FINAL REPORT

The External Review of NOAA's Ecosystem Research and Science Enterprise - A Report to the NOAA Science Advisory Board

Evolving an Ecosystem Approach to Science and Management Throughout NOAA and its Partners

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Preface

Public media and scientific circles are demanding better management of our ocean and aquatic environments. As a society, we value the benefits of clean water and coasts as well as sustainably managed marine and coastal resources. Many critics argue that these benefits are declining as a result of inadequate single sector management and lack of coordination throughout the coastal oceans and the Great Lakes. Some argue that a broader management framework informed by ecosystem science and research would improve management and restore or increase benefits. Legislative proposals are being made at local, state, regional and national levels to reorient management mandates and institutions to accommodate this broader societal initiative. Others argue that it is not necessary to shift to a different management paradigm and that properly implemented Best Management Practices will restore declining social benefits. Further, they argue that society has neither the political will nor the resources necessary to implement a broader ecosystem-based approach to management. These debates and supporting trend data are prompting NOAA to build from its strong marine science base towards a future where social benefits from our uses of aquatic ecosystems are secure and sustainable. As part of those efforts to get ahead of the debate, the NOAA Science Advisory Board appointed the eight members of the External Ecosystem Task Team (eETT) to provide outside perspectives on the science support needed for its approach to ecosystem services over the next few decades.

The eETT is pleased to provide this Report of its findings and recommendations for consideration by the Science Advisory Board. We hope that placing this report before the public, scientific community, tribes, environmental groups, user groups and various local, state and federal agency personnel, will engender discussion on how to employ ecosystem science to improve management decisions and how to evolve institutions capable of managing at different ecosystem scales. We fundamentally agree that the most direct way for NOAA to grow into an agency that manages human activities in a full ecosystem context is to start by expanding the use of ecosystem science enterprise under present mandates. In doing so, NOAA should emphasize the development of ecosystem science by integrating resources across the agency, and should encourage organizational form to evolve with function over the longer term. This report provides the eETT's rationales for this incremental and adaptive approach to developing and using scientific information in NOAA.

Although we have taken a critical look at NOAA's ecosystem science and research enterprise, our purpose is not to criticize the people and programs at work in NOAA today. Rather, we want to encourage the expansion of efforts made so far to move a very large agency serving multiple and sometimes conflicting mandates toward an ecosystem approach to management. We offer our recommendations to promote NOAA's ability to fulfill its ecosystem vision and we ask that user groups, environmental stakeholders, tribes, academics and other professionals as well as the general public join in this effort.

David Fluharty, Chair

Executive Summary and Key Recommendations

I Introduction

This report provides advice on how to improve NOAA's ecosystem science enterprise over the next decades, acknowledging existing legislative mandates and an uncertain fiscal environment. NOAA's "ecosystem science enterprise" includes all aspects of planning, conduct, and application of ecosystem science: development of hypotheses, monitoring, modeling and analysis, field and experimental research, development and provision of advice, and communication of results to all audiences

NOAA posed two sets of questions to the eETT:

1. Is the mix of NOAA's scientific activities appropriate to its ecosystem science needs, including its legislative and regulatory requirements, in terms of subject matter; distribution along the continuum from long term research to products for immediate use (including mandated scientific advice); distribution between efforts internal and external to NOAA; and links to international science programs? Is the mix optimal, and if not, how can it be improved?
2. How should NOAA organize its ecosystem research and science enterprise in terms of the relationship to non-ecosystem science activities ; the continuum from long term research to information products for immediate use (including mandated scientific advice); Line Office distribution; Program Structure used in NOAA's Planning, Programming, Budgeting, and Execution System; and other categorization schemes such as scientific discipline, mission area or mandate (implicitly including all sectors that are users of science advice), ecosystem or region, internal vs. external, etc. Is the organization optimal, and if not, can it be improved?

II Context of NOAA's Ecosystem Science and Research

NOAA's ecosystem science enterprise comprises a broad set of monitoring, research, and advisory services implemented to meet NOAA's growing statutory mandates for aquatic resource and coastal management. These statutory mandates are augmented by the US Ocean Action Plan, and responsibilities from policies of the federal Executive Branch and decisions of the Judicial Branch. These mandates set the foundation for NOAA's missions, and changes to NOAA's ecosystem science enterprise must ensure that all mandates to NOAA and to other agencies with which NOAA partners continue to receive essential support. NOAA's ecosystem research, observing, and management activities (at $1.3 billion in 2005 approximately 1/3 of NOAA's budget) are distributed over four NOAA Line Offices (LOs). The ecosystem science enterprise is organized along eight regional ecosystems, coordinated by the matrix-positioned Ecosystem Goal Team. NOAA also supports a comprehensive network of cooperative and joint institutes, the National Undersea Research Program (NURP) Centers, Sea Grant institutions, and other cooperative arrangements.

The EETT concluded that NOAA must make integrated assessment the normal mode of business for assessing the status of marine ecosystems and their components, and for evaluating options for human uses of ecosystems. The Integrated Ecosystem Assessments require structured, accountable collaboration among multiple LOs, with science partners, and with clients of ecosystem products and services. Some parts of this transition in science and management are underway; some will require changes of emphasis; some even changes in direction. All require greater resources because of the greater demands for science support for ecosystem-based approaches to managing multiple activities.

III Guiding Considerations

NOAA's present set of ecosystem programs and mandates provide a sound starting point, but do not constitute a program that provides an adequate science foundation for an Ecosystem Approach to Management (EAM). Transitioning from the current set of programs and mandates to an integrated ecosystem science enterprise should be guided by the following considerations:

- It is essential to account for environmental forcing in dynamics of ecosystem components and relationships;
- It is essential to understand how humans impact the natural components of marine ecosystems and, in turn, how humans are impacted by variations in the natural ecosystem components;
- It is essential to integrate ecosystem science information when applying it to policy and management, and to account for how different policies and human uses of the sea interact with each other; each potentially affecting the success of other policies and the sustainability of other uses.

The transition toward EAM is a process already underway and it must continue in the longer term. It will not be possible for NOAA to sustain a credible ecosystem science enterprise, and support mandates with science advice in an ecosystem context, without significant increases in resources.

IV Regional Ecosystem Assessments

In order to guide development of an adequate ecosystem science enterprise, NOAA should develop an explicit description based on current knowledge of what it sees as adequately "ecosystem rich" assessments and advice. They should be developed for all NOAA LOs, and brought together nationally, as a precursor to identifying where further change is most necessary. NOAA should then prepare "ecosystem development plans" for its assessment and advisory activities within each Region, and assemble them into an overall vision of where NOAA ecosystem services and science are going nationally. **(Recommendations 1-3)**

Regionally based Integrated Ecosystem Assessments (IEAs), conveying information on the status of ecosystem health and evaluating the impacts of current and proposed human activities, should be the central products of NOAA ecosystem science. For the regional ecosystem science enterprises to produce the IEAs, three classes of core capabilities must be present in each region. These capabilities do not necessarily have to be housed completely in NOAA facilities, but can be provided in part through formally structured and mutually accountable partnerships. (**Recommendations 4-7)**

Each region must have an adequate core competence and capacity in:

- Monitoring: to collect reliable information using state-of-the-art tools to produced sustained observations.

- Analysis: to apply, adapt, and interpret state-of-the-art analytical methods. Increased capability in social sciences focused on ecosystems is particularly necessary.
- Integration and Forecasting: to analyze, forecast and interpret relationships and interactions among ecosystem components and between human activities and natural ecosystem components.

Monitoring
Observations of representative indicators of all key elements of the ecosystem should be expanded and sustained, and closely connected to analyses and modeling of status and trends. These elements include: managed species and the unmanaged species that interact with them; geological, physical, chemical and biological aspects of habitat; the climate processes affecting habitat and behavior; and economic, demographic, social and policy factors that affect habitat, resource extraction, and the societal benefits of the ecosystem. **(Recommendations 8-10)**

Analysis
Extracting information from sustained observations requires analyses to determine the status and trends of the components being observed. For ecosystems, the analyses must include the variations of different species, habitat parameters, environmental and human factors. Analysis of status and trends of population and ecosystem dynamics, habitat and spatial factors, and social, economic and demographic forces that shape human activities are critical. **(Recommendation 11)**

Integration and Forecasting
Modeling tools also require augmentation for several reasons. Exploring scenarios to investigate the response of linked ecosystem components to natural or anthropogenic forcing, the sustainability of different combinations of human activities, or how different management options may perform under a range of hypotheses about future states of nature all require forecasting future trajectories of the ecosystem components and benefits to humans under different hypothesized scenarios. There will be increased demand by managers for spatially- and temporally-dynamic models of ecosystem processes, for human activities linked to the natural components, and for bio-socio-economic linkages. There will also be increasing calls to conduct performance evaluations of management measures to mitigate ecosystem effects of human activities and to provide for integrated management. **(Recommendation 12)**

V Additional Capabilities Needed to Deliver Effective Ecosystem Science

Some 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 as a Center of Specialized Expertise, which can become key components of planning and priority setting. These include:

- Building new tools - computer modeling and forecasting, and monitoring instruments and probes:
- Develop social sciences methods for linking ecosystem science to governance
- Understanding society and its response to changing ecosystem components
- Ecosystem structure and function

- Ecosystem impacts of specific human activities

In addition NOAA should consider whether consolidation of efforts should occur and develop plans for efficient regional and inter-regional coordination in the following areas

- Technical analyses (contaminants, toxicology, etc.)
- Biodiversity and taxonomy
- Data archiving and integration

(Recommendations 13-14)

VI How to Make the Transition

NOAA must have incentives to make its parts interact, common products on which they structure their collaboration, and mechanisms to oversee and be accountable for integration across LOs and with partners at the regional level. It must also have mechanisms at the NOAA-wide scale to ensure coordination at all levels. Meeting these needs can be facilitated through:

Implementing Regional Ecosystem Science Boards with mandatory representation from all relevant LOs and other partners providing key science capabilities in the Region. The Boards would be responsible for a variety of tasks related to planning, assessment, and the provision of ecosystem-level management advice, products and services.

Enhancing the Role of EGT and PPBES, addressing the steep learning curve for how to use the process effectively, and ensuring that the timelines facilitate coordination among NOAA entities and their partners. The EGT should have a key role, in collaboration with the RESBs, in developing a common set of objectives for all regions, a set of guidelines for the IEAs, and regional charters for the operations of the RESBs.

Using the IEAs to provide incentives for ecosystem science across LOs. The EGT and RESBs should identify key services that could be provided by various LOs and programs within NOAA, and each RESB should solicit LO participation through a competitive proposal process, with follow-up structured review and evaluation of performance. (Recommendations 15-17)

VII Answers to the Specific Questions

The final section of this report provides direct answers to the questions posed by NOAA in its charge to the eETT. These answers repeat the information in the body of the report, organized according the flow of the questions. The theme of this report is that a regional organization would best provide the research and applied science support to comprise the scientific basis for ecosystem based management. This approach fits the nature and role of ecosystem science much better than any we can envision, particularly better than disciplinary, time-to-fruition, internal vs. external, or management-sector orientations.

I INTRODUCTION

This report provides advice on how to improve NOAA's ecosystem science enterprise over the next decades, acknowledging existing legislative mandates and an uncertain fiscal environment. NOAA's broad definition of "ecosystem" applies throughout the report:

> *For NOAA's purposes, an ecosystem is defined as a geographically specified system of organisms (including humans), the environment, and the processes that control its dynamics*.

When we refer to the "ecosystem science enterprise" we include all aspects of planning, conduct, and application of ecosystem science – development of hypotheses, monitoring, modeling and analysis, field and experimental research, development and provision of advice, and communication of results to all audiences.

The eETT divided its task into five steps:
1. Review the statement of task and determine our approach to it.
2. Examine the context for NOAA's science and management responsibilities, including international setting, private sector models, and future trends in demand.
3. Develop guiding considerations to organize our view of ecosystem science and its multiple roles in policy, management, and public understanding.
4. Develop findings and recommendations built on these considerations.
5. Integrate our findings and recommendations to answer the major questions posed to the eETT.

I.A Statement of Task

The NOAA Research Review Team (http://www.sab.noaa.gov/Reports/Reports.html) recommended that NOAA should establish an external review team to evaluate and strengthen ecosystem research in NOAA. This recommendation was elaborated in an extensive statement of task by NOAA (Appendix 1), that poses two questions:

1. Is the mix of NOAA's scientific activities appropriate to its ecosystem science needs, including its legislative and regulatory requirements, in terms of subject matter, distribution along the continuum from long term research to products for immediate use, including mandated scientific advice, distribution between efforts internal and external to NOAA, and links to international science programs? Is the mix optimal, and if not, how can it be improved?

2. How should NOAA organize its ecosystem research and science enterprise in terms of the relationship to non-ecosystem science activities; the continuum from long term research to information products for immediate use (including mandated scientific advice); Line Office distribution, program structure used in NOAA's Planning, Programming, Budgeting, and Execution System, and other categorization schemes such as by scientific discipline, mission area or mandate (implicitly including all sectors that are users of science advice), ecosystem or region, internal vs. external, etc. Is the organization optimal, and if not, can it be improved?

I.B Approach and Methods

A task team of eight members was selected by the NOAA Science Advisory Board (SAB) in consultation with NOAA leadership. The organizational meeting (Washington, D.C., June 20-22, 2005), included briefings by the SAB and all NOAA Line Offices (LOs).

This review intends to position NOAA to meet issues that will become prominent by 2025. Major sources for these emerging issues include the US Ocean Commission and Pew Commission Reports, the NOAA 5-year and 20-year plans, and six ecosystem white papers (Appendix 2) prepared by NOAA experts for the eETT, addressing:

- Management of Living Marine Resources in an Ecosystem Context
- Ecosystem Responses to Climate Variability
- Freshwater Issues
- Marine Zoning and Coastal Zone Management
- Near-Real Time Ecological Forecasting
- Science Requirements to Identify and Balance Societal Objectives

To inventory NOAA's ecosystem science portfolio geographically and organizationally, and to gain a sense of the clients that each unit felt it served with specific ecosystem products, eETT members met with NOAA staff (Ecosystem Goal Team Leads and program managers, senior leadership, leading scientists, Physical and Social Science Task Team); external stakeholders (other agencies, Ocean Studies Board, Congressional staff, Office of Management and Budget; US Commission on Ocean Policy), and participants at scientific conferences, agency meetings, and user group meetings (Appendix 3). Discussing the material gained through the consultations led the eETT to three principles that guided its assessment of NOAA's portfolio of ecosystem-related activities (Section III). Following a vetting by the SAB of the principles and ideas flowing from them, the conclusions, recommendations, and report were drafted, presented to the SAB, circulated to selected experts, and made available for comment on the Federal Register. The resultant responses were considered in preparing this Final Report of the eETT.

II THE CONTEXT OF NOAA'S ECOSYSTEM SCIENCE AND RESEARCH

NOAA's ecosystem science enterprise comprises a broad set of monitoring, research, and advisory services, implemented to meet NOAA's growing statutory mandates for aquatic resource and coastal management. (Appendix 4). These mandates set the foundation for NOAA's missions to meet societal objectives for fisheries management, protected species recovery, coastal zone management, and managing estuarine and coastal sanctuaries and reserves. Changes to NOAA's ecosystem science enterprise must ensure that all mandates to NOAA and other agencies with which NOAA partners continue to receive essential support. Additionally, legislation, treaties, and conventions mandate NOAA participation in a number of international management and scientific organizations, requiring a global perspective for many of NOAA's key research activities.

NOAA's mandated responsibilities influence its division into LOs. NOAA recently has adopted a matrix organizational structure to address issues that cut across LO boundaries, with ecosystem management and research as one of the featured matrix programs. This review assesses the effectiveness of the LO and matrix structure in ensuring science support for understanding ecosystem structure and function and managing human activities in an ecosystem context.

II.A International Context

Globally, science and assessments supporting management of human activities in marine ecosystems are adopting an ecosystem approach. In Europe, the North Sea Council of Ministers adopted the Bergen Declaration (2002) committing signatories to apply an ecosystem approach to management of human activities in the North Sea and calling on the scientific community to develop operational ecosystem management objectives. The revised Common Fisheries Policy (2004) featured the ecosystem approach and acknowledged as a priority the need to consider ecosystem impacts of fishing. That was followed by development of the European Marine Strategy, and associated Policy, scheduled for a general vote in 2006. The European Marine Strategy has an ecosystem approach as its central theme, and the Guidelines for Implementation are built on ecosystem assessments, integrated management, and regional delivery of programs.

In Australia, the Sustainability Act requires that all industries impacting environmental quality meet a high standard of accountability for ecological sustainability, and seek science advice in a broad ecosystem context. Integrated management of human activities in the coastal zone within an ecosystem context is also a legislated priority. CSIRO, the main government science body, has responded to these changes with both program refocusing and organisational changes that emphasize an ecosystem approach to all science in support of marine management and policy, and an integrated approach to planning and decision-making.

In Canada, the Oceans Act (1997) features an ecosystem approach, precautionary approach, and integrated management as the cornerstones for policy and program development. Integrated Ecosystem Assessments of Large Ocean Management Areas are the foundation for suites of operational ecosystem management objectives and integrated management plans. Canada's commitment to an ecosystem approach in fisheries was embodied in the text of the St John's Declaration (2005) and is being written into the revisions to the Fisheries Act.

The commitment to an ecosystem focus is not restricted to the developed world. Guided by the Reykjavik Declaration (2002), the FAO Code of Conduct for Responsible Fishing adopted Annex 4 in 2004, placing the FAO support for fisheries in developing and developed states onto an ecosystem-based footing. Likewise, international standards for ecocertification of fisheries gives sustainability of fisheries in an ecosystem context equal weight with sustainable harvesting of the target species.

II.B Legal Context for NOAA's Science Activities

Appendix 4 presents a partial list of US Federal legislation authorizing NOAA to undertake science programs in the coastal oceans and the freshwater ecosystems of the Great Lakes. Each NOAA LO has primary, and occasionally, sole responsibility to implement some of these legislative mandates. Some of these acts and treaties authorize specific sums of money supporting them. However, in many cases appropriations have neither been commensurate with the scope of science required to meet these mandates, nor kept pace with inflation.

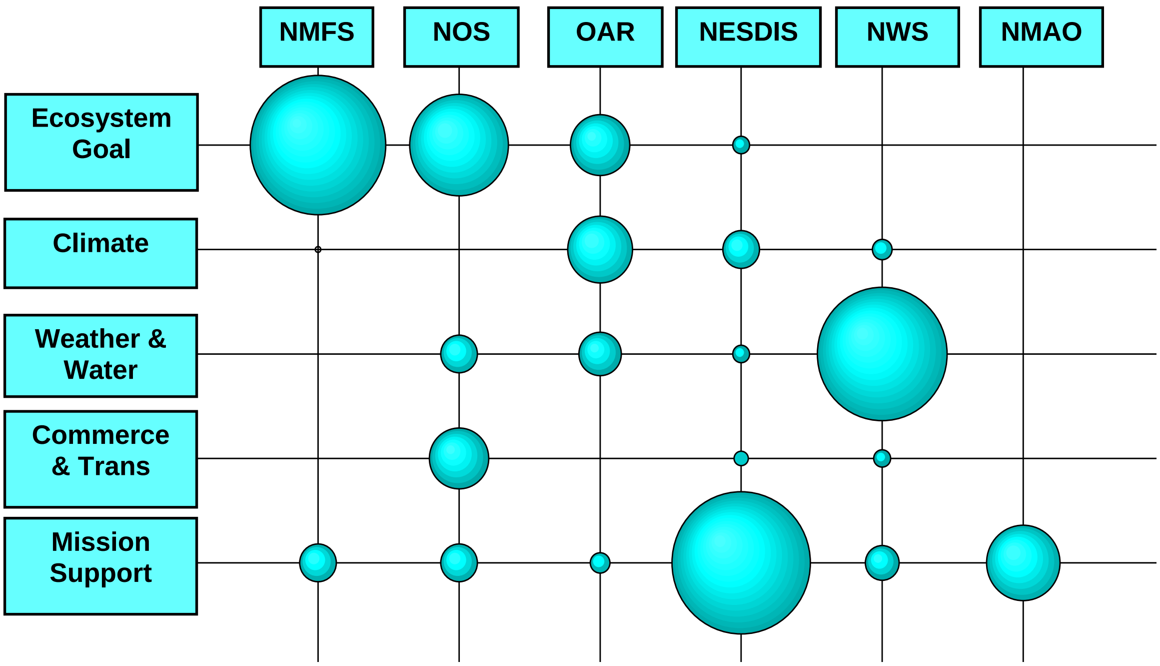
NOAA's authorizing legislation is only one set of mission drivers to which the Agency responds. Building on the US Ocean Commission and Pew Ocean Commission reports, the President's US Ocean Action plan detailed nearly 200 specific recommendations for which NOAA had exclusive or shared responsibility (http://ocean.ceq.gov/actionplan.pdf). The Ocean Action plan created a number of interagency coordinating committees, including the National Science and Technology Council's Joint Subcommittee on Oceans Science and Technology (JSOST), co-chaired by NOAA, and required it to prepare a comprehensive Ocean Research Priorities Plan. NOAA also has Executive Branch responsibilities to provide science input to a number of management and coordinating groups formed as a result of the establishment of the Committee on Ocean Policy (http://ocean.ceq.gov/) and to coordinate its science activities with other federal agencies, states, tribes and other countries.

In addition to legal and executive-level mandates, the Judicial Branch of government often drives scientific issues within NOAA. NOAA is also a regulatory agency and litigation often involves the scientific basis supporting management decisions. Accordingly, some of its science programs stem from legal findings or legislative action in response to them. NOAA's peer review processes for science supporting management activities (particularly in fisheries) and compliance with the federal Information Quality Act (http://www.whitehouse.gov/omb/inforeg/agency_info_quality_links.html) strengthen NOAA's science applied to issues with potential for litigation.

II.C NOAA Today -- NOAA's Ecosystem-related Activities

As the nation's principal mission-oriented ocean agency, NOAA undertakes science and management programs related to living marine resources (fisheries and protected species), coastal zone management, marine sanctuaries and estuarine research reserves, coral reefs, and related activities, consistent with its mandates (Table II C 1). The Agency comprises seven "Line Offices" (http://www.pco.noaa.gov/org/NOAA_Organization.htm) supported by additional headquarters corporate services and allied functions (for more information see http://www.noaa.gov/). Its ecosystem research, observing, and management activities, (at $1.3 billion in 2005, approximately 1/3 of NOAA's budget) are distributed over four NOAA LOs: the National Marine Fisheries Service (58% of the ecosystem budget in 2005); the National Ocean Service (30%); Oceanic and Atmospheric Research (11%); and the National Environmental Satellite, Data and Information Service (1%). Additionally, under its Office of Marine and Aircraft Operations (OMAO), NOAA operates a fleet of research vessels and aircraft supporting ecosystem missions (Figure II C 1).

Figure II C 1 NOAA's Matrix Structure Integrating Line Offices and Goal Teams



Symbol area proportional to 2005 budget. Source: Mike Ford, NOAA

The ecosystem science portfolio undertaken by NOAA is primarily developed by the individual LOs to address responsibilities under their assigned missions, with the Ecosystem Goal Team (EGT) intended to provide coordination across LOs. In order to coordinate research and observational systems, NOAA has developed several boards, councils and teams (http://www.ppi.noaa.gov/councils.htm). The Research Council is responsible for developing NOAA's 5-year research plan (http://nrc.noaa.gov/Docs/NOAA_5-Year_Research_Plan_010605.pdf), which describes current activities, facilities and missions, and provides an institutional context for meeting current challenges faced by the LOs and the Agency. The 20-year research vision of the agency (http://nrc.noaa.gov/Docs/Final_20-Year_Research_Vision.pdf) outlines a series of long-term societal challenges, and describes how NOAA seeks to position its research activities to help meet them to produce NOAA's long-term vision for its science:

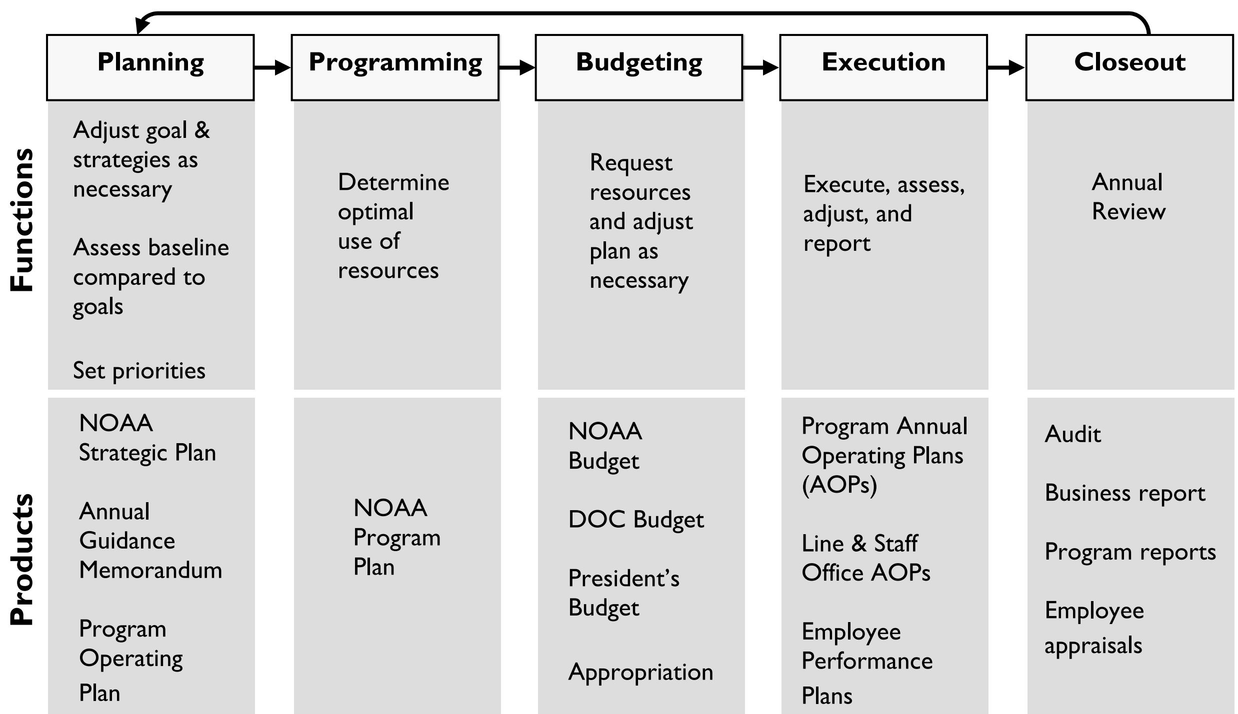
> *"An informed society that uses a comprehensive understanding of the role of the oceans, coasts, and atmosphere in the global ecosystem to make the best social and economic decisions"*

PPBES Process

NOAA has established a matrix organizational structure around four organizing themes that describe the bulk of its mission mandates (Figure II C 1). This matrix organization explicitly recognizes that many of the demands made of the Agency involve resources controlled by two or more of its LOs. Specifically, four cross-line office mission goals have been established for Climate, Weather, Commerce and Transportation, and Ecosystems. The mission goal for Ecosystems is to “ensure the sustainable use of resources and balance competing uses of coastal and marine ecosystems, recognizing both their human and natural components”.

The mission goal teams have primary responsibility in NOAA’s Planning, Programming, Budgeting, and Execution System (PPBES) (Figure II C 2). This is a comprehensive planning and budgeting system that seeks to align NOAA’s strategic goals with its long-term budget needs, working simultaneously on three different budget cycles, each at a different stage of planning.

Figure II C 2 Phases of NOAA’s PPBES Process – Annual Cycle



Cycle begins 2.5 years prior to execution year. Source: Mike Ford, NOAA

Ecosystem Goal Team (EGT)

NOAA’s Ecosystem Goal Team (http://ecosystems.noaa.gov/general_information.htm) was created to integrate its ecosystem science, research, and management activities among the four participating LOs. The EGT consists of nine programs (Table II C 1), some with activities within one LO, others (the “matrix programs”) with multiple LO representation. Those programs designated “matrixed” include habitat, corals, aquaculture, enforcement, ecosystem observations and ecosystem research, each led by senior scientific staff familiar with the program activities. The programs develop comprehensive lists of their capabilities and performance metrics to describe their progress in meeting annual and long-term goals. In addition to LO management of their financial and human resources, the matrix programs are responsible for annual execution of the budget, including assuring that milestones are met and that grants, contracts and other financial and personnel requirements are met. Goal team planning is for a five year period beginning current year+3 (for example, the plan being developed in 2006 under the PPBES process is for fiscal years 2009-2013).

Table II C 1 Programs Contained in NOAA’s Ecosystem Goal Team with their Capabilities, Associated Line Offices and their Approximate Fiscal Year 2005 Budgets

Ecosystem Goal Team Program	Capabilities	NOAA Line Offices	Budget FY-05 ($m)
Habitat	- Protect habitat - Restore habitat - Assess, characterize - Stewardship	NMFS, NOS, OAR	$88.5
Corals	- Observe and assess - Predict, warn, and respond - Research reef decline - Manage threats - Strengthen partnerships	NOS, NESDIS, NMFS, OAR	$28.7
Coastal & Marine	- Ecosystem approaches to management - Education and outreach - Science, technology and observations - Regional ecosystem integration	NOS	$264.1
Protected Species	- Pre-listing conservation - Status, listing - Recovery, conservation - Outreach, education - International coordination, cooperation	NMFS	$176.4

Fisheries Management	- Regulatory analysis, evaluation, implementation - Fishery plan development - State Partnerships - Policy development, implementation - International coordination, cooperation - Economic sustainability - Outreach and education	NMFS	$143.5
Aquaculture	- Legal, regulatory, administrative - Science, technology - Education, outreach	NMFS, NOS, OAR, NESDIS	$6.7
Enforcement	- Investigations - Patrol, inspections - Outreach, education - Management, training, support	NMFS, NOS	$44.0
Ecosystem Observations	- Fishery monitor, assess, forecast - Protected resources monitor, assess - Ecosystem monitor, assess, forecast - Economic, sociocultural monitor, assess - Data management, technology transfer - Education, outreach	NMFS, NESDIS, OAR, NOS	$339.9
Ecosystem Research	- Characterize ecosystem health - Causes, consequences of ecosystem change - Predict ecological impacts - Technology, tools - Outreach, education	OAR, NOS, NMFS	$269.4
EGT Total			$1,361.2
NOAA Total			$4,945.9

NOAA's Ecosystem Resources

Currently, NOAA has about 7,000 employees supporting EGT activities, with the vast majority assigned it its 340 field centers, offices and laboratories (http://www.st.nmfs.gov/). The largest programs in FY 05 were ecosystem observations, ecosystem research, coastal zone programs, and protected resources science and management (Table II C 1). In addition to ecosystem activities undertaken in its science and research facilities, NOAA supports a comprehensive network of cooperative and joint institutes (Table II C 2). These institutes, along with the National Undersea Research Program (NURP) Centers, Sea Grant institutions, and other cooperative arrangements, allow NOAA to leverage its assets and to engage academic partners in pursuit of ecosystem research and technology in support of its diverse mandates. Some of these institutes maintain regional focus, whereas others pursue issues of national or global scope.

Table II C 2 NOAA's Cooperative and Joint Institutes for Scientific Research Supporting Line Offices Involved in the Ecosystem Goal

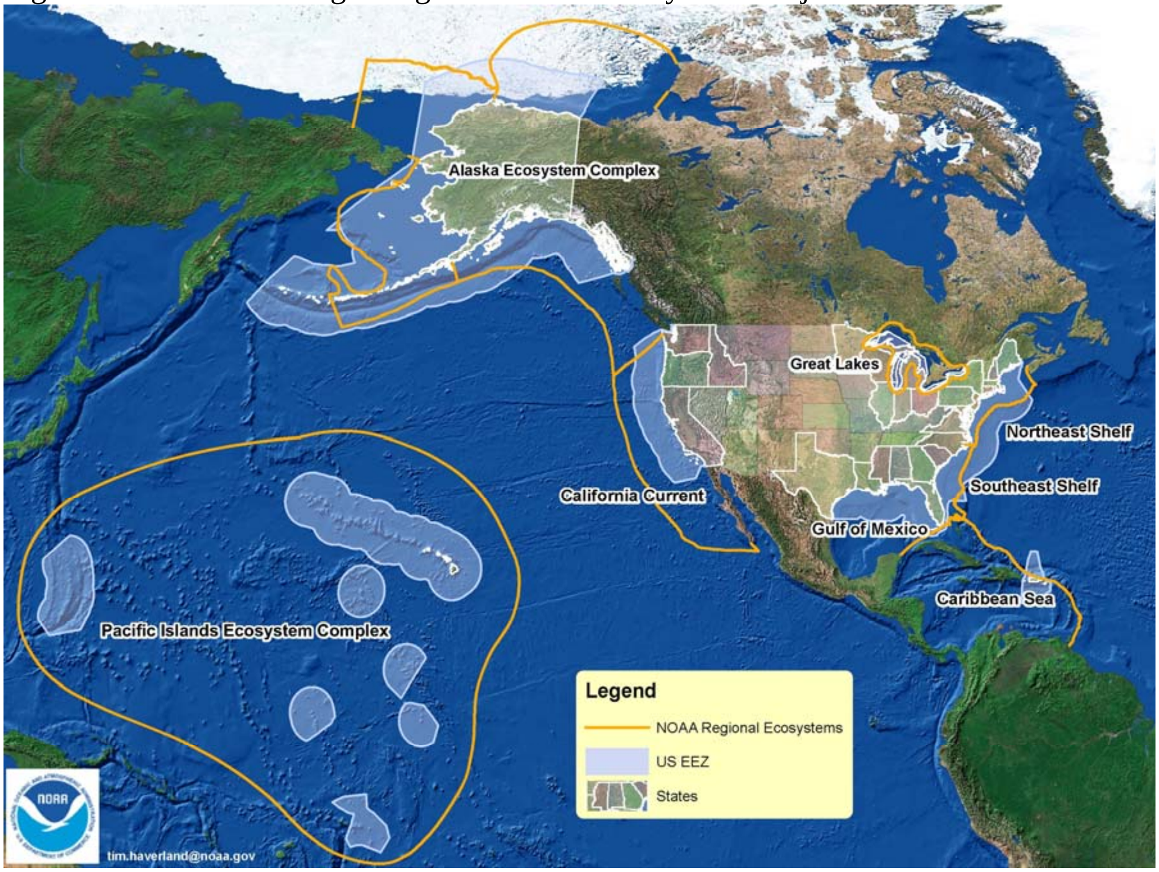
Institute – Sponsoring Line Office	Location	Primary Missions
Cooperative Institute for Arctic Research (CIFAR) – OAR	Fairbanks, Alaska	Fisheries oceanography, hydrography, sea ice, atmospheric research, climate dynamics, environmental prediction
Cooperative Institute for Atmospheric and Terrestrial Applications (CIASTA) – OAR	Las Vegas/Reno, Nevada	Weather research, climate, air quality, terrestrial ecosystems, hydrology
Cooperative Institute for Climate Applications and Research (CICAR) - OAR	Palisades, New York	Climate variability, climate change prediction and assessment
Cooperative Institute for Climate and Ocean Research (CICOR) - OAR	Woods Hole, Massachusetts	Coastal ocean and nearshore processes, ocean influences on climate, marine ecosystem process analysis
Cooperative Institute for Climate Science (CICS) – OAR	Princeton, New Jersey	Earth systems studies, biogeochemistry, coastal processes, paleoclimate
Cooperative Institute for Limnology and Ecosystems Research (CILER) – OAR	Ann Arbor, Michigan	Climate and large-lake dynamics, coastal and near-shore processes, remote sensing, marine engineering
Cooperative Institute for Marine and Atmospheric Studies (CIMAS) – OAR	Miami, Florida	Climate variability, fisheries dynamics, coastal ocean processes
Cooperative Institute for Mesoscale Meteorological	Norman, Oklahoma	Forecast improvements, climatic effects, socioeconomic effects of

Studies (CIMMS) - OAR		weather systems, regional climate studies
Cooperative Institute for Research in the Atmosphere (CIRA) - OAR	Fort Collins, Colorado	Global and mesoscale weather and climate research, cloud physics, satellite observations, air quality, numerical modeling
Cooperative Institute for Research in Environmental Sciences (CIRES) - OAR	Boulder, Colorado	Environmental chemistry, biology, atmospheric and climate dynamics, polar processes, solar-terrestrial environment
Joint Institute for Marine and Atmospheric Research (JIMAR) – OAR	Honolulu, Hawaii	Equatorial oceanography, climate research, tsunamis, fisheries oceanography, coastal research
Joint Institute for Marine Observations (JIMO) - OAR	La Jolla, California	Coupled ocean-atmosphere research, biological oceanography, marine geology and geophysics, ocean technology
Joint Institute for the Study of the Atmosphere and Ocean (JISAO) - OAR	Seattle, Washington	Climate variability, environmental chemistry, estuarine processes, fisheries recruitment
Cooperative Institute for Marine Resources Studies (CIMRS) - NMFS	Newport, Oregon	Living and non-living marine resources and their interrelationships
Cooperative Marine Education and Research Program (CMER) - NMFS	Massachusetts, Kingston, Rhode Island, New Brunswick, New Jersey, Gloucester Point, Hampton, Virginia	Resource management and marine environmental studies supporting NOAA and NMFS missions
Cooperative Institute for Coastal and Estuarine Environmental Technology (CICEET) - NOS	Durham, New Hampshire	Develop and apply new environmental technologies and techniques
Joint Hydrographic Center (JHC) - NESDIS	Durham, New Hampshire	Ocean mapping, hydrographic science, and applications
Cooperative Institute for Climate Studies (CICS) – NESDIS	College Park, Maryland	Satellite climatology, climate diagnostics, modeling, prediction
Cooperative Institute for Meteorological Satellite Studies (CIMSS) - NESDIS	Madison, Wisconsin	Passive remote sensing for meteorological and surface-based applications
Cooperative Institute for Oceanographic Satellite	Corvallis, Oregon	Ocean remote sensing and ocean-atmosphere modeling

Studies (CIOSS) - NESDIS		

NOAA has organized its activities through the EGT along eight regional ecosystems (see Figure II C 3) adjacent to the USA coasts. These regional ecosystems align physical oceanographic processes, biodiversity, and human use activities. Although to address some mission demands it may be necessary to delineate ecosystems at smaller or larger spatial scales, the regional ecosystem boundaries are a useful and appropriate basis to organize research supporting multiple management requirements. Except for the Caribbean Sea, all LOs supporting the EGT have a physical presence adjacent to each of the eight regional marine ecosystems. The importance of the physical alignment of NOAA's facilities with the regional ecosystems is discussed later in our report.

Figure II C 3 NOAA's Eight Regional Marine Ecosystems Adjacent to US Coasts



Source: Tim Haverland, NOAA.

II.D Policy Trends and NOAA's Vision for the Future

The Ecosystem Goal Team has articulated a long term vision for its activities (http://ecosystems.noaa.gov/docs/EGT_Poster_Handout_03.29.05_v2.pdf) as management founded on the interrelated nature of societal needs and ecosystem goods and services. The fundamental vision is based on developing the knowledge and understanding of ecosystem structure and processes and how these will respond to both natural and human-induced forcing.

Specifically, NOAA's vision for ecosystems includes ecosystem approaches to management, which are collaborative with more diverse groups of stakeholders, and progress incrementally and adaptively as new information emerges and a greater willingness to engage occurs among sectors. NOAA's vision includes specifying ecosystems geographically (on multiple scales depending on issues being considered), accounting for uncertainties and multiple influences on ecosystem outcomes, and balancing diverse stakeholder needs when making management decisions regarding the marine environment.

The six white papers (Murawski and Matlock 2006; http://spo.mnfs.noaa.gov/tm/) develop parts of this vision more completely for climate change, living resource management, human uses of fresh water, competing uses of coastal areas, improved forecasting of a variety of marine phenomena, and more formal and integrated marine governance institutions. The white papers emphasize that NOAA will have to expand its science capabilities and place them in a social science context, in order to serve these and other pressing ecological issues. These themes help set the "guiding considerations" formulated by the eETT below in Part III.

NOAA must meet its statutory responsibilities in a manner consistent with its enabling legislative mandates. Bills are pending in Congress for a NOAA "Organic Act," and for reauthorization of the Magnuson-Stevens Fishery Conservation and Management Act, Marine Mammal Protection Act and Coastal Zone Management Act (www.thomas.loc). Each is accompanied by considerable discussion about whether and how to include an ecosystem approach through legislative action, with the outcomes still unclear in July 2006. The Ocean Action Plan calls for high level coordination among federal agencies, and although progress is slow, the direction of change is not contested.

Developments at the state and regional ocean governance levels are also fostering wider adoption of an ecosystem approach to managing human activities. Nine coastal states have passed ocean policy legislation, developed ocean advisory councils, or have shown significant new interest in ocean affairs. In addition, some well-established regional ocean governance efforts like the Gulf of Maine Council on the Marine Environment, the Great Lakes Regional Collaboration, and the Southeast Aquatic Resources Partnership have been invigorated and discussions are taking place among governors in the Gulf of Mexico and West Coast regions. NOAA ecosystem science supports each of these efforts. Looking more broadly around federal agencies, especially those with primarily terrestrial land management (e.g., US Forest Service, US National Park Service and the US Fish and Wildlife Service) ecosystem approaches have been under development for a much longer time, with mixed results and many lessons for NOAA.

In the arena of private non-governmental organizations, there is significant interest in developing ecosystem approaches. Funding and human resources have been assigned to developing scientific research, education and communication of scientific results, development of inventory methods for species and habitats and, in some cases, linking these to patterns of use. NGOs are pushing to accelerate the pace of change through litigation and political advocacy for legislation.

The contemporary environment for NOAA's transition to an ecosystem approach features many initiatives, some start from the top down and some from bottom up. **There is not a convergence on a single ecosystem approach "end product". Rather the likely way forward will be**

incremental and adaptive, as current approaches to management take on more complex elements involving multiple drivers and issues. Protected species management, for example, is being integrated more fully into coastal zone management, fisheries management, national marine sanctuary and other management venues supported by NOAA under its diverse mandates. It is certain that ecosystem approaches will expand in NOAA's science and management; the uncertainties are about how and how fast (see Appendix 5).

Our report focuses on how NOAA can best transition its ecosystem activities to facilitate these inevitable changes. Overall, despite incomplete integration of the ecosystem science enterprise and substantial capacity gaps, it is appropriate for NOAA to provide more integrated science in the existing venues now. Both natural and social sciences, including communication of science, are critical elements at whatever scale and for whatever purpose ecosystem approaches are being developed. NOAA is already positioned to play a central role in provision of scientific support to multiple parties, but must expand and integrate its capacity for the ecosystem science enterprise, to keep pace with growing demands of government and society. This Report is intended to advance that task.

II.E Now Is the Time for NOAA to Move to an Ecosystem Approach

The US Ocean Action Plan has committed the Federal government to enhancing inter-agency coordination of its ocean activities, consistent with recommendations of the Ocean and Pew Commissions. Through its Ecosystem Goal Team, its 5-year plan and 20-year vision, and the contributions of its many staff, NOAA has set a direction towards a more integrated, ecosystem-based approach to its science and management activities. NOAA is using the EGT and PPBES process to expand from its traditional LO orientation, identifying and undertaking cross-line programs at the regional ecosystem level. Individual teams of researchers also identified the need and possibility of ecosystem-scale collaborations, and found ways to do so. Initiatives such as FOCI in the North Pacific and GLOBEC in New England have already demonstrated the feasibility and value of integrated ecosystem science. NOAA now must make these special cases the normal mode of business for assessing the status of marine ecosystems and their components, and for evaluating options for human uses of ecosystems. Some parts of this transition in science and management are underway; some will require changes of emphasis; some even changes in direction. All require greater resources because of the greater demands for science support for ecosystem-based approaches to managing multiple activities.

NOAA's own elements must collaborate effectively because no one entity has or will have all the diverse resources necessary to address the wide range of relevant ecosystem components and human activities. The collaboration must extend to NOAA's diverse stakeholders providing science capabilities, and engaged in the many and sometimes conflicting activities in marine and coastal ecosystems. NOAA has a unique role as leader in formulating and implementing a collaborative approach because of the diversity of its mandates, and can lead by example through establishment of effective collaboration within its own sub-agencies and with its stakeholders.

The transition to an ecosystem basis should maintain focus on NOAA's mandates. Each of the science enterprises currently in NOAA's ecosystem portfolio had its genesis in authorizations by Congress to expend funds for a particular purpose, e.g., fisheries assessment, coral reef assessment, marine mammal assessment, monitoring in sanctuaries, or coastal zone monitoring. Congress has provided some impetus for this ecosystem transition, amending many of these mandates to incorporate wider arrays of issues known or suspected to be affecting its trust resources. The totality of these expanding mandates is a clear recognition that ecosystem approaches to analysis and management of marine areas are required. NOAA must now lead the response to that need, which, for reasons developed through the rest if this Report, we conclude is best structured at the regional scale, and built around the core science product of regional Integrated Ecosystem Assessments (IEAs).

The rest of this Report outlines key components of NOAA's transition to an ecosystem basis for its science enterprise, for its products, and its services to clients. Section III gives the basic principles on which NOAA's transition to an ecosystem basis should be built. Section IV describes a regional approach based on Integrated Ecosystem Assessments that should be a central element in NOAA's plans for ecosystems ecosystem science. Section V outlines the capabilities that must exist nationally (V.A) and regionally (V.B), and highlights where enhancement is most needed. Section VI outlines processes by which NOAA can facilitate the transition to the proposed regional basis for ecosystem science.

III GUIDING CONSIDERATIONS

The eETT identified three Guiding Considerations from which its findings, conclusions, and recommendations flow. Specifically:

- NOAA science and management needs to take account of **environmental forcing** on the ecosystem properties for which it is steward;
- NOAA science and management needs to take account of **how human activities affect the ecosystem** properties for which NOAA is steward – and how those ecosystem properties affect the wellbeing of citizens socially, economically, and culturally; and
- Because of the two preceding points, NOAA science support for decision-making must be **integrated across ecosystem components and** across its role **supporting** management **of different human activities**.

NOAA's present set of ecosystem programs and mandates does not constitute a program that produces the full scientific basis needed for an EAM. These existing elements were developed in response to a wide range of objectives, and simply aggregating them will not result in an effective and sustainable EAM. However, there are many important existing components that will form the basis of a program and others that will need to be modified or significantly changed. The existing program elements will need to come together to develop a shared vision that will put NOAA's ecosystem program elements on a new path towards a sustainable ecosystem science enterprise in support of EAM.

In addition, transition within government must address a variety of institutional and legal realities that affect the ease and pace of change. The expectations and established practices of both those being served by the agency and those providing the services from within the Agency must change, with support of education and training. The findings, conclusions, and recommendations in this Report acknowledge these realities, and take them into account.

III.A Environmental Forcing

A key part of an ecosystem approach to management is taking account of the effects of the physical, geological and chemical environment on biological communities and the implications of this forcing for sustainability of human activities in marine ecosystems.

The environment directly impacts marine ecosystems in three general ways:
(1) Primary production; is affected by, *inter alia*, chemical nutrients, dissolved carbon, light, ocean currents, upwelling, and near-surface oceanic mixing:

(2) Biology of marine animals; affected by environmental characteristics including, *inter alia*, temperature, bottom type, frontal activity; and factors affecting the mobility of the animals.

(3) Ecosystem health; affected by, *inter alia*, chemicals, sediment and microbes introduced into the ocean,

Time series of populations and ecological communities show substantial changes linked to ocean-atmosphere variability (El Niño cycles, the North Pacific Oscillation and the North Atlantic Oscillation), as well as smaller and less sustained variations on more localized and transient scales. Pollution and habitat destruction impact nearshore and estuarine habitats, with consequences that propagate offshore.

To properly manage marine resources and ecosystems it is necessary to observe the important environmental forcings, develop management strategies that accommodate them, and strive to include them in the models that will eventually help to predict ecosystem change. To account for environmental forcing in managing marine resources and ecosystems the ecosystem science enterprise must strengthen both **knowledge of the structure and dynamics of climate variability <u>in the ocean</u> so that observed ecosystem changes can be properly attributed to their causes and eventually predicted and the mechanisms by which environmental forcing affects different biological communities must be better understood in order to identify management strategies which accommodate them appropriately.**

III.B Role of Human Actions

The growth and settlement of populations in the coastal zone, in conjunction with the associated economic activities, constitute a set of major forcers on coastal and ocean ecosystems. Humans' activities often lead to, *inter alia*, the degradation and loss of natural habitats, overexploitation of fishery and other living marine resources, added waste disposal and pollution discharges to water bodies, invasive species, pathogens, toxic contaminants, harmful algae blooms, increased noise in the marine environment, and increased vulnerability to coastal hazards. Land use practices may increase sediment loading in the nearshore zone, and atmospheric transport can result in deposition of pollutants far from their sources. Some of these effects are well understood (e.g., nitrate-rich runoff from agricultural activities stimulate phytoplankton growth) whereas others are not (e.g., viruses in sewage treatment outfalls that can be transmitted to marine species).

In light of these conditions, the US Commission on Ocean Policy (USCOP 2004) expresses the concern that:

> *Our failure to properly manage the human activities that affect the nation's oceans, coasts, and Great Lakes is compromising their ecological integrity, diminishing our ability to fully realize their potential, costing us jobs and revenue, threatening human health, and putting our future at risk.*

An ecosystem approach to management is needed to address the full impacts of both local and global human activities in order to develop effective policies.

III.C Integrative and Scientifically Informed Management and Policy

NOAA produces high quality science advice for management at multiple spatial scales, and varying across regions. Section II underscores that management and policy will become even more dependent on science advice in future. Currently management itself is not integrated, and the willingness of managers and decision-makers to seek and apply science advice varies among regions and industry sectors. However, by managing each human activity in the context of the larger ecosystems, advice provided to one client on one management or policy issue will necessarily include considerations also addressed in advice to other clients on other issues. Thus, not only will users become more dependent on the ecosystem advice developed by NOAA, provision of such advice will become more complex. Moreover, mandatory NEPA provisions require both disclosure of environmental impacts (including cumulative effects) and measures to mitigate such impacts, thus making NEPA a stepping stone to broader application of an integrated ecosystem approach to managing human activities in marine ecosystems. All these considerations will affect how NOAA's ecosystem science best supports management and policy, but none negate the growing need for such support, and for education in where and how to seek the support.

Thus, the scientific enterprise must be mindful of basic and applied management and policy, and be oriented to support decision-making. Advisors to different clients must communicate effectively with each other, and encourage those receiving the advice to communicate as well. The advice must be packaged at the scale appropriate to the local or regional management body, and must be perceived as non-partisan by competing interests in the management issues. Moreover, as the advice to each client addresses more ecosystem considerations, inconsistencies in advice to different clients would damage both the credibility of the advice itself and the effectiveness of any decisions based on it. The favored approach in this Report allows all participants in a management process to have access to and input into the development of scientific advice for management yet ensures that the provision of scientific advice is policy relevant without being policy-directed. Effective advisory processes can allow significant interactions between the scientists and the interested parties so that there can be learning about the scientific basis for all options, while preventing management and stakeholders from influencing the science results and advice.

III.D Transition Realities

Transition toward EAM is a process already underway (and must continue in the longer term.). Making a transition towards supporting EAM based on investment in NOAA's ecosystem science enterprise is a process akin to turning a large ship – inertia must be overcome without compromising stability. Absent a crisis or strong legislative mandate and facing limited resources, change can only come by constant pressure applied in the direction of the turn. In NOAA this pressure is being applied by leadership at the top and by experts throughout the Agency. Reprogramming of support for ecosystem science on which to prioritize missions and resources is incrementally turning the NOAA approach. Many things may affect this ability to expand NOAA's scientific capacities, including future budgets, potential litigation and legislation, and extent of public support.

It will not be possible for NOAA to sustain a credible ecosystem science enterprise, and support mandates with science advice in an ecosystem context, without significant increases in resources. This will require strong support for the changes proposed in the rest of this Report from both direct clients of the NOAA ecosystem science enterprise and the general public. Care must be taken, though, to ensure that the public and especially clients of NOAA ecosystem science understand that the support they will get in future may be different from the support that they have gotten from NOAA in the past. Close cooperation with the clients will be needed so they can continue to fulfill their own missions and mandates, take advantage of the changes in support from NOAA to make appropriate changes in their own activities, and make more integrated management in a broader ecosystem context a reality.

Moreover, many scientific experts inside NOAA perceive their role as serving a particular constituency. NOAA experts need to see their own role in this new ecosystem science enterprise, making the creation of an ecosystem culture within NOAA a critical step. We found strong support among NOAA staff for a greater ecosystem focus for NOAA science. To keep that support, it will be necessary to ensure the staff members are part of the process of change, rather than just some of the "objects" which are moved around by others.

IV REGIONAL ECOSYSTEM ASSESSMENTS AS A CENTRAL FOCUS FOR THE ECOSYSTEM SCIENCE APPROACH

IV.A A Development Plan for Ecosystem Science Is Needed

Ecosystem science, assessments, and advice support the current management and regulatory responsibilities of NOAA and needs of other clients. Today the broader ecosystem contexts for this science are being achieved through incremental changes; adding new ecosystem considerations to "business as usual." Examples of such changes can be found throughout the assessment and advisory activities of NOAA, as environmental forcers are added to assessment models, or bycatch estimates to advice, but much remains to be done. However, even those engaged in the incremental changes have no clear idea how far this incremental journey will go; or what is the adequate number and type of ecosystem increments to an assessment or advice. It is premature to make definitive statements about how much ecosystem content is "enough." because globally the scientific community is learning by doing. However, it is also impossible to plan or organize for a successful future without a clear vision of what success looks like.

In order to guide development of an adequate ecosystem science enterprise, NOAA should develop an explicit description, based on current knowledge, of what it sees as adequately "ecosystem rich" assessments and advice. This does not have to require specifying exactly which ecosystem forcers and species interactions to include in assessments, or exactly which ecosystem impacts of individual human activities will be considered in advice. It does require being explicit about the criteria that are to be used to select the forcers, interactions, and impacts to include, and the criteria to be used to decide which relationships are worth including as increments to "business as usual". It also requires using the current knowledge of where current assessments and advice fall short as bases for informed management, of where current knowledge is underutilized in assessments and advice, and of what current uncertainties and unknowns will be addressed by research currently "in-stream." The descriptions should include the major incremental steps that can be foreseen at present and an expected timeline for being able to take these steps. They should be developed for all NOAA LOs concerned with ecosystems, not just NOAA Fisheries. Such an ecosystem developmental plan is not needed for each individual activity (each stock assessment; each sanctuary), but the greater the level of disaggregation in the planning, the more informative the exercise would be. Brought together, these descriptions should determine where NOAA science is currently evolving. This is a precursor to identifying where further change is most necessary.

RECOMMENDATION 1. NOAA should develop an explicit description, based on current knowledge, of what it sees as adequately "ecosystem rich" assessments and advice for the current products of its ecosystem science enterprise.

RECOMMENDATION 2. NOAA should prepare an "ecosystem development plan" for its assessment and advisory activities within each Region. These plans would lay out the major incremental steps foreseen for increasing the ecosystem content of these activities, and the expected timelines, in a proactive but not proscriptive manner.

RECOMMENDATION 3: When the regional "ecosystem development plans" are completed, they should be assembled into an overall vision of where NOAA ecosystem services and science are going nationally.

This consolidated plan should be an informative basis for analysis of gaps, redundancies, and synergies and provide insights into the similarities and differences in what the LOs see as "the ecosystem approach".

There is little cause to expect that incremental but independent development of component-specific assessments and sector-specific advice will converge on a consistent view of ecosystem status and dynamics, and provide all the information that each management sector needs to know about the activities and effects of the others. Some form of integrated priority setting and Integrated Ecosystem Assessment at regional scales will be a necessary step as NOAA and its partners move to an ecosystem basis. They will not emerge from separate LO activities; they have to be planned and produced as an activity in themselves.

IV.B Integrated Ecosystem Assessments are a Useful Framework for Coordination

Integrated Ecosystem Assessments (IEAs) are an effective vehicle to convey information on the status of ecosystem health and to evaluate the impacts of current and proposed human activities. IEAs bring information sources together – organized geographically and supporting a diverse set of stakeholder needs. Ecosystem assessments are intended to do the following:

- Compile and archive all relevant data sets for a defined ecosystem, including physical oceanography, atmospheric, climatological and weather observations, human use patterns and statistics, abundance and distribution of biological resources.
- Report on current conditions and trends in relevant data time series of physical, biological and human use information
- Synthesize time series information to link important ecological outcomes to changes in relevant climate and human use drivers, as a basis for forecasting
- Evaluate data time series to provide suites of key indicators of ecosystem state (status), and utilize time series data and modeling results to propose reference levels for safe and for desired states of marine ecosystems
- Forecast the relationship between state indicators and pressure indicators (e.g., pollution, climate change, fishing-related removals, coastal development, etc.) in order to inform the development of management options for marine ecosystems.
- Provide periodic ecosystem assessment updates to inform the managers, stakeholders and the public on the state of marine ecosystems and management options to achieve societal goals and targets, including social science aspects relevant to decision making.

An IEA has several advantages over relying on the incremental expansion of component-specific assessments and sector-specific science support in order to converge on an integrated ecosystem approach in support of management and policy. Inherent in conducting an integrated ecosystem assessment is devoting greatest effort to assessing the status and trends of those components of the ecosystem (including humans) most important to its integrity. Features important to each specific human use which NOAA (or another client of NOAA ecosystem science) is mandated to regulate also receive direct attention in the integrated assessments. The features are assessed relative to the overall ecosystem status and trajectory, giving the desired ecosystem context for regulating individual activities, and providing insight into potential conflicts between different uses of the ecosystem. Both allocation of science resources and quality of the science products are better when the assessment focuses first on the ecologically most significant features and works outward towards the components of the ecosystem where statutes or regulations require additional directed evaluation.

Providing information through IEAs is not only more efficient than compiling all assessments sectorally, it also allows for scientific integration and exploration of alternative hypotheses for observed changes that may be difficult to explain when assessments are done piecemeal. Compilation of IEAs is inherently multidisciplinary and requires collaboration across LOs and with other agencies. The process of developing IEAs requires a governance system that fosters such collaboration, and should include stakeholder-relevant information as well as outcomes for the various sectors and interests under alternative management scenarios. This facilitates subsequently bringing diverse agencies and stakeholder groups together to consider tradeoffs inherent in making marine resource management decisions.

Given the considerations above, **Integrated Ecosystem Assessments are key components of NOAA's ecosystem science enterprise. Their production should be the priority for NOAA and its science and management partners.**

RECOMMENDATION 4: NOAA's Ecosystem Goal Team should lead and participate in the development of Integrated Ecosystem Assessments (IEAs) for all ecosystems in which NOAA has a statutory or trust responsibility. Where possible, NOAA should use multi-agency venues, including its participation in the Integrated Ocean Observing System (IOOS), to foster the production of IEAs.

Integrated Ecosystem Assessments and Integrated Management approaches are inherently spatially based. This will require some re-orientation of classical fisheries assessments, which usually gave little attention to spatial pattern within the range of the stock being assessed. IEAs must work from the spatial area of interest, assessing the populations, physical/chemical systems, human activities, and the corresponding interactions among these at the specified scale. An assessment may still estimate the status and trends of selected ecosystem components, such as exploited populations, but the integrating aspect of the assessment is the area wherein the ecosystem components interact. Not only must IEAs consider relationships and patterns of ecosystem components on region scales, but they must be designed so finer-(and occasionally larger-) scale resolution of trends and interactions can be extracted when needed to address issues such as local depletion of fish populations, effects of human activities on corals, interactions of fisheries with protected species, and coastal or estuarine effects of human activities.

RECOMMENDATION 5: NOAA leadership should commit to supplying ecosystem-science support on a <u>regional</u> basis.

This will require collaboration between LOs and other agencies to coordinate science and management activities in several sectors. As a preliminary step, NOAA should organize a forum for all LOs, federal, state and local agencies concerned with, or able to support, coastal and marine management, regulation and policy, as described in Section VI.D. Objectives would be sharing information and plans, developing a common scientific basis for management, and building cooperation between organizations.

RECOMMENDATION 6: NOAA should specify that the eight regional ecosystems it has defined should be the starting points for coordinating regional ecosystem science and assessments.

These ecosystems have direct correspondence to the Fishery Management Council activities, which NOAA must continue to support as one of its primary responsibilities, and have adjacent NOAA facilities that can provide centers for coordinating preparation and dissemination of IEAs.

V WHAT CAPABILITIES ARE NEEDED?

Based on the context, guiding considerations, and the central role of Integrated Ecosystem Assessments, the eETT identified three classes of core capabilities that must be present in each region to comprise the necessary ecosystem science enterprise. Several additional capabilities do not need to be replicated in every region, but must be available as needed for the regional enterprises to draw on. All of these capabilities need to be enhanced if NOAA is to implement the changes needed to position its ecosystem science enterprise to meet its mandates in the future and support an ecosystem approach to management.

V.A Core Capabilities Required for Integrated Ecosystem Assessments

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.

RECOMMENDATION 7: NOAA must formally structure those partnerships that are important to the science capability to perform regional integrated ecosystem assessments, in order to ensure that all partners are accountable for their contributions to the assessments, and that the integrity of the science content is assured.

V.A.1 Sustained Observations

Time series observations of the status of ecosystem properties, environmental conditions, and human activities will remain essential because of the complexity of ecosystems and the unprecedented perturbations from climate variability and change, habitat change, resource extraction, invasive species, and pollution that they face. Our increasing ability to model and predict variability in the ecosystem will not soon replace the robustness and clarity of interpretation afforded by sustained measurements.

The most numerous ecosystem time series in the U.S. are those collected by NOAA and states as the basis for assessing and managing fisheries and protecting endangered species, including fishery-independent surveys and monitoring commercial and recreational catches. Data on habitat status and trends are also collected as part of coastal-zone and protected-area management. Academic and nongovernmental organizations support scattered ecological time series not necessarily related to management. Data from satellites provide key information on physical and biological oceanographic features. The complexity of this network of observations from different sources and of differing and sometimes changing accuracy and precision means that the resultant data have yet to be integrated into a unified data system.

As management shifts toward an ecosystem approach, sustained observations must expand to better capture interactions among species within the ecosystem and with factors that impact ecosystems. Regional NMFS centers have proposed initiatives, such as ones within IOOS that would greatly expand the comprehensiveness of NOAA's monitoring beyond managed and protected species. The US climate observing systems also must augment monitoring programs that are focused on ocean impacts on the atmosphere with ones focused on effects of climate variation in the ocean upon marine ecosystems. Satellite measurements of the physical characteristics of habitat (including the water column), of the processes that change habitat, and of the phytoplankton foundation of the food web are essential sustained observations. NESDIS must recognize this importance and maintain in operational satellites the ability to accurately observe key oceanic variables like sea-surface height and temperature, surface wind, and ocean color.

The most rapidly changing impacts on marine ecosystems are from human activities that have direct social, cultural, and economic impacts. NMFS and NOS both recognize that monitoring changes in human populations and activities is central to their mandates, and they have added several social scientists to their staffs during the last few years. However time series data that will support investigations of human activities that impact habitat, pollute, and overexploit marine and coastal natural resources are also needed. Gaps in time series data on non-market uses and values of ecosystem resources; on social perceptions, attitudes and values; and on local laws and regulations that govern the use of land and other coastal ecosystem resources all must be closed.

Observations of representative indicators of all key elements of the ecosystem should be expanded and sustained. These elements include: managed species and the unmanaged species that interact with them; geological, physical, chemical and biological aspects of habitat; the climate processes affecting habitat and behavior; and economic, demographic, social and policy factors that affect habitat, resource extraction, and the societal benefits of the ecosystem. Identification of measurements that describe functional parts of, and interactions within, the ecosystem should be incremental and closely connected to analyses and modeling of status and trends. <u>To ensure that this happens, the Ecosystem Goal Team should play an active role in the evolution of NOAA's ocean observing system.</u>

RECOMMENDATION 8: The Ecosystem Goal Team should lead all LOs and Goal Teams in developing a national plan for an expanded regional ecosystem monitoring capability. For example, expertise within the Climate Observing System should be exploited to develop improved sustained observations of ocean climate variability that affects ecosystems.

RECOMMENDATION 9: The NOAA social science plan should specify more comprehensively what social science monitoring data are required for managing human activities that affect, or depend on, the use of marine ecosystems, and develop a strategy to ensure such data are available.

RECOMMEDATION 10: NOAA should develop a national plan to archive, organize, and distribute all the types of data needed to track, forecast and understand change in regional ecosystems. Starting from now-separate managed-species and climate data, effort should be made to gather and organize existing socio-economic data collected by all sources, observations of unmanaged species and inter-species interactions made by NOAA and others, and all available descriptions of habitat.

V.A.2 Analysis of Status and Trends in Space and Time

Extracting information from sustained observations requires analyses to determine the status and trends of the components being observed. For ecosystems, the analyses must include the variations of different species, habitat parameters, environmental and human factors. NOAA takes the lead in areas like managed and protected species and climate whereas in other areas, like economic factors or near shore habitat, states and other agencies have significant roles. In what follows we address the mix of analyses that must be included.

Population Dynamics

Stock assessments of commercially important species have involved data collection, research, statistical analysis, and forecasts. Over the past 20 years, stock assessment has evolved to use increasingly complex population dynamics models to integrate data sources and biological information. Also population viability analyses are frequently conducted to assess the risk of eventual extinction for protected species. There is also increasing interest in multi-species and ecosystem models to supplement single species investigations, addressing predator-prey relationships of particular species, mass-balance status of major functional groups, or even ecosystem models representing dynamic physical/chemical, biological and sometimes bioeconomic components.

The complexity necessary for integrated modeling and assessment of regional ecosystems and selected subcomponