FY-2010-2014 Strategic Investment Question

Integrated Ecosystem Assessments:  
A synthesis and quantitative analysis of information on relevant physical, chemical, ecological and human processes in relation to specified ecosystem management objectives.

1. Executive Summary

Strategic Question: What is the appropriate balance of spatial scales (regional ecosystems vs. smaller scale systems) for Integrated Ecosystem Assessments (IEAs) conducted by NOAA? What capacities are needed across NOAA for the IEA effort as a whole, and what options does NOAA have to pursue IEAs in light of the capabilities required to meet changing mandates that drive NOAA’s ecosystem mission requirements?

Proposed Solution: The production of routine integrated ecosystem assessments (IEAs) represents a significant and forward-looking leadership opportunity for NOAA to more effectively address ocean and coastal resource management issues in the United States and internationally. Ocean and coastal marine ecosystems are both complex (multiple simultaneous issues to be resolved) and complicated (relationships between living and non-living components of ecosystems behave in non-incremental, abrupt or unanticipated ways). Typically, management benchmarks and forecasting tools are developed assuming relatively simple interactions among ecosystem components, if at all, and they cannot predict how ecosystems may respond to new pressures or how pressures affect biological communities as opposed to single species. The need for a new class of ecosystem-level assessments and management benchmarks is clearly articulated in recommendations by the U.S. Ocean Commission, the NOAA Science Advisory Board, and the Ocean Research Priorities Plan. Reauthorizations of existing NOAA legislation and new, anticipated authorities means that NOAA and its partners will have to consider more complex and complicated issues than ever before.

We provide a comprehensive strategy for NOAA, along with its state, tribal, local and federal agency partners, to realize NOAA’s vision to, “protect, restore, and manage the use of coastal, ocean, and Great Lakes resources through an ecosystem approach to management.” Achieving this vision requires a scientific basis for management that addresses the complexity of ecosystem issues as scales appropriate to the management questions and to the natural and human-caused mechanisms affecting the ecosystem. IEAs represent a new product line for NOAA that enables integration across our existing science programs and capabilities to better fulfill NOAA’s stewardship responsibilities.

The Ecosystem Goal Team’s IEA strategy begins with the development of pilot programs in three regions where existing capability, capacity, and ongoing activities indicate a high likelihood of success for both implementing and evaluating the feasibility of the IEA concept. NOAA’s current program already incorporates $8M for this effort. The pilots will evaluate the ability of NOAA and partners to:

1. Identify major human and natural factors affecting ecosystems and the scale at which ecosystems or their parts will be assessed
2. Organize the relevant existing ecosystem data (from various sources) and develop appropriate indicators of ecosystem status
3. Link ecosystem status indicators to human and natural pressures on the ecosystem that drive change
4. Evaluate ecological and economic impacts of management options, consistent with NOAA and other statutory responsibilities, and
5. Use IEAs as the science tool supporting an adaptive approach to management to achieve target levels for appropriate ecosystem goals while avoiding thresholds for undesirable ecosystem conditions.

These five implementation steps will be applied in the three pilot regions, and the lessons learned applied to the expansion of the IEA concept to create a comprehensive, hierarchical series of IEAs at appropriate local and regional scales, consistent with NOAA’s stewardship responsibilities for ecosystems.

NOAA has many management responsibilities that require ecosystem science at varying scales ranging from local, place-based scales (e.g., marine protected areas), to local to regional scales (fisheries and protected species management), to the global scale (e.g., migratory species managed through international conventions). Two product lines will be developed at the regional level for IEAs: a dynamic, web-based data portal containing all available data and a periodic, peer-reviewed regional assessment document. The regional data portals and regional assessments would incorporate local data and assessment information. From local and regional assessments, a periodic national overview of the status and impacts of human activities on the coastal and ocean ecosystems of the United States will be produced. Successfully achieving the vision of comprehensive ecosystem assessments supporting management will require the capabilities of all of NOAA’s line offices and support capabilities, as well as the involvement of NOAA’s partners.

The pace at which pilot activities transition into a comprehensive set of regional assessments and a national overview is outlined in three budget scenarios, described in detail in section 3. The Ecosystem Goal recommends that NOAA pursue Option 3, which funds full implementation of IEAs in all eight regional coastal and marine ecosystems and development of a National Assessment report by 2015.


Strategic Challenges
NOAA’s wide range of stewardship responsibilities related to ocean, coastal, and Great Lakes natural resource management involves the collection of information about the status of trust and other resources to use as the basis for developing management strategies and regulations. Marine and coastal managers struggle to balance environmental, socio-cultural, and economic goals while mitigating the impacts of ecosystem stressors. Currently, NOAA does not have a formal mechanism for incorporating information on these individual resources across an ecosystem or region. An improved scientific basis to evaluate ecosystems in relation to human pressures on them is needed to assess trade-offs in ecosystem uses and to optimally manage competing uses of coastal and ocean resources. Making effective management choices requires
NOAA to improve the process by which it identifies and prioritizes management needs, conducts and synthesizes relevant science, and transfers scientific findings and management tools to decision makers, NOAA partners, and the public.

IEAs address this need by providing a new level of synoptic analysis of the status of relevant natural resources and the threats they face in a particular ecosystem. This view of the ecosystem as a whole will allow NOAA to better evaluate options for resource management and lead to improved forecasts of resource status. IEAs focus on integrating *existing* datasets and building models for ecological forecasts, conducting assessments, and developing decision support tools. The assessments will identify where further data and information gaps remain, allowing NOAA to better prioritize future observational and research investments.

The three investment options presented in this paper specifically do not propose additional ecosystem observation systems. Rather, the options focus on integrating existing data held by NOAA and partners, translating management questions into data and information relevant to managed ecosystems, informing management about the likely impacts resulting from various management options, and identifying key uncertainties associated with forecasts of ecosystem outcomes. Quantifying key uncertainties in data and research will help NOAA prioritize activities needed to fill gaps and guide future investment.

One of the key challenges faced by NOAA in assembling IEAs is that no single entity, within or outside of NOAA, maintains all of the necessary information, expertise or capacity to produce IEAs. Within NOAA, ecosystem-relevant information collection programs are housed in NMFS, NOS, OAR, NESDIS, and the NWS. Thus, there is a critical organizational requirement for bringing the parts of NOAA together around a common, shared vision to serve its diverse customer base with information products that add value to existing systems and product lines.

NOAA currently produces numerous scientific information products important for meeting statutory responsibilities, including fish and protected species stock assessments, coral reef assessments, habitat evaluations, sanctuary assessments, wetlands inventories, social and economic surveys, information about coastal communities, coastal and marine oceanographic information, and forecasts at various time and space scales, to name a few. As an integrating element that will add value to existing observations and research, IEAs will rely heavily on the information collected for these other products and services, all of which are undertaken to meet NOAA’s many ecosystem requirements. IEAs will not supplant the provision of these existing service functions, but rather will provide context for them, enable more scientific analysis of their interrelationships, and drive analysis and synthesis about how biological resources, human communities and ocean climate systems interact. Figure 1 depicts the differences between a single sector assessment and an IEA.
Organizing across NOAA’s Line Offices and working at appropriate spatial scales to conceive, deliver and update IEA products that serve customer needs is the critical institutional challenge for NOAA’s ecosystem science. This topic has been the focus of intense work by the Ecosystem Goal Team, the IEA Priority Area Task Team, and several regional entities in which NOAA has a lead role. For IEAs to be successful, a broad-based, “one-NOAA” focused regionally located entity needs to take “ownership” of NOAA’s interests in the task of conducting regional IEAs. To be effective, such an entity must represent the diversity of NOAA’s programmatic requirements and capabilities, reach out beyond NOAA to incorporate information and expertise from other partners, commit to working in a coherent fashion with higher-level coordinating entities so that the evolution of the concept is based on shared principles and so results can be rolled up and down across and within ecosystems, and commit to a degree of altruism that leverages combined resources.

**Demand for IEAs**
The mission of NOAA’s Ecosystem Goal is to, “protect, restore, and manage the use of coastal, ocean, and Great Lakes resources through an ecosystem approach to management.” Taking an ecosystem approach to management requires a comprehensive framework for marine, coastal, and Great Lakes resource decision-making, since, as shown in Figure 1, ecosystem approaches to management considers a wider range of relevant ecological, environmental, and human factors bearing on societal choices regarding resource use and protection. Just within NOAA’s various Line Offices and mission requirements, we are faced with an increasingly diverse set of issues to

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**Figure 1 – Single Sector Assessments vs. IEAs**

**Single Sector**
- Assesses individual species and groups.
- Narrow perspective and varying spatial scales.
- Short-term and equilibrium perspectives.
- Humans may be considered independent of ecosystem processes.
- Sector-by-sector management.
- Single use observations.

**Integrated Ecosystem Assessment**
- Provides a “big picture” of an ecosystem.
- Broad perspective and multiple scales.
- Long-term perspective.
- Human impacts considered in models.
- Adaptive and integrated management.
- Shared and standardized observations.
- Supports regional ecosystem governance.
manage, many with overlapping jurisdictions, such as new mandates to end overfishing and rebuild depleted fish stocks and increasing interest in mitigating pressures of intensive development in coastal areas. Responding to the increasing pressures and working to resolve conflicts between competing uses is predicated on solid scientific information that integrates a wide variety of information and makes it readily and easily available within NOAA and to external partners and the public.

Recently, several high-level reviews of ocean science and management issues have highlighted the importance of incorporating ecosystem principles into ocean and coastal resource management, and specifically calling for IEAs as a critical science-based tool supporting EAM. For example:

- **U.S. Ocean Commission Report Recommendation 5–5** states that, “NOAA, and EPA, working with other appropriate federal and regional entities should coordinate the development of regional ecosystem assessments, to be updated periodically.” IEAs will support the Commission recommendations by incorporating ecosystem-based approaches to management and providing assessments of ecosystem health and socio-economic benefits. (http://www.oceancommission.gov)

- **The Ocean Research Priorities Plan** of the Joint Subcommittee on Ocean Science and Technology (JSOST) supports EAM and IEAs, stating that, “development of integrated ecosystem assessments will…expand understanding of interrelationships among the physical environment, ecosystems, and human activities…” (http://ocean.ceq.gov/about/sup_jsost_prioritiesplan.html)

- **The External Review of NOAA’s Ecosystem Research and Science Enterprise Report** states, “Regionally based Integrated Ecosystem Assessments (IEAs)...should be the central products of NOAA ecosystem science.” (http://www.sab.noaa.gov/Reports/eETT_Final_1006.pdf)

NOAA’s customers are also increasingly demanding new and more imaginative products and services consistent with the production of IEAs. For example, at NOAA’s 2007 Stakeholder Forum, (http://www.ppi.noaa.gov/2007_stakeholder_forum.htm) constituents called for, among other priorities:

- Greater NOAA leadership to set “…a national vision for ocean and coastal ecosystem management”
- Strengthened partnerships with international, regional and local emphasis working at the right scales
- Greater national coordination of regional activities
- Improved ecological data and information services that “rescue” historical information, and provides synthesized information products and disaggregated (raw) ecological data and enhanced web tools for various users
- Enhanced ability to understand risks and costs of environmental decision making

All of these priorities are emphasized as organizing principles or products of the IEA process.
that the EGT envisions. A more detailed summary of stakeholder comments related to IEAs is included in Appendix 1.

Additionally, the benefits of an integrated approach have been recognized internationally. The United Nations, Australia, Great Britain, Canada and others all have varied approaches to IEAs and their uses, which serve as models for NOAA. Scientists from NOAA and Department of Fisheries and Oceans, Canada, met in 2007, to discuss how the two countries could work on IEA products together to improve coordination over shared waters and resources. The most complete example of IEAs is the recent national overview report produced for the UK territorial and surrounding seas (http://www.defra.gov.uk/environment/water/marine/uk/stateofsea/). This document provides a model for the national overview report that we propose be part of NOAA’s IEA process. This type of report provides a national context for region-specific evaluations of socially relevant indicators of the state of the ocean ecosystems and trends in these indicators, both temporally and spatially. However, the UK document does not provide the data electronically (e.g., web-portal), which is a critical value-added component of NOAA’s IEA product line, nor does it provide evaluation capabilities of management options and interactions. NOAA’s IEA process would merge the overview provides in the UK example with the functionality necessary to be relevant within the management context of the United States. Appendix 2 provides an annotated bibliography of methods and implementation of both domestic and international application of IEA concepts.

And finally, in the regional, science-based approaches to ecosystem assessments and management priority within the FY10-14 Annual Guidance Memorandum (AGM), NOAA identified, “integrated assessments and forecasts of ecosystem health and productivity, including socioeconomic impacts and the effects of ecological factors on ocean and coastal resources” as a focus area. Investing in IEAs would also inform other priorities and focus areas identified in the AGM, including improving the effectiveness of natural resource management and stewardship supported by appropriate scientific capabilities, integration of scientific and technical support for federal, state, and local officials responsible for coastal resource management, understanding climate-ecosystem interactions, developing quantitative ecosystem models and forecasting capabilities, and improving research tools and technologies for understanding ecosystem processes and implications for human health.

**How will NOAA benefit?**

Periodic assessment of biological, physical, and socio-economic attributes of ecosystems allows for coordinated evaluations of national marine, coastal and Great Lakes ecosystems to promote their sustainability under a variety of human uses and environmental stresses. Moreover, IEAs involve and inform a wide variety of stakeholders and agencies that rely on science support. IEAs integrate and enhance the value of knowledge and data collected by NOAA and other regional entities including other federal agencies, states, non-governmental organizations, and academic institutions. IEAs also identify critical knowledge and data gaps, which, if filled, will reduce uncertainty and improve our ability to fully employ ecosystem approaches to management.

IEAs will improve NOAA’s capability to manage trust resources, forecast marine and coastal conditions and resource use patterns under different scenarios, and improve scientific
understanding of the status and trends of key ecosystem components. This effort will produce
the following major benefits:

**Decision-makers will be able to access relevant scientific information and basic analytical tools for their area of interest.** NOAA’s IEA product line will include a web-based portal that provides access to quality controlled data streams about ecosystems. Additionally, the web-portal would enable users to select data appropriate for their particular geographic scale of interest. With all data available in one place, users will have an easier time identifying and accessing relevant information.

**Decision-makers will have a scientific basis for balancing competing uses of marine resources.** IEAs will consolidate and assess the scientific data available to inform decisions about trade-offs made by managers. NOAA has specific regulatory and management missions that increasingly require integrated information to better target actions. IEAs will begin to underpin decisions that today are made based on limited, and often singularly-focused, observations and studies.

**Forecasts of the condition of natural marine resources under different policy options will result in informed decision-making.** Combining ecological, economic and social data with information on community risk characteristics in existing economic and social models (e.g., climate models, regional economic models, and emerging ecosystem models) will enable policy makers to evaluate the effects of management actions and the cost-effectiveness of key investments in alleviating risk and/or achieving their intended outcome in an uncertain environment.

**Science will be better focused on priority management needs.** By formalizing the process for identifying and addressing priority management needs, the IEA ensures that NOAA science is relevant, timely, and credible. Furthermore, the identification of data gaps will guide future research and observing efforts.

Apart from these direct benefits of the IEA products to the user communities within NOAA and its external partners and constituents, the process of developing and updating IEAs represents a major new cross-NOAA business model that very clearly is predicated on breaking NOAA’s line office “stovepipes.” By sharing the responsibility for production and improvement of IEAs, NOAA will focus its assets, research priorities and investments in ways that strengthen the interactions among its line offices, regions and people. Even the act of pulling the IEA proposal together, which started formally during planning for the FY09-13 PPBES process, has created a significant degree of enthusiasm for finding ways to collaborate among NOAA entities that may have only tangentially collaborated in the past. The fact that this cross-NOAA initiative is inherently region-based means that field personnel will collaborate directly and the success of this endeavor will critically depend on the ability of cross-NOAA elements to do so. As a concrete, important, and forward-looking NOAA effort, the production of IEAs will drive future non-traditional collaborations among NOAA offices – which is one of the primary benefits of the one-NOAA focus of the PPBES framework.

**How will others stakeholders benefit?**

*Other federal agencies, states and local governments with natural resource management responsibilities will use IEAs to address a range of issues.* These include near-shore fisheries
and ecosystem changes (state governments with jurisdiction 3-7 miles from the coast); marine bird and endangered species management (DOI-FWS in collaboration with NOAA); ocean energy production (windmills, wave energy) and environmental impacts (DOI-MMS); and coastal water quality at beaches and estuaries (EPA). Mechanisms to obtain information on public priorities and management objectives will entice stakeholders at the earliest stages to help shape the IEA development process and to ensure that societal objectives are being met.

Researchers, managers, and the public will have one-stop shopping for ecosystem characterization information. Web-based IEA tools will be useful to state and local agencies in addressing management issues, scientists and students in studying ecological processes, and could even be useful outreach and communication tools to promote environmental stewardship. IEAs will likely stimulate a value-added private sector whereby NOAA produces science-based information used by industry to produce products tailored to particular consumers: regulated communities, other sectors, or the general public. Access to disaggregated ocean and coastal ecosystem data will provide the basis for forecasting products addressing many issues, for example, public health and safety, fishing, recreational boating, scuba diving, whale watching, public education (at all levels), and will enable greater knowledge-based participation in regulatory activities.

An additional and likely outcome will be to reduce costs to agencies and the public in complying with environmental requirements of various statutes. For example, development projects of significant magnitude or in sensitive areas requires the preparation of environmental impact statements under a wide variety of federal, state and local regulations. The preparation of these statements usually is costly and involves consultants and agency scientists reviewing literature and summarizing data from widely dispersed sources in order to make appropriate evaluations. The current situation is costly to industry and government agencies because it is inefficient, and there are long time delays in producing required information. We envision that compliance with EIS and NEPA requirements involving ocean and coastal environments will enhanced by the online data access and information products provided by IEAs. This could potentially provide billions of dollars in cost savings to industry and governments.

What are the socio-economic benefits?
The primary socio-economic benefit of IEAs is that decisions about trade-offs made by managers will be better informed scientifically, and regionally targeted to protect a particular resource or resources. This will result in greater clarity of the impact on economically sensitive sectors. NOAA will be the primary public sector beneficiary of IEAs and can use the tool to advance stewardship responsibilities for coastal and marine resources. The produces from IEAs will help to provide more realistic, complete and better justified environmental decisions consistent with statutory mandates.

Combining ecological, economic and social data with information on community risk characteristics in existing economic and social models (e.g., climate models, regional economic models, and emerging ecosystem models) will enable policy makers to evaluate the effects of management actions and the cost-effectiveness of key investments in alleviating risk and/or achieving their intended outcome in an uncertain environment.
As noted above, the annual costs to the private sector and government agencies for compliance with NEPA and EIS requirements related to ocean and coastal programs is enormous. IEAs will provide online and spatially disaggregated environmental data on a wide variety of ecological and oceanographic parameters. Additionally, we envision a series of web-based tools to access current and archived information across participating agencies. With these tools governments and the private sector will be able to customize their analyses of existing information for time trends, interactions and projections of future states. The IEA will clearly show where data gaps exist, and will allow people to assemble data at a variety of scales consistent with the likely environmental consequences of their proposed activities. While this use is now somewhat speculative, by using web resources that are Information Quality Act compliant, this should provide a standard for data access supporting these activities.

**What are the consequences of not having IEAs?**

The risks of not implementing this alternative include: (1) a lack of scientific understanding to derive effective and prudent measures to optimize competing uses, (2) a lack of data and information to evaluate effectiveness of existing management strategies, (3) continued missed opportunities to maximize socioeconomic benefits related to subsistence, recreational and commercial use of marine, coastal, and Great Lakes resources, and (4) slower movement to implementing an ecosystem approach to management consistent with NOAA’s strategic mission.

NOAA will fall behind in fully exploiting its scientific capability to deliver 21st century products. The IEA is a well established product used internationally as an efficient and transparent means of summarizing the status of ecosystem components, screening and prioritizing potential risks, and evaluating alternative management strategies against environmental variability. NOAA is a science-based agency and needs to provide the best available science including management tradeoffs and scenarios among increasingly competing ecosystem use sectors. Additionally, if NOAA does not lead this effort, there is no likely alternative public or private sector entity that can envision, lead, support and execute this effort. The result will be the status quo of highly fractionated information about ocean ecosystems that fails to support comprehensive decision making. This will result in two negative consequences. First, decision making about complex multisectoral issues will be determined either by precautionary considerations, or, more likely, difficult allocation decisions will be simply deferred to await more clarity in impacts and outcomes. Second, we may see single sectoral decisions continue with consequent loss of societal benefits foregone and potentially very high and unnecessary regulatory burdens placed on the private sector and governments.

3. **NOAA Authority to Act**

NOAA has clear mandates in its enabling statutes to develop and implement the IEA program. Below we detail some of these authorities as reflected in law. NOAA’s Ecosystem programs allied with the EGT are responsible for implementing and/or complying with over 100 laws and executive orders. These requirements are diverse, sometimes competing, and overlap geographically.

IEAs do not require any additional authority for NOAA, as many of our ecosystem requirements include requirements to collect data and information and base decisions on the best available
scientific information. Additionally, a number of pieces of major legislation that NOAA is responsible for call specifically for information that is integrated and/or available within an ecosystem context, supporting the need for better integration of data and information to answer more complex questions about ecosystem condition and the relationships between ecosystem components. For example:

- **National Environmental Policy Act:** IEAs address the NEPA requirement to assess the impact of alternative actions (including activities conducted, funded or permitted by the agency) on the human environment. The cumulative impacts of each activity in combination with other natural and anthropogenic phenomena are included among the analyses, and are a key focal area that will be enabled by the IEA process.

- **Magnuson-Stevens Fishery Conservation and Management Act:** The Act, which was re-authorized in early 2007, includes a requirement to conserve and manage fishery resources found off the coasts of the United States, and the anadromous species and Continental Shelf fishery resources of the United States. The revision of MSA particularly emphasizes ongoing efforts to approach fisheries from a more holistic ecosystem context, and provides new authorities to consider deep corals, and bycatch in the process. Additionally, the Act authorizes ecosystem pilot projects, and the EGT sees these pilots as including IEAs as a scientific tool supporting ecosystem approaches to fisheries management.

- **Coastal Zone Management Act, Section 306A and 310:** IEAs will enable managers to better meet the objectives, including identifying areas requiring preservation or restoration. IEAs, presented through the use of tools, technologies, and training will directly address technical assistance requirements of Section 310, and will also allow for effective delivery of management-oriented research results to coastal states, also required under section 310.

- **National Marine Sanctuaries Act (NMSA):** NOAA’s National Marine Sanctuary Program is mandated to protect and manage the trust resources in 14 sites across the country totaling an area of over 150,000 sq. miles of coastal and ocean waters. Development of IEAs is essential to not only developing and implementing management strategies within sanctuaries, but also to evaluating effectiveness of those strategies in meeting the NMSP mission. Multiple spatial scales of local and regional IEAs will allow Sanctuary managers to anticipate the wider impacts of ocean changes on their locations and will incorporate observed changes in Sanctuaries into a wider data collection scheme.

- **Endangered Species Act:** This Act requires NOAA to undertake activities to conserve endangered and threatened species and to conserve ecosystems upon which endangered and threatened species depend. IEAs could provide important information for ESA Section 7 consultations by connecting data on the various pressures affecting threatened and endangered species and how those pressures may positively or negatively affect these species in the future.

- **Marine Mammal Protection Act.** This Act emphasizes the role of marine mammals in
the ecosystem and includes provisions the consideration of ecosystem implications in setting optimum population sizes. IEAs can be used to help determine these ecological relationships and in understanding the role of mammals as predators at various trophic levels.

- **Executive Order 13158 (Marine Protected Areas (MPAs))**: IEA products will support the mission of the MPA center and its requirements to develop integrated assessments of ecological linkages among MPAs, including ecological reserves in which consumptive uses of resources are prohibited, and to generate assessments of the economic effects of the preferred management solutions.

- **OMB Circular A-16**: The development and delivery of IEAs, through the Digital Coast, will directly contribute to the coordinated approach and electronic development of the National Spatial Data Infrastructure (NSDI), by providing a means of sharing NOAA-responsible NSDI spatial data themes with state and local groups.

