In contrast to more conventional approaches to resource management, the IEA approach considers interactions among

multiple components of the Mid-Atlantic marine ecosystem and recognizes that people are an integral part of the ecosystem. The IEA approach incorporates an understanding of the whole social and ecological system, not simply the individual components, into the management of marine ecosystems.

As part of the IEA approach, NOAA scientists gathered ecological, social, economic, and management indicators. Indicators measure the status and trends of key ecosystem components. Key indicators are then synthesized and presented annually to the council in the State of the Ecosystem report. The State of the Ecosystem report provides an overview of the current state of major system dynamics.

In August 2016, the Council approved the Ecosystem Approach to Fisheries Management Guidance Document. This guidance document formally adopted consideration of the IEA approach. The Council's stated goal for their Ecosystem Approach to Fisheries Management is "to manage for ecologically sustainable utilization of living marine resources while maintaining ecosystem productivity, structure, and function."

To accomplish this, the Council agreed to a framework that 1) prioritizes ecosystem interactions, 2) specifies key questions regarding high priority interactions, and 3) tailors appropriate analyses to address them. This would complement existing single stock assessment and essential fish habitat analyses by considering the whole system.

PRIORITIZING MANAGEMENT EFFORTS and Assessing Risk to the Ecosystem

Guided by the IEA approach, NOAA scientists conducted an ecological risk assessment of the Mid-Atlantic marine ecosystem. An ecological risk assessment evaluates the potential extent and consequence of negative events occurring to the ecosystem. The Council intends to use results from this risk assessment to analyze the highest risk interactions for each species and identify strategies for addressing these risks. According to Brandon Muffley, a staff member for the Mid-Atlantic Fishery Management Council, "This approach has helped give the Council structure with specific steps to define what our management goals and objectives are, figure out how we can address those, and understand what that means for areas such as economics."

The Council selected what ecosystem components would be evaluated in this risk assessment at public meetings under the standard council stakeholder engagement processes of consensus-driven decision making. A diverse group, representing interests in fisheries and marine resources, provided significant feedback through open public meetings and online access. Recommendations from public comments were fully discussed and integrated to the extent possible.

In October 2018, the Council used risk assessment results to focus on species with the largest number of high-risk rankings across all elements. The Council, scientists, and stakeholders will collaboratively develop a conceptual model to inform more in-depth modeling. There is potential for a management strategy evaluation, which would test alternative methods for achieving specific management objectives under uncertainty.

National Marine Sanctuaries

*An example of how NOAA's IEA approach is supporting **SANCTUARY** needs.*

Northeast IEA and STELLWAGEN BANK NATIONAL MARINE SANCTUARY

The IEA approach provided an objective and quantifiable way for Sanctuaries to track the health of the Sanctuary's marine ecosystems. The Stellwagen Bank National Marine Sanctuary has begun to use NOAA's Integrated Ecosystem Assessment approach to support ecosystem-based management of marine resources in the sanctuary. In April 2017, as part of the Northeast IEA process, NOAA released a synthesis of indicator data in the 'State of the Ecosystem - Gulf of Maine and Georges Bank'. On August 10th, 2017 NOAA scientists met with Sanctuary staff to discuss relevant indicator data to be used in the development of quantitative metrics for the Sanctuary Condition Report. This information will be used to inform the next management plan review.

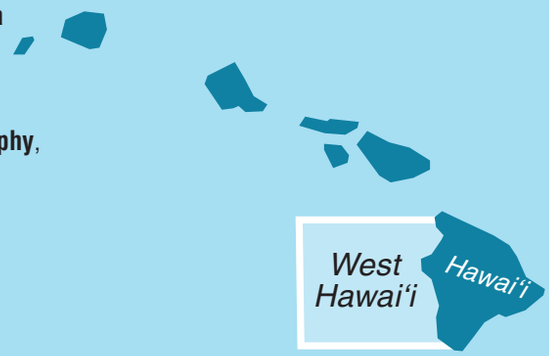
West Hawai‘i
Integrated Ecosystem Assessment

In a collaborative effort with researchers, managers, and community, NOAA scientists use the IEA approach to provide ecosystem science to support natural resource management off the west coast of Hawai‘i Island (referred to as “West Hawai‘i”). In contrast to more conventional approaches to resource management, the IEA approach relies on collaborative, interdisciplinary, and adaptive methods to consider interactions among multiple components of marine ecosystems and recognizes that local communities are an integral part of the ecosystem.

