Putting the “Integrated” in NOAA’s Integrated Ecosystem Assessments (IEAs)

Steve Murawski

NOAA’s Ecosystem Goal Team Lead

NODC Seminar

16 August, 2007
Integrated Ecosystem Assessments (IEAs) Overview

- What are Ecosystem Approaches to management, and what science products support them?
- What are IEAs?
- Why is it appropriate for NOAA to conduct them?
- How do IEAs impact NOAA’s statutory responsibilities?
- How are IEAs developed (the steps & content)?
- Where is NOAA proposing to develop IEAs?
- Have IEAs ever been done before?
- Who in NOAA is appropriate to develop IEAs (e.g., NOAA’s FY-09 proposal)?
- What are the IEA products and outcomes?
NOAA & other Agencies currently assess many ecosystem components

Primary Focus: Ecosystem indicators
NOAA Working Definitions for EAM*

- An ecosystem is a **geographically specified** system of organisms (including humans), the environment, and the processes that control its dynamics.

- Characteristics of EAM are:
  - adaptive,
  - incremental,
  - takes account of ecosystem knowledge and uncertainties,
  - considers multiple external influences,
  - strives to balance diverse social objectives, and
  - geographically specified.

* NOAA’s Ecosystem Goal Team (EGT)
Operational Objectives for EAM

(1) Develop broad Stakeholder-Based Governance system
(2) Conserve essential Parts of the ecosystem
(3) Conserve essential ecosystem Processes

Key Question:
What are the science processes and products necessary to support EAM/EBM?
What is an Ecosystem Approach to Management (EAM)?

“Look at the whole picture, not just the parts.”
Dave Goethel
New England Fishery Management Council
SIMOR Fisheries Constituent Listening Session - October 2006

“An ecosystem approach to management is one that provides a comprehensive framework for living marine resource decision making. In contrast to individual species or single issue management, EAM considers a wider range of relevant ecological, environmental, and human factors bearing on societal choices regarding resource use.”......NOAA EGT

The #1 Myth Concerning EAM:
“Ecosystem approaches to ocean resource management are not well defined and we do not know how to implement them”
UN Law of the Sea Meeting, April 2006
Develop Ecosystem Governance System

- **Manage Tradeoffs**
  - assess management allocation among sectors, optimize benefits, use management processes that are fair, equitable and transparent, consider cumulative impacts, evaluate impacts of non-consumptive sectors, include diverse stakeholder views

- **Use Adaptive Approaches to Management**
  - consider multiple causes for observed changes and sources of uncertainty in assessment & prediction, reverse burden of proof where consequences are great, imbed experiments in management approaches to increase ecosystem knowledge

- **Establish Appropriate Ecosystem Boundaries**
  - allows for interconnections between adjacent ecosystems, allows for imports and exports, includes multiple spatial scales depending on issue - paradox of scale
Key Science Needs Supporting EAM

- **Operational Ocean Observation System** integrating biology, physical oceanography, chemistry, ocean-atmosphere links and socio-economic data (at appropriate geographic scales) ~ ½ built

- **Systematic reporting on the status of marine and coastal ecosystems through Integrated Ecosystem Assessments (IEAs), including key indicators of pressures on ecosystems and their state**

- **Ecosystem research plan** that enables linking of human activities to incremental change in ecosystem state indicators

- **Modeling, experimental ecology, and observation systems linked to support adaptive approaches to human uses of marine ecosystems consistent with goals of sustainable use**
What are Integrated Ecosystem Assessments?

Integrated Ecosystem Assessment (IEA):
- “A synthesis and quantitative analysis of information on relevant physical, chemical, ecological and human processes in relation to specified ecosystem management objectives”.

An IEA:
- Incorporates multiple indicators of the environment and ecosystem, including human factors
- Is geographically specified
- Establishes target levels and thresholds for important ecosystem components
- Evaluates the impacts of management options and risks of not attaining target ecosystem states
What are Integrated Ecosystem Assessments?

**Single Sector Assessment**
- Assesses individual species.
- Narrow perspective and spatial scale.
- Short-term perspective.
- Humans are independent of ecosystem.
- Conservative resource management.
- Single use observations.

**Integrated Ecosystem Assessment (IEA)**
- Provides a “big picture” of an ecosystem.
- Broad perspective and scale.
- Long-term perspective.
- Human impacts considered in models.
- Adaptive and integrated management.
- Shared and standardized observations.
Why is it Appropriate for NOAA to Conduct IEAs?

- Increasing risk of litigation due to poor scientific basis for decision-making
- Increasing demand on NOAA to improve status of stocks -- beyond ending overfishing in 2010
- Increasing pressures among coastal states to balance competing uses of ecosystem goods and services using science
- NOAA has data, research, models, and science components needed to conduct IEAs.....

.....and could do the integration.
How do IEAs impact NOAA’s statutory responsibilities?

• Magnuson Stevens Fishery Conservation & Management Reauthorization Act – provides more complete information on factors affecting regulated species & ecosystems
• Marine Mammal Protection Act – allows consideration of the impacts of cumulative human impacts on marine mammals
• Coral Conservation Act – enables coral reef management to consider ocean and land-based threats to corals
• Endangered Species Act – allows comprehensive ecosystem considerations to be included in endangered species recovery
• Marine Sanctuaries Act – allows sanctuary managers to monitor ecosystem status in relation to threats and conditions in broader regional ecosystems
• Coastal Zone Management Act – incorporates watershed, coast, nearshore and offshore ecosystem conditions into comprehensive coastal zone planning
Other Drivers for NOAA to Conduct IEAs

Ocean Research Priorities Plan (ORPP) by the Joint Subcommittee on Ocean Science & Technology

“Development of integrated ecosystem assessments will…expand understanding of interrelationships among the physical environment, ecosystems, and human activities”.

“…Metrics and indicators, evaluated through integrated ecosystem assessments, will provide feedback for assessing management efficacy…”.

US Ocean Commission Report
Recommendation 5–5:
“NOAA, and EPA, working with other appropriate federal and regional entities, should coordinate the development of regional ecosystem assessments, to be updated periodically.”
Other Drivers for NOAA to Conduct IEAs

Magnuson Stevens Fishery Conservation and Management Reauthorization Act (2007)
“The Secretary shall undertake and complete a study on the state of the science for advancing the concepts and integration of ecosystem considerations in regional fishery management.”
“The Secretary is authorized to provide necessary technical advice and assistance… to the Councils for the development and design of regional pilot programs that build upon the recommendations of the advisory panel and, when completed, the study.”

“Regionally based Integrated Ecosystem Assessments (IEAs)...should be the central products of NOAA ecosystem science”.

Dimensions and Outcomes of IEAs

• An IEA addresses five dimensions:
  – Status of the topic being considered
  – Causes and consequences of the status
  – Forecast of future status with and without management action
  – Costs and benefits of possible management actions
  – Evaluation of past management actions’ success or failure.

• A successful IA:
  – Responds to policy relevant questions
  – Quantitatively identifies uncertainties in existing data and information
  – Includes public participation and peer review
  – Integrates data across multiple disciplines:
  – Uses existing high-quality data and information
  – Forecasts future conditions and outcomes.
Components of an IEA

• An IEA typically consists of the following components:
  – Assessment of ecosystem baseline conditions (States)
  – Assessment of stressors on the ecosystem (Drivers, Pressures)
  – Prediction of the ecosystem status with no change in management actions (status quo response)
  – Prediction of the ecosystem status under different management strategies to meet target states (optional responses)
  – Evaluation of the success of management actions (update states relative to targets and thresholds)

• N.B. Ecosystem status reports ARE NOT integrated ecosystem assessments (DPSIRs)
Multiple Dimensions of Ocean & Coastal Ecosystems

Drivers & Pressures
- Physical
  - air temperature
  - sea temperature
  - weather patterns
  - waves
  - salinity
  - pH
  - circulation
  - sea level
  - decadal indices
  - upwelling
  - wind stress
  - sediment transport
  - freshwater input
  - sea ice cover
  - extreme events
- Human-Related
  - nutrient input
  - contaminants
  - microbiological inputs
  - radioactive input
  - hydrocarbons
  - atmos. deposition
  - wetlands change
  - fishing effort
  - vessel traffic
  - bycatch
  - non-native species introductions
  - marine debris
  - coastal & seabed modifications
  - marine sound

States & Impacts
- Conditions
  - extent of hypoxia
  - HAB events
  - invasive species interactions
  - primary production
  - secondary production
  - benthic production
  - species richness
  - species diversity
  - protected species status & mortality
  - overfishing status
  - trophic balance
  - body burden of contaminants
  - distributions of biota
  - human factors
- Goods & Services
  - species
    - abundance
    - biomass
    - recruitment
  - fishery catch
  - fishery revenue
  - recreational use
  - aquaculture production
  - non-consumptive uses
  - social use and Importance
  - transportation
  - commerce
  - energy

IOOS “Core” Variable
How are IEA’s developed (steps & content)?

**IEA Steps**

- **Driver**: Identify major human and natural factors affecting Ecosystem. Define scale.

- **Pressure**: Organize relevant data. Select key indicators of Ecosystem status.

- **State**: Link ecosystem status indicators to drivers & pressures.

- **Impact**: Evaluate ecological & economic impacts of management options.

- **Response**: Adaptive management.

- **Management Evaluation**: Forecasts & Risk Assessments.

- **Ecosystem Indicators**: Ecological Models.
Some Desirable Characteristics of
Ecosystem Indicators to Describe Ecosystem
Pressures and States

• Easy to Understand
• Responsive to Manageable Human Activities
• Responses Linked in Time to Management Action
• Easily and Accurately Measured
• Low Responsiveness to Other Factors (e.g., multiple factors)
• Measurable Over Large Portion of Area
• Existing Data to Provide Historic Perspectives to inform the selection of Targets and Thresholds

Source: ICES Working Group on Ecosystem Effects of Fishing
Ecosystem Models & Forecasts to Assess Responses & Understand Relationships

Types of Models Used in IEAs

- Food web dynamics & species interactions (tradeoffs)
- N-P-Z-D Models (nutrients, phytoplankton, zooplankton, detritus)
- Population dynamics models
- Habitat selection models (benthic habitats, ocean conditions)
- Spatial dynamics (hydrodynamics, movement models, human responses)
- Risk assessment & management strategy evaluation (MSE) models
- Models necessary to understand complex multispecies and non-linear relationships between pressures, states and impacts
- Quantitative risk assessments determine the probability and consequences of not attaining target ecosystem states
- Impact analyses evaluate the benefits and costs of options to attain desired ecosystem states
Where is NOAA proposing to develop IEAs?

First three priority areas:
- NE Shelf
- California Coral Reef Systems
- Alaska Ecosystem Complex

Legend:
- US EEZ
- Regional ecosystems
What are the appropriate scales for IEAs?

Assessing the Status of Ocean and Coastal Ecosystems of the United States

Heirarchical Structure

- National jurisdictions
- International collaborations

Regional
- Large Marine Ecosystems
- Sub-Regional Ecosystems (as appropriate)

Local
- Place based (e.g., sanctuaries, NERRs)
- Bays, Harbors, Estuaries

Basin-Wide
- National jurisdictions
- International collaborations

Extra-basin assessments

National Overview
Regional Dimensions
Determining the appropriate spatial scale for IEAs

LME → Sub-Region → Local Area
Data systems should allow hierarchical assessment
[political and management boundaries need to be
Red indicates the largest 1/3 of values in the record. The middle third are shown in grey and the lowest third are shown in green. To demonstrate covariability over time, the values in some series have been inverted, as noted by a star.
NOAA’s Proposed IEA Schedule:

- California Current
- Alaska
- Northeast
- Followed by:
- Gulf of Mexico
- Caribbean
- Great Lakes
- South Atlantic
- Pacific Islands

Exact order to be determined by the following criteria:

- strength of NOAA statutory missions
- regional NOAA capabilities to support IEA development
- emerging regional needs
- broad-based external partnerships (states, academia, regional govts., federal agencies)
NOAA’s First three Proposed Pilot Ecosystems for IEAs
Who in NOAA is delivering data/information for IEAs?

NMFS
- Scope NMFS statutory management needs at the **regional ecosystem scale**
- Assess data gaps and test ecosystem indicators
- Develop in-house operational regional ecosystem-wide modeling capability
- Co-develop final integrated assessments

NOS
- Scope NOS statutory management needs at **local & coastal ecosystem scales**
- Organize and integrate existing local & coastal data into IEA data framework
- Competitively foster model development in highest priority regions
- Identify changes driving observed trends & describe consequences for NOS statutory needs
- Co-develop final integrated assessments; develop format for **national scale synthesis**

OAR
- Continue scoping research needs at all scales (Sea Grant)
- Integrate coastal data into IEA data framework
- Competitively foster model development in highest priority regions
- Identify changes driving observed trends & describe their consequences
- Develop final integrated assessments

NESDIS
- Develop Regional Ecosystem Data Management Framework
How is NOAA merging efforts to deliver IEA products and outcomes?

- Overall Planning currently provided by the Ecosystem Goal Team and IEA Task Team to assure consistency.
- Regional collaborations among NOAA Line Office elements and external partners to take “ownership” of the regional and local process.
- FY-09 Proposal provides resources to the regional collaborations to develop data and models & manage the process of IEA production.
- Using an IEA Task Team to define criteria and standards for data, reporting and peer review.
- FY-09 Proposal will use expertise of NESDIS to develop overall data framework to achieve seamless data integration among local → regional → national levels. Resources would move regionally to build data systems.
- Define an overall office lead (NOS NCCOS) to prepare the national synthesis report of regional IEAs.
- Envision an IEA coordinating office as the program matures.
What are IEA Products?

Paper or Plastic?

‘Paper’ = Regional Ecosystem IEA Reports
- Produced routinely (~4 years)
- Peer-reviewed
- 8 Regional Ecosystem-scale IEAs + 1 National Synthesis Report

E.g. Alaska Ecosystem Considerations Report used by the North Pacific Fisheries Management Council

‘Plastic’ = Dynamic, web-based IEAs
- IEA products created on demand on-line
- Local or ‘place based’ scales
- ‘If-then’ scenarios and other assessment tools to inform specific management questions

Pacific Ocean Observing System (PaCOOS Website)

“Google ocean”
Partnership Roles
Acting in concert with constituents & partners

- Identify appropriate spatial scales for IEAs
- Determine key ecosystem issues
- Incorporate all relevant ecosystem information and to prioritize the development of indicators
- [determine targets and thresholds for management-related indicators, consistent with legislative authorities]
- Evaluate the relationships between pressure and status indicators using appropriate research, models and forecasts
- Provide routine reporting and updates on the status of the nation’s coastal and ocean ecosystems
### Major Resource Management Concerns Identified by NOAA Regional Teams

<table>
<thead>
<tr>
<th>Issue</th>
<th>North Atlantic</th>
<th>S. At Caribb.</th>
<th>Gulf of Mexico</th>
<th>Great Lakes</th>
<th>West Coast</th>
<th>Alaska</th>
<th>Pacific Islands</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sustainable Fisheries</td>
<td>critical</td>
<td>critical</td>
<td>critical</td>
<td>moderate</td>
<td>low</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protected Species</td>
<td>critical</td>
<td></td>
<td>critical</td>
<td>critical</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coastal management</td>
<td>moderate</td>
<td>moderate</td>
<td>moderate</td>
<td>low</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coral management</td>
<td>critical</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Habitat Protection</td>
<td>critical</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>various</td>
<td>restoration</td>
<td>Resilient ecosysms</td>
<td></td>
<td>MPAs &amp; networks</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Critical** indicates the highest concern.
- **Moderate** indicates a concern of medium importance.
- **Low** indicates a concern of low importance.
- **N/A** indicates no data available.

**Pacific Islands**

- **Submerged cultural resources**
### Additional Threats Identified by NOAA Regional Teams

<table>
<thead>
<tr>
<th>Issue</th>
<th>North Atlantic</th>
<th>S. Atl Carrib.</th>
<th>Gulf of Mexico</th>
<th>Great Lakes</th>
<th>West Coast</th>
<th>Alaska</th>
<th>Pacific Islands</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toxics</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nutrients</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Debris</td>
<td></td>
<td></td>
<td>?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HABs/Hypoxia</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coral Bleach</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Invasives</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marine Sound</td>
<td></td>
<td></td>
<td>?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fresh water/diversions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Events/Hazard</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>Storm-water, NPS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Increasing Societal Demands Identified by NOAA Regional Teams

<table>
<thead>
<tr>
<th>Issue</th>
<th>North Atlantic</th>
<th>S. Atl Caribb.</th>
<th>Gulf of Mexico</th>
<th>Great Lakes</th>
<th>West Coast</th>
<th>Alaska</th>
<th>Pacific Islands</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land Use / development</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy development</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maritime &amp; Port Development</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aquaculture</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dredging</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recreation</td>
<td></td>
<td>Beach protection</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enforcement of regulations</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>Beach closures</td>
<td></td>
<td></td>
<td></td>
<td>Population growth</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>mining</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
An Opportunity:
Consistent reporting of a subset of variables will allow a national overview, viz:

“An Integrated Assessment of the Status of the Coastal and Ocean Ecosystems of the United States”
Have IEAs Ever Been Done Before?

YES!

Charting Progress
An Integrated Assessment of the State of UK Seas

issues & challenges differ by sub-region

Table S.2. Main issues for each region (considered important issue per region)

<table>
<thead>
<tr>
<th>Region</th>
<th>N. North Sea</th>
<th>S. North Sea</th>
<th>E. English Channel</th>
<th>N. Channel and Approaches</th>
<th>W. Irish Sea</th>
<th>S. Western Scotland</th>
<th>N. Scottish Continental</th>
<th>S. Scottish Offshore</th>
</tr>
</thead>
<tbody>
<tr>
<td>Climate Impacts</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fisheries</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sediments</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Benthic bottom</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Microbiological Contaminants</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pesticides</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pesticides</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All Oil Industry</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sedimentology</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Construction</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drilling</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sedimentation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Litter</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* See also Map (Figure S.2)
Science Strategies

• Develop consistent data standards and procedures among and within IEA regions to allow comparability and synthesis
• Propose, develop and test suites of pressure and state indicators (some common to all regions, some unique to each)
• Determine research priorities for understanding ecosystem responses to changes in physical and human pressures
• Develop periodic reporting mechanisms for IEAs
Next Steps
Creating a vision and path to IEAs

- Distribute IEA white paper on process, content, strategies, clients, inventory, and annotated bibliography
- Determine appropriate entities to oversee IEA production; identify regional priorities
- Support pilot IEA activities in several regions to emphasize data management and communication procedures, development of appropriate indicators, and modeling and forecasting for understanding ecosystem response
- Seek cross-agency and international regional buy-in
- Enhance ongoing IEA-related activities