4. **What Products and Services Does NOAA Need to Produce to Fill this Need?**

**What are IEAs?**

An Integrated Ecosystem Assessment (IEA) is defined as “a formal synthesis and quantitative analysis of information on relevant physical, chemical, ecological and human factors in relation to specified ecosystem management objectives.” It brings together citizens, industry representatives, scientists, and policy makers through formal processes to evaluate a range of policy and/or management actions on difficult environmental problems. An IEA provides an assessment of baseline conditions and identifies important stressors to the system. It also delivers ecological forecasts and scenario developments under changing ecosystem conditions as well as different management actions. IEAs are an emerging concept under development in the USA, and elsewhere in the world. While our concept shares many attributes with related efforts, NOAA’s IEA concept, if implemented as outlined here, will be more comprehensive, complete and useful over a broader constituency than any previous efforts.

The primary objectives of the IEA are to:
- Identify key management or policy questions
- Assess status and trends of the ecosystem
- Assess the environmental, social, and economic causes and consequences of these trends
- Forecast likely ecosystem status under a range of policy and/or management actions
- Identify crucial gaps the knowledge of the ecosystem that will guide future research and data acquisition efforts.

An IEA uses approaches that determine the probability that ecological or socio-economic properties of systems will move beyond acceptable limits as defined by management objectives. A useful IEA must provide an efficient, transparent means of summarizing the status of ecosystem components, screening and prioritizing potential risks, and evaluating alternative management strategies against a backdrop of environmental (e.g., climatic, oceanographic, seasonal) variability. An IEA provides a means of evaluating tradeoffs in management strategies among potentially competing ecosystem use sectors.
What is the process for conducting IEAs?
The process by which a regional or local entity produces IEAs is outlined in the Figure 2 and in the subsequent text. The DPSIR (Drivers, Pressures, States, Impacts, Response) framework is a well accepted model for environmental management supporting a wide variety of disciplines. The DPSIR framework illustrates the process of IEA development in relation to stated ecosystem problems and goals, and is a model for continuous process improvement supporting an adaptive approach to ecosystem-based management.

Drivers are considered large-scale anthropogenic and earth system phenomena that act through specific pressures to influence ecosystems. Examples of drivers include the increasing demand for seafood, increased human populations and their disproportionate migration to coasts, and long-term climate change affecting the atmosphere and oceans.

Pressures are the specific agents acting as a result of the drivers that affect ecosystems. For example, increase demand for seafood drives fishing effort, prices and imports. Increasing human populations at the coasts generate higher levels of pollution and result in lower habitat quality, and global change may result in warmer temperatures and less sea ice.

States are various measures of current ecosystem conditions, such as the number of fishery stocks that are overfished, the average nutrient loads in coastal waters and the average water
temperatures. Often these state variables are measured relative to some management imposed standards (e.g., through various laws).

*Impacts* are the consequences of the observed state of the system usually expressed in human terms such as total net benefits (or those foregone when ecosystems are degraded). They can also be expressed in other currency such as jobs, recreational opportunities and other impacts humans care about. We envision IEAs to incorporate a risk assessment module to evaluate the risks and consequences of not meeting prescribed management targets as articulated in the selected set of state variables.

Last, the *response* part of DPSIR evaluates how the ecosystem state variables respond to the various management actions implemented. By iterating this model it is possible to build an empirical and modeling-based understanding of how the ecosystem responds to human pressures and to support adaptive learning and management schemes that achieve ecosystem objectives.

There are several key steps in the production of IEAs requiring institutional (organizational) infrastructure, information management and dissemination capability, scientific expertise in data synthesis, modeling and forecasting, and observational capabilities to produce relevant data supporting IEAs (see above). Additionally, by definition, IEAs extend beyond NOAA’s statutory responsibilities and thus there is a requirement to entrain important observations and capabilities of other state, local, and federal agencies to participate in these processes. The five key steps required for IEA production and NOAA’s capabilities required for each step follow:

1. **Identification of major human and natural factors affecting ecosystems, and the scale at which ecosystems or their parts will be assessed**

Developing the *scope* (what ecosystem factors will be considered) and the *scale* (geographic definition) are the two critical first steps in IEA development. Given the myriad of potential issues to consider in reporting on ecosystem status, it is impossible to consider every factor, particularly as they bear on the subset of important issues deemed so by relevant local and regional managers, the public and the scientific community. In order to provide appropriate scope and scale definitions, NOAA needs to engage the communities of managers, scientists and the public stakeholders as well as external management authorities on what issues will be considered (particularly in initial IEA iterations), and over what set of spatial scales. In order to initiate these discussions some combination of local, regional and national entities have to engage first internally among relevant Line Offices, Goals, and regional teams, and second with the external communities.

The NOAA regional team model provides a useful starting point to assure that various NOAA capabilities that exist at the regional scale are aware and can participate in these discussions. While NOAA’s regional teams may not possess the specific expertise to engage in detailed discussions on scope and scale, they represent the parts of NOAA possessing such expertise. As these regional discussions progress they will become more specific, and will require an operational team to assist in the development of the additional IEA steps.
The regional level of organization is the most important link in the hierarchical model of local → regional → national IEAs because it provides a strong organizational link to many of NOAA’s responsibilities, and can capture many of NOAA’s assets which may or may not focus specifically on lower or higher levels of organization. Creating a strong regional NOAA team to focus on the definition of IEA scope and scale issues is the primary ingredient in executing this first IEA step. Additionally, there may be a number of local-scale IEA activities also important to NOAA and stakeholder interests. In order to work at these scales, NOAA needs to utilize consistent principles to assure that the local scale products nest into regional scales and support a consistent national overview of the state of ocean and coastal ecosystems. These principles are currently being formulated by the IEA Priority Area Task Team (PATT).

(2) Organization of relevant ecosystem data and development of indicators of ecosystem status

One of the foundational principles of the IEA construct is that it is not an end-to-end observational to management advice model. Rather, the starting point for IEAs is the state of a defined ecosystem as we know it through existing information. Thus, the critical first step is to organize existing information relative to the scope questions identified in step #1, over geographic scales also previously identified. The IEA concept we envision would put the majority of its initial resources into this step because NOAA and other relevant agencies already posses substantial relevant information informing many of the likely questions to be identified.

Organizing relevant information is followed by the selection and testing of candidate indicators of ecosystem state, and the evaluation of targets and thresholds for those indicators informing management authorities. A number of criteria have been developed for what constitutes appropriate ecosystem indicators. For example, the International Council for the Exploration of the Sea’s Working Group on Ecosystem Effects of Fishing has stated that appropriate ecosystem indicators should be: (1) easy to understand, (2) responsive to manageable human activities, (3) responses should be linked in time to management actions, (4) easily and accurately measured, (4) have low responsiveness to other factors, (5) be measurable over large portion of the defined ecosystem area, and (5) existing data on the indicator should be available over some time frame to provide historic dynamics and for setting targets and thresholds. It should be noted that this is a comprehensive list of indicator characteristics but that these conditions cannot all necessarily be met in all circumstances so they are considered desirable but not necessary.

A rigorous testing and selection process is useful because a well chosen and small set of critical indicators having the above set of characteristics is more useful in the DPSIR context than are large numbers of data sets many of which are confounded (measuring similar conditions and trends), or that may be imprecisely measured or in fact irrelevant to management questions being asked. Furthermore, testing of ecosystem indicators in a rigorous framework relative to management goals provides a strong link to the observational framework, and potentially identifies requirements for precision and accuracy of data collection, and perhaps the impetus to collect new indicator information of current data are insufficient to meet the requirements of management.

(3) Linking of ecosystem status indicators to human and naturally occurring pressures on the ecosystem that drive change
As noted in the discussion of indicator selection, above, status of the system should be tightly linked to manageable human activities that bear on the system state. Linking drivers to state indicators can be accomplished in a variety of ways ranging from simple linear correlations to complex, non-linear feedback models. This step is critical to understanding the benefits and costs of management alternatives because it provides the expectations of system responsiveness to incremental management changes. If a small incremental change results in some corresponding increase or decrease in a state indicator, then there is predictability and responsiveness that can be quantified in ecological and economic terms. This occurs in some sectors such as pollution abatement and fisheries management (to some extent). However, these links may be much more complex when considering highly linked ecosystems with many species and numerous simultaneous drivers. Thus, ecological models that incorporate such complexity are a critical component of IEAs if they are to become more than a simple statement of the status of the ecosystem at any point in time.

(4) Evaluating ecological and economic impacts of management options (consistent with statutory responsibilities of NOAA and other relevant management authorities)

Understanding how ecosystems may respond to a variety of management options is a critical element of environmental decision making because it potentially quantifies the “business case” for management action. If the cumulative social costs greatly exceed the benefits (how ever measured) then the management impetus for change will be difficult. There are many challenges to providing the links between management options and the ecological and economic consequences. These include the complexity issues as identified above (ecological links), and the complications that result from many simultaneous human pressures.

Perhaps one of the most difficult but urgent problems revolves around competing uses of ecological space for a variety of human activities and conservation purposes. The highly dynamic nature of ocean ecosystems makes marine spatial planning analysis difficult but the growing list of alternative and competitive uses (e.g., energy, fishing, aquaculture, conservation “open space”, military uses, etc.) make such analyses of cumulative impacts on ecosystems evermore important. Additionally, there are important questions to be resolved in how we account for ecological goods and services in evaluating management options and tradeoffs. For example, how can we simultaneously account for recreational value, the services that ocean ecosystems provide in regulation of the earth’s climate and goods such as fish, oil, and alternative energy, as well as cultural benefits in a coherent set of management option analyses? Yet, these are the choices faced by marine environmental managers every day. In the absence of the right scientific information, such choices will be subjective, incomplete, and politicized. Thus, the element of IEAs supporting comprehensive ecosystem decision making provides potentially great benefits to objective decision making, especially considering risks associated with incomplete information and understanding of how ecosystems respond.

(5) Linking of the IEA to adaptive ecosystem management programs that seek to achieve target levels for important attributes and avoid threshold levels for other conditions, resulting in a continuous cycle of process evaluation and improvement
The DPSIR model provides a closed cycle allowing for continuous process improvement and adaptive management. The term “adaptive management” is one that is perhaps over used and subject to considerable abuse. A vernacular definition is generally that one changes the management measures in response to what appears to work or not. However, the precise definition of an adaptive management system is one that initially recognizes the uncertain nature of imperfect information, and the potential for multiple hypotheses underlying observed states of the ecosystem. A true adaptive management system recognizes alternative hypotheses and views management as an experimental undertaking with a clear objective to observe the system and hopefully to invalidate one of more competing hypotheses of change, thereby making management more precise and responsive. Management rarely follows the adaptive definition, for a variety of reasons, but ecosystems are, by definition, complex and complicated, and any management regime must incorporate learning if it is to maintain and increase its credibility. The IEA model is an ideal vehicle to provide a framework for formalizing the adaptive management paradigm as it applies to marine and coastal ecosystems.

What are the appropriate spatial scales for IEAs?
IEAs provide a synthesis of available information about the oceanographic, biological, chemical and socio-economic conditions in a defined geographical region. The defined regions applicable to IEAs can be of varying size, depending critically on the set of stewardship issues being considered. At the largest scale, NOAA has defined eight Regional Ecosystems of the coastal United States, based on the Large Marine Ecosystem framework, where IEA activities would be focused. These include: (1) the California Current, (2) Alaska, (3) Pacific Islands, (4) Gulf of Mexico, (5) Caribbean, (6) South Atlantic Bight, (7) Northeast, and (8) Great Lakes. Beyond the priority to initiate pilot IEA activities in the California Current, Alaska, and the Northeast, the timing and priorities for the next regions will be partially determined by the financial scenario selected in the PPBES process and through the application of a criteria currently being developed by the IEA PATT, including regional capacity to support IEAs, an organizational structure for doing so, and management priorities.

Within any of these ecosystems, IEAs can also be provided on smaller spatial scales (e.g., Puget Sound or the marine sanctuaries of the California Current System). Assessments at these smaller scales, however, need to be informed by what is occurring at the broader scale since many critical ocean processes occurring at broad scales impact the resources in smaller regions and visa versa. The IEA process will allow for a consistent set of principles that link the local, regional and national scales. Thus, there is no inconsistency in how the IEA model is applied and thus no inherent conflict among the scales. We have focused on the regional scale because it provides a basis to compare among coastal and marine ecosystems of the United States over many consistent ecosystem quantities, and particularly those of importance to NOAA’s statutory responsibilities. Within these ecosystems we envision a series of sub-IEAs that provide detailed place-based IEAs focusing on entities such as Sanctuaries or Estuarine Research Reserves, and local or state partnerships focusing at this level (e.g., Puget Sound, the Aleutian Islands, etc.). If undertaken using the principles outlined herein and by the PATT, we anticipate a set of hierarchical, linked IEAs that provide the specificity and consistency that would be useful to a wide cross section of NOAA’s stakeholders, managers and the public (see Figure 3)
IEAs will provide NOAA three critical outcomes. First, by synthesizing all of the existing information on the state of ecosystems that the agency already collects, NOAA resource managers will have a more complete picture of the threats posed by various human activities as they undertake their stewardship responsibilities. Understanding the complexity of ecosystems allows managers to anticipate a wider range of factors that will influence the outcomes for their specific missions. Having a global view of an ecosystem and the threats it faces will also help ensure that NOAA allocates resources to the highest priority regional needs.

Second, the IEA will provide a higher level performance metric for NOAA and other federal and state agencies (e.g., the state of the ecosystems under management), that will integrate the series of disparate ecosystem parts that are not the primary focus for management.

Third, by providing a forum for the development of IEAs, NOAA will better engage other federal agencies, the states, tribes and other non-governmental agencies as these entities undertake their missions in ocean, coastal, and Great Lakes management. For example, activities conducted by the Environmental Protection Agency, the Department of the Interior and others provide information critical for successful outcomes for NOAA’s missions. Similarly, these other agencies potentially would benefit from a structured access to the diversity of ecosystem information held by NOAA.
What are the products of IEAs?
Full implementation of the IEA program would allow NOAA to produce the following set of products

1. A national suite of eight linked regional ecosystem scale IEAs, which are peer reviewed and updated approximately every four years
2. A limited number of local-scale IEAs nested within some of the regional IEAs
3. A “dynamic” web-based capability that will produce customized IEA products and scenarios by region and at any spatial scale on demand
4. A national overview of the eight regional IEAs that summarizes the state of the nation’s ocean and coastal ecosystems in relation to a variety of human and natural factors.

Three funding scenarios are provided in the options section below (section 7) that outlines the delivery of these products at a status quo, maintenance, and full implementation levels of investment.

5. What is NOAA’s current ability to fill this need?

Core NOAA IEA Capabilities
IEA could not be done without the current investments in collecting, analyzing, understanding, and communicating ecosystem data that is already done to meet existing requirements within the Ecosystem Goal. This expertise draws on the manage, produce, and provide aspects of NOAA’s functional model. The direct and core capabilities for conducting IEAs come primarily from the Ecosystem Observations and Ecosystem Research Programs, which crossing through NMFS, NOS, OAR, and NESDIS. The Coastal and Marine Resources Program through NOS’ Coastal Services Center also contributes critical expertise in the development and delivery of web-based decision-support tools. Other Ecosystem Goal Programs contribute expertise and are also key customers for determining priority management information needs that would be served by IEAs.

At the national planning and coordination level, NOAA’s Ecosystem Goal Team will initially manage the IEA process with appropriate input from the Line Offices, Programs, IEA PATT, and NOAA’s Regional teams. The Ecosystem Goal and NOAA’s constituent Line Office expertise is uniquely positioned to undertake IEAs due to expertise in: 1) coordinating management interests in a region and defining the principal concerns and requirements; 2) identifying ecosystem-related data, information and management gaps that need to be filled; 3) collecting, integrating and analyzing data to create information products that; 4) directing research and identifying solutions that improve our understanding and management of coastal and marine resources; and 5) developing web interface tools for resource managers to access assessment products; and 6) integrating IEA forecasts and products into resource management and policy development processes.

To produce Regional IEAs, a cross-LO team will be established to coordinate and manage the IEA process and ensure appropriate connections between participating programs. Once all eight regional-scale IEAs are complete, NOAA will produce a national ecosystem assessment.
Although this assessment would be a “one-NOAA” product, we envision that the National Centers for Coastal Ocean Science (NCCOS), a part of NOS, would be an appropriate entity to coordinate the national synthesis and report due to experience with integrated assessment efforts. NMFS and OAR would be partners with NOS in designing and developing the report due to similar expertise producing national scientific assessment reports (e.g., Our Living Oceans).

The entire IEA process will draw on the capabilities, expertise, and partnerships of all of the Ecosystem Goal programs. For example, Sea Grant, through the Ecosystem Research program, is conducting a series of regional ecosystem research priority setting workshops. These workshops will identify critical science gaps on a region-specific basis which will inform the types of science necessary to support ecosystem approaches to management at regional and local scales. These research priorities and any ensuing new science will have great benefit to the IEA process.

The Fishery Management Program will be able to engage Fishery Management Council partners and state fishery agencies in the scoping and needs assessment process to identify priority management questions that IEAs could help address. The Fishery Management Program will also be a key partner in design and execution of risk assessment information, ensuring that FSA parameters are integrated appropriately.

The Coastal and Marine Resources Program, working with state Coastal Zone Management, Estuarine Research Reserve, and Sanctuary partners, will also be a key component of the scoping and needs assessment process, as well as a conduit to bring state and local-scale data into the IEA process. This program will also provide input on indicators and, through the Coastal Services Center, be a key NOAA partner in developing web-based technologies, tools and products for the dynamic IEA product, including expanding the existing Digital Coast capability.

**Other federal agencies:** NOAA is establishing relationships with key other federal agencies, particularly EPA and DOI. These relationships will improve data availability and also serve to coordinate overall federal IEA efforts.

**States and Regional Organizations:** As various regional organizations get increasingly organized, NOAA has established formal mechanisms (including in the California Current) to engage state and regional partners in ensuring that our products will be useful for their needs.

**Non-Governmental Organizations:** Many NGOs have interest and assets to contribute to the IEA effort. NOAA is already making strategic connections, particularly in the California Current, with key NGOs to discuss where interests overlap.

**Academic Institutions:** Academic institutions provide critical research infrastructure and capabilities that are particularly useful in ecological modeling, selection of ecosystem indicators, and risk assessments for management strategy evaluation. Additionally, the outreach capabilities afforded by the Sea Grant programs will be important in effective implementation of IEAs.
**Private Sector:** A key partnership in expanding the Digital Coast to accommodate IEAs, will include private industry. As IEAs become more robust, there may be opportunities within the private sector in developing value-added tailored products for various audiences.

6. **Gap Analysis**

**Organizational challenges**
As discussed earlier in this paper, a key organizational challenge for producing IEAs is ensuring that NOAA identifies an organizational entity that is regional, cross-LO, can act to execute financial arrangements fairly and altruistically, and has sufficient dedicated expertise assigned to the task. Various arrangements are possible at the regional level and local level, and will likely vary between regions based on existing infrastructure and investment, for example: the PaCOOS program in the California Current; the PMEL/AFSC partnership in Alaska, and; GLERL, Sea Grant and NCCOS activities in the Great Lakes.

Working with the NOAA regional teams, we expect that similar arrangements can be developed for the other regional ecosystems. Since the local needs tend to be mostly single Line Office arrangements, it is anticipated that there will be primarily Line Office arrangements for these sub-regional IEA products, but even those efforts should make concerted efforts to include other LO interests.

Financial resources dedicated to this program can provide for contractors, limited new FTEs and IT support to enable development of the four IEA products. No new observations will be supported from these funds, but the process of identifying gaps and optimizing observations for IEAs may influence future investments.

**Data and Observations /Research and Development**
IEAs rely on existing data streams, so investment in IEAs in and of themselves do not increase the gap for data and observations. However, the process of conducting an IEA may inform priorities for future data and observation collections. Similarly, IEAs themselves do not increase the gap for research and development, but may identify key priority areas for future research investments.

One of the critical tasks to be undertaken in the data framework to establishing data standards and IEA standards, so local activities can be compared regionally, and so that regional products can be compared nationally. Although there will be some variation between local IEAs and also between regional IEAs, there also needs to be an appropriate level of consistency.

**Modeling**
NOAA currently does not have a comprehensive capability for ecosystem modeling, so the IEA process does invest in building this capability. Ecosystem models that are comprehensive, spatially disaggregated, and that incorporate physical forcing and ecosystem interrelationships will need to be developed so that the data sets can be analyzed in an integrated manner. In particular, risk assessments and management strategy evaluations for ecosystems are required to support IEAs. Modeling is a core capacity requiring tailored investments to support IEAs.
Management/Decision Support Tools
As discussed in section 6, many mechanisms already exist to assist with identifying management challenges and information needs from internal and external sources. NOAA would continue to use these well established mechanisms. Modest resources are included as part of the IEA proposal to conduct comprehensive needs assessment processes in each region. Additionally, resources are included to ensure web-access to NOAA’s data and information through the data portals.

External Input About Needed IEA Capabilities for NOAA
The text below is excerpted from the External Review of NOAA’s Ecosystem Research and Science Enterprise Report regarding capabilities necessary to support IEAs within NOAA.

To conduct integrated ecosystem assessments, certain core science capabilities have to be dedicated to each regional unit. These will usually be located in the region itself, but occasionally logistical considerations might justify a more remote site. The important point is that the expertise is focused on the specific regional ecosystem. For effective ecosystem science and integrated assessments, core capabilities are needed in three areas:

- **Monitoring**: The Region has the competence and capacity to collect reliable information using state-of-the-art tools.
- **Analysis**: The Region has the competence and capacity to apply, adapt, and interpret state-of-the-art analytical methods.
- **Integration**: The Region has the competence and capacity to analyze and interpret relationships among ecosystem components and between human activities and natural ecosystem components, and to develop and apply models of those relationships.

These core capacities are needed to ensure that within each regional team experts can:

- Evaluate the quality and completeness of the data sources used in the assessments;
- Evaluate the suitability of the functional relationships assumed;
- Guide the assessments to address the management issues of greatest regional relevance; and
- Detect and respond to changes in the needs of the users of the integrated assessments.

These capabilities also provide the knowledgeable and known experts to speak with authority to the diverse clients of ecosystem assessments and NOAA science more generally. Importantly, they have the regional knowledge to know when results of the regional integrated assessments just “don’t make sense,” even if the formal diagnostics look normal. Having the competence and capacity within a Region does not mean that all the expertise has to be housed in NOAA facilities and employed by NOAA. Partnerships with academia, industries, and public interest groups will all play important roles in ensuring that the competence and capacity are available. Nor does the competence and capacity have to be delivered in the same way in every region. However, the partnerships need to be reliable, so the capacity is available when it is needed, and NOAA must remain responsible for the content and interpretation of the IEAs. For both of those reasons, partnerships comprising important parts of the science capability to perform the regional Integrated Ecosystem Assessments should be sufficiently formally structured that partners are accountable for their contributions to the assessments, and the integrity of the science content is assured.

Whereas collectors and users of data and interpreters of the assessment results require strong regional knowledge to be credible and effective, many support tasks do not need to be duplicated in each Region. Many of these service functions have economies and efficiencies of scale that justify an important role for Centers of Specialized Expertise. These centers do not mean that Regional NOAA researchers cease to do cutting-edge science. The opportunity to strive to scientific excellence should be provided universally to NOAA scientists and their partners in research. Nor does it mean that every region will get what it wants when it wants it. These Centers of Specialized Expertise become key components of planning and priority setting. Many of the core capacities required for Integrated Ecosystem Assessments already exist within NOAA whereas other capacities need to be strengthened before IEAs
can be successfully prepared. In the following sections we described the range of core capabilities that must be available at the regional level or in Centers of Specialized Expertise.

Each Regional ecosystem science enterprise must have an adequate core capacity in sustained observations, analysis of status and trends of ecosystem component, and analysis and modeling of interactions. Increased capability in social sciences focused on ecosystems is also necessary. These capabilities do not necessarily have to be housed completely in NOAA facilities, but can be provided in part through partnerships.

7. Options

Three investment options for implementing IEAs through are provided, as summarized in the following table, with the funding profile shown in Figure 4. The three options are: (1) status quo, (2) "maintenance funding, and (3) full-implementation funding. These three options provide NOAA leadership with a range of investment strategies and their relative impact on the timing, scope, and completeness of the development of the dynamic IEA product (web-based data portal), the series of regional IEAs, a limited set of high-priority local IEAs, and the national synthesis document.

Under the Option 1, Status Quo, level of investment, the projects in the California Current, Northeast and Alaska remain pilot activities, but do eventually provide both “dynamic” data access capabilities as well as periodic evaluations of the status of these ecosystems. Activities in the remaining regions remain in a planning mode, and no national overview is possible.

Under Option 2, Maintenance Funding, NOAA invests in IEAs at the level of funding estimated to be needed in the-long term, after initial start up investments getting each regional system stood up were made. This investment would ensure that the regional products, once developed, stay current and relevant, including continuing to update and refresh the web-based data portal, improve and incorporate improved models, forecasts, and decision-support tools, and produce peer-reviewed regional assessments and a national report approximately every four years. The level of investment allows more broad-based progress throughout the eight regions, and limited local-scale IEA development, but pushes the full set of regional IEAs products out until 2017, with the national synthesis following after that.

Under Option 3, Full Implementation, there is considerable early investment in all regions and a number of local-based IEA activities. These initial developments allow the data frameworking activities to occur in all regions and for an early transition to maintenance mode in all regions. Relatively high investments in 2011-2013 provide the necessary infrastructure to sustain the program, which then transitions to the operational mode. Under the full implementation scenario all products are produced within the 2010-2015 timeframe.
<table>
<thead>
<tr>
<th>Option</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Title</strong></td>
<td>Status Quo</td>
<td>Maintenance Funding</td>
<td>Full Implementation</td>
</tr>
<tr>
<td><strong>Description</strong></td>
<td>Pilot-level activities in California Current, Alaska, and Northeast.</td>
<td>Fund IEAs at the long-term maintenance level. Because a more intense investment is needed in each region to stand-up the IEA, delivery of products would be stretched out over a longer period of time than under the Full Implementation option.</td>
<td>Regional peer-reviewed reports, national synthesis report, and live web-enabled data portals available for all eight regional coastal and marine ecosystems by 2015.</td>
</tr>
<tr>
<td><strong>Funding</strong></td>
<td>$8M. Continues FY09-13 current program funding for pilot IEAs.</td>
<td>$28M starting in FY10</td>
<td>$43M maximum. Scales back to $28M maintenance level</td>
</tr>
<tr>
<td><strong>Products</strong></td>
<td>Pilot regional ecosystem-scale IEA in California Current(*); pilot IEA activities in Alaska and the Northeast; limited “dynamic IEA” capability</td>
<td>Full set of regional ecosystem-scale IEAs completed by 2017; “dynamic IEA” completed and fully operating with manager training in all regions by 2013; limited number of high priority local-scale IEAs nested within regional ecosystem IEAs</td>
<td>Full set of regional ecosystem-scale IEAs and national synthesis completed by 2015; “dynamic IEAs” completed and fully operating with manager training by 2012; limited number of high priority local-scale IEAs nested within Regions</td>
</tr>
<tr>
<td><strong>Schedule</strong></td>
<td>FY12 – Dynamic IEA</td>
<td>FY13 – Dynamic IEA in all Regions</td>
<td>FY12 – Dynamic IEA in all Regions</td>
</tr>
<tr>
<td></td>
<td>FY14 – Pilot California Current IEA</td>
<td>FY14 – 2-7 Local IEAs</td>
<td>FY14 – 4-8 Local IEAs</td>
</tr>
<tr>
<td></td>
<td>FY14 – 2-3 Local IEAs</td>
<td>FY17 - Full set of regional IEAs completed</td>
<td>FY15 – Full set of regional IEAs completed</td>
</tr>
<tr>
<td><strong>Pros</strong></td>
<td>• NOAA begins to build an IEA capability; one Region will have a full IEA capability implemented</td>
<td>• National IEA service possible for all Regions • Stakeholder concerns for integrated information met • Funding profile consistent with long-term maintenance profile</td>
<td>• National IEA service possible for all Regions on a faster time-line • Stakeholder concerns for integrated information met • implementation allows for a scale-back of program funds by 2014</td>
</tr>
</tbody>
</table>
Cons

- No comprehensive national IEA service for all regions; regional-scale IEA activities limited to 1-3 regions
- Stakeholder concerns for integrated data and ecosystem information not met
- Full set of regional scale IEAs not implemented until 2017
- National synthesis based on regional synthesis reports developed over a longer time horizon, may make comparing information across regions less accurate and meaningful
- Requires relatively quick ramp-up of funds in early years

*Note: The pilot activities focus resources in the California Current because a group of NOAA entities has already been formed and is already working in an IEA-type framework. The PaCOOS (Pacific Ocean Observing System) is supported by agreements among many NOAA entities. Additionally academic, state and other federal groups as well as IOOS regional associations support the program (http://www.pacoos.org/). PaCOOS is an example of a regional entity that can execute the IEA program for that region. Acting with NOAA elements focusing at local scales (such as the California Sanctuaries), and other entities focusing on sub-regional ecosystems (e.g., Puget Sound), PaCOOS can assemble a science team focused on coordinating these IEA efforts.
The three options are based on several assumptions:

- The FY09-13 “current program” investment in IEAs of $8M ($6M requested in the NMFS FY09 budget funding NMFS, NOS and OAR IEA pilot activities, plus an additional $2M in the NESDIS budget funding data development activities) continues to be funded as programmed and has success in the FY09 budget process. This forms the basis for the Status Quo Option 1 and a critical step before moving onto larger-scale implementation.
- FY08 President’s Budget decisions, which currently are not incorporated into NOAA’s “current program,” do get incorporated into NOAA’s budget. Within the Ecosystem Goal, the President added almost $100M in funding for high priority activities (e.g., Ocean Research Priority Plan implementation, Magnuson-Stevens Reauthorization Act).

8. Portfolio Impact

The cumulative FY10 budget for the EGT currently in the out years profile is $1.098 billion, distributed over the nine Goal Programs. As mentioned above, this does not currently include FY08 President’s Budget additions to NOAA’s budget. Of this, the IEA piece accounts for $8M, or 0.7% of total Ecosystem Goal investment. The Status Quo option maintains this funding level in the outyears. It is important to understand that the IEA program as envisioned by the Ecosystem Goal in all three Options does not include, but leverages, NOAA’s significant current investments in the Ecosystem Observations and Ecosystem Research Programs, as well as more modest relative investment levels in other Ecosystem Goal Programs. Additionally, physical observations of the marine and coastal environments are funded by NOAA in the other mission Goals and Sub-Goals.

The “Maintenance” budget for IEAs (Option 2) plateaus at $28 million per year, or about 2.5% of the total Ecosystem Goal budget. Some of the $20M increase relative to the Status Quo Option is covered by funds that have already been programmed into the Ecosystem Goal in past PPBES cycles, but that have not yet been requested by NOAA through the budget process. These funds include investment in regional ecosystem forecasting centers, indicator identification and testing, and data integration and management. In total, these “pre-programmed” funds add up to $14.8M. During programming, the Ecosystem Goal would look more closely at which portion of the $14.8 should be redirected to specifically support IEAs.

The “Full Implementation” scenario (Option 3) assumes investment increases to $38.6M in FY10, rising to a peak of $43.3M in FY11-13, and declining to the “maintenance” level of $28M by 2015 million in 2015. This option also incorporates some of the “pre-programmed” funding, plus an additional investment to stand up the IEA process in each regional ecosystem so that all products in all eight regions would be available by 2015. Under this scenario, IEA investments rise to about 4% of the EGT budget in FY11-13, declining to 2.5% in FY15.

Risks
The IEA options as outlined above represent modest financial investments in these activities but build on investments in most of the Ecosystem Goal programs, as well as investments in the other three mission goals and several of the sub-goals. The fact that IEAs have not been
produced until now is partly a result of the lack of a coherent organizational structure within NOAA, and because the IEA construct has only recently emerged as a unifying science activity enabling ecosystem-based management. There is a clear opportunity for NOAA to assume a leadership position to help guide regional ecosystem-based governance, and the production of IEAs will by their nature involve various levels of local, state and regional governments. If NOAA is successful in the FY09 budget process, there is clear guidance from the U.S. Ocean Commission to engage EPA (and by inference other federal agencies) in ecosystem-level assessments. Over the next five years NOAA can institutionalize ecosystem approaches to management through its science and management responsibilities, and IEAs represent a concrete step in this direction.

If NOAA chooses not to pursue IEAs as an operational product, there is considerable risk that other institutions will do so, but in an uncoordinated and non-systematic manner (e.g., regional or local efforts addressing issues which may not address NOAA’s needs, and which are not coordinated into an overall synthesis). As local or regional efforts emerge, pushed by NGOs, academics, and state entities, there will be the obvious calls for Congress to fund them as earmarks from NOAA’s budget. Thus, NOAA would likely be in the position of funding such efforts but with little leverage on their form or outcome. Thus, there is some urgency for NOAA to initiate these efforts and “brand” IEAs, while entraining other interested groups in the process.

There is currently much debate in Congress and in the states about the form of regional ecosystem-based governance models, and there will likely be uneven and ambiguous policy directions over the next several years. IEAs can help to add structure to that debate by identifying clearly the issues that require additional management attention, and the types of management measures necessary to influence and improve the status of the nation’s coastal and marine ecosystems.
INTEGRATION OF DATA AND MANAGEMENT
NOAA stakeholders voiced the need for greater integrated and dynamic management by NOAA, overall. Stakeholders asked that NOAA conduct integrated ecosystem assessments (IEAs) that include decision support systems, visualization and analysis tools, and data sharing among partners. In particular, stakeholders want to see the integration of coastal science management with living marine resource management, and more integration of data management, research actions (e.g., coordinating offshore and nearshore surveys), and science and management knowledge within NOAA as well as with external entities. They ask that NOAA aim to balance and integrate all the pieces of the ecosystem through an ecosystem approach, with more emphasis on the land-water interface, and better integrate industry data into assessments.

COLLABORATION
NOAA stakeholders ask for collaboration on many levels. They would like to see the collaboration of data use and management across local/state/federal government agencies as well as NGOs, businesses, academic institutions, and coastal residents. Some stakeholders ask that NOAA partner with local organizations on baseline studies and integrating data to answer locally defined issues/initiatives. They also voiced that NOAA should: partner with entities in coastal states in collecting and analyzing data; collaborate internationally and share lessons learned; join the Millennium Assessment (led by the World Resources Institute and in partner with the UN and others); work with other agencies to link the variety of defined regions for management; include partners in data analysis and allow them to participate in the decision-making; and foster collaboration while respecting ownership of data.

ACCESS TO DATA / DATA FORMATS AND SYSTEMS
Many stakeholders urged that NOAA provide greater access to its data by using new technologies/web-based solutions to share results, foster communication, and collaborate. Equally accentuated was that NOAA should get information out in a timely and user-friendly manner. Many suggested that NOAA provide stakeholders a web-based NOAA repository for raw data, synthesized data (at different levels of synthesis for various user needs), as well as information about NOAA research, best practices, management tools, accomplishments, and abilities. Stakeholders also want access to dynamic, web-based IEAs.

A number of stakeholders asked that NOAA serve as a nexus for marine research of other agencies, NGOs, and academics. They suggested the establishment of a NOAA-rooted search engine that searches across other agencies and organizations in the US and abroad for research information – a tool that could also help promote smarter collaborations. Some suggested the search engine have the option to be geo-spatially based. Finally, a few stakeholders suggested the use of Internet2, a networking consortium, to communicate with universities and disseminate information.

DATA / TOOLS / MODELING NEEDS
Stakeholders want NOAA to aim for more balanced assessments of ecosystems that include a variety of ecosystem components, and that focus on identifying, maximizing, and putting a value on ecosystem services. Stakeholders asked for an increased amount of fishery independent data (in real-time when possible), observers, and vessel monitoring systems to expand the scope of observations.
Stakeholders asked that NOAA develop and/or provide: more information on ecosystem thresholds and projected impact levels to help them manage more effectively; management tools that work effectively with uncertainty; a data management system to preserve old baseline data; a long-term biological time-series data set in association with other ocean observing systems; and coastal and marine models that include landscape ecology, linking marine and terrestrial habitats.

Overall, stakeholders asked for more data and greater quantification of data. Stakeholders specifically noted the need for greater habitat mapping; strong, science-based stock assessments; more non-fish living marine resource data; an increase in the spatial and temporal resolution of surveys of living marine resources; global climate change impact monitoring; a focus on the Integrated Ocean Observing System (IOOS); and assessments of deep sea corals, sea turtle populations, and undisturbed systems.

Finally, some stakeholders suggested that NOAA create a cross-agency geographical information system (GIS) to better understand human activities in the coastal zone.

GEOGRAPHIC AREA / REALM
In support of the ecosystem approach to management, many stakeholders felt that NOAA needs to expand its realm to link land management to marine management for a fuller ecosystem view. This would include extending NOAA influence to the headwaters of streams used by anadromous fish.

APPROCCH
Stakeholders want NOAA to adopt a user-driven (client/customer-oriented) management approach for conservation research. Stakeholders support NOAA’s continuing development of the regional approach, and also emphasize that NOAA should create comprehensive networks of marine reserves, or bioreserves, and utilize them for research, monitoring, and understanding of human impacts.
Appendix 2  
Annotated Bibliography of Integrated Ecosystem Assessments:  
Concepts, Methods, Evaluations, and Implementation Examples

Charting Progress: An Integrated Assessment of the State of UK Seas  
This integrated status report provides the first holistic view of the ocean and coastal areas of the UK, and concludes the following:  
• UK seas are productive, supporting a wide range of fish, mammals, seabirds and other marine life.  
• The open seas are generally not affected by pollution and levels of monitored contaminants have decreased significantly.  
• The main contamination problems identified are in part due to the legacy of the past and are generally observed at higher levels in industrialized estuaries or areas local to the activity.  
• Human activity has already resulted in adverse changes to marine life and continues to do so, for example, continued widespread commercial fishing practices threaten many fish stocks by over-exploitation and damage sea floor areas.  
• Evidence exists that the marine ecosystem is being altered by climate change, for example for example sea temperatures are rising and the distribution of plankton species is changing. These effects are not yet well understood.  
http://www.defra.gov.uk/environment/water/marine/uk/stateofsea/  

Canada’s Oceans Strategy/Policy and Operational Framework for Integrated Management of Estuarine, Coastal, and Marine Environments  
This strategy provides the overall strategic framework for Canada’s oceans-related programs and policies, based on the principles of sustainable development, integrated management, and the precautionary approach. The document proposes an Operational Framework with governance, management by areas, design for management bodies, and the type of planning processes that could be involved.  

Translating Ecosystem Indicators into Decision Criteria  
Ecosystem-based decision criteria are suggested, based on indicators empirically derived from the Georges Bank, Gulf of Maine ecosystem.  
Identification of Ecologically Significant Species and Community Properties
This report contains the results of a national workshop held in 2006 to develop a priori criteria to assess species and community properties that are “particularly important” or “significant” with regard to maintaining ecosystem structure and function.


Climate Change Impacts for the Conterminous USA: an Integrated Assessment
This special issue of the journal Climatic Change describes an effort to improve methodology for integrated assessment of impacts and consequences of climatic change.


Canadian Guidelines on Evaluating Ecosystem Overviews and Assessments: Necessary Documentation
Initial ecosystem overview reports and partial integrated ecosystem assessments were prepared for two ecosystems for which integrated management approaches are currently being developed: the Eastern Scotian Shelf and Gulf of St. Lawrence systems. The overview and assessment documents for the two systems were prepared in different ways, allowing the Department of Fisheries and Oceans to report here on insights gained from a review held in 2005 on the desirable contents to be included in both types of documents.


ICES Regional Ecosystem Study Group of the North Sea Report
The report summarizes the results of a meeting of the study group held in May 2006 to evaluate and prepare plans for finalization of an integrated assessment of the North Sea Ecosystem, an activity initiated by this group in 2003. The assessment, based on the compilation and analyses of a comprehensive integrated data set, has provided some valuable insights into the significance of the relationships between different human pressures (e.g., nutrient inputs and fisheries) and state changes (e.g., plankton, fish and seabirds) at different spatial scales and the time scales over which changes take place.

Other sources:

- Environmental Health Indicators, http://www.sciencedirect.com/
- Supporting European Marine Integrated Ecosystem Assessments (SEMIEA), http://www.ices.dk/globec/regns/SEMIEA.pdf
- An Integrated Assessment of Hypoxia in the Northern Gulf of Mexico, http://www.nos.noaa.gov/products/pubs_hypox.html#fia