REGIONAL PARTNERS

IEA scientists work in various offices across NOAA and collaborate with a variety of partners; some are listed below.

- **State of Hawai‘i Division of Aquatic Resources**
- **West Hawai‘i Fishery Council**
- **The Nature Conservancy** - Hawai‘i
- **Conservation International** - Hawai‘i
- **West Hawai‘i Habitat Focus Area**
- **University of Hawai‘i**
- **Scripps Institution of Oceanography**, 100 Island Challenge
- **Carnegie Airborne Observatory**



Coral reef fish in West Hawai‘i. Photo: Christine Shepard

COMMUNITY CONNECTIONS

NOAA’s West Hawai‘i Integrated Ecosystem Assessment (IEA) program considers it crucial to understand the connections between humans and ecosystems, and the significant role that the environment plays in human well-being. The program is engaging with local community members, non-profits, the state of Hawai‘i and others to understand key social and ecological relationships in the region. The shared understanding of these relationships is helping to guide management efforts.

Members of the local community in West Hawai‘i answered the question “How does the marine ecosystem contribute to the things that matter most to the people in West Hawai‘i?” and this word cloud shows their responses.

A word cloud created from input from local community.
Image: NOAA’s West Hawai‘i Integrated Ecosystem Assessment

West Hawai‘i IEA In Action

Sea turtle swimming off of the west coast of the big island of Hawai‘i.
Photo: Christine Shepard

*An example of how NOAA's IEA approach is supporting **STAKEHOLDER** needs.*

NOAA's IEA approach was used to evaluate climate change and human impacts on West Hawai‘i coral reefs, and communities' reliance on those ecosystems. This was shared with the state of Hawai‘i resource managers to help prioritize management efforts as part of the Marine 30x30 Initiative, which aims to "effectively manage 30% of Hawai‘i's nearshore waters by 2030."

CORAL REEFS Found Nowhere Else in the World

If you go swimming in the tropical waters off the west coast of the Big Island of Hawai‘i (West Hawai‘i) you can see bright fish, sea urchins, shellfish, green sea turtles, spinner dolphins, whales, manta rays, and coral reefs found nowhere else in the world. Nearly a quarter of Hawai‘i's corals and fish are only found near the Hawaiian Islands.

These coral reef ecosystems are not just unique but also important for the region's economy, history, culture, and environment. Reefs in this area are home to culturally significant species, used for recreational, subsistence, and commercial fishing. A thriving tourist industry brings in jobs and money to the region. Shorelines are protected against storms by the reefs.

STRESSORS to Reefs and the Community

Coastal development, wastewater pollution, sedimentation, invasive species, and fishing pressure are undermining marine ecosystem function. Excess nutrients promote algal blooms, increases in harmful bacteria, and coral disease. Uncontrolled grazing by goats and other feral animals have removed vegetation leading to soil erosion, which suffocates the coral. Ship groundings, dive fin, and anchor damage are harming sensitive corals and other reef organisms. Invasive algae species are out-competing naturally occurring species for space on reefs. Over-harvesting of reef fish, especially herbivores, has resulted in declines of reef fish populations and reduces the natural ability of reefs to recover after bleaching events and other disturbances. Increasing sea surface temperatures and rising sea levels are exacerbating these local stressors and contributing to the overall decline in the condition of coral reef ecosystems in West Hawai‘i.

LOCAL COMMUNITIES and Management Partners Come Together

Local communities have come together with the State of Hawai‘i and others to address these issues. The state has announced the Marine 30x30 Initiative, which aims to "effectively manage 30% of Hawai‘i's nearshore waters

by 2030.” Yet, with limited resources, reef managers and communities lack capacity to research and prioritize management actions to reduce these stressors.

ECOSYSTEM SCIENCE to Build Capacity and Prioritize Management Efforts

In a collaborative effort with scientists, managers, and community members, NOAA scientists are using NOAA’s Integrated Ecosystem Assessment (IEA) approach to provide the ecosystem science West Hawai‘i communities and managers need to build research capacity and prioritize management efforts. In contrast to managing each component separately, the IEA approach relies on collaborative, interdisciplinary, and adaptive methods to consider interactions among multiple components of West Hawai‘i’s coastal and marine ecosystems and recognizes that people are an integral part of the ecosystem. The IEA approach provides an understanding of the whole social and ecological system, not simply the individual components, which is necessary to manage marine ecosystems.

An important step of NOAA’s IEA approach is to conduct a risk or vulnerability assessment. Vulnerability assessments evaluate the frequency and severity of negative impacts on the ecosystem. NOAA scientists used the IEA approach to evaluate how vulnerable West Hawai‘i coral reef ecosystems are to climate change and human impacts and evaluate how vulnerable communities are to potential ecosystem changes.

In evaluating reef fishing, invasive algae species, ship groundings, sediment and nutrient pollution, and damaging forms of tourism along the coast, NOAA scientists found that severity of human impacts varies along the coastline. Impacts from reef fish fishing, sedimentation, and tourism are all most severe near Puakō and Kailua-Kona. All of these impacts reduce coral reef ecosystems’ ability to resist the effects of climate change. Climate models suggest that severe annual bleaching will happen along the coast of West Hawai‘i starting between 2035 and 2045.

Another important part of NOAA’s IEA approach is incorporating human well-being into management decisions. NOAA scientists used the IEA approach to evaluate how reliant, and therefore vulnerable, communities are on coastal marine ecosystems. Scientists evaluated a variety of services, including cultural practices, coastal protection, recreation, tourism, and food resources. Communities in Hawai‘i are reliant on the local marine ecosystem for their livelihood and well-being. Results indicate that social vulnerability is relatively low in North Kohala, South Kohala, North and South Kona, and high in Ka‘ū.

SCIENTISTS, MANAGERS, AND STAKEHOLDERS Take Action

NOAA IEA scientists partnered with NOAA’s West Hawai‘i Habitat Focus Area team and The Nature Conservancy to ensure that this ecosystem science is provided to West Hawai‘i communities and actionable by management. According to Gerry Davis, NOAA’s Assistant Regional Administrator for Habitat Conservation in the Pacific Islands, “IEA provided key information [...] that had management application”. The unique result of this partnership has been the creation of a government-NGO-community exchange that provides an effective mechanism to share information and ideas, develop strategies to tackle challenges and ensure community ownership and participation. This has empowered the State’s efforts by bringing science, government and community into a trusted alignment. Together they are reducing land-based pollution, increasing ecosystem resilience to climate change, amplifying community engagement, and coordinating numerous other restoration, research and monitoring activities which target these highly vulnerable areas in West Hawai‘i.

Outcomes of this collaborative work include erosion maps that will enable landowners to target sediment hotspots, modeled effects of sea level rise on unique West Hawai‘i ecosystems including anchialine ponds, and over three acres of fishponds restored.

In particular, the programs coordinated coral reef resilience surveys along the West Hawai‘i coastline. This and other data were incorporated into the vulnerability assessment which was shared with the state of Hawai‘i resource managers to help prioritize management efforts as part of the Marine 30x30 Initiative.

NOAA scientists will continue to build strong partnerships with communities, scientists, managers, and other stakeholders using the IEA approach to protect the unique coral reef ecosystems of West Hawai‘i.

DEPARTMENT OF COMMERCE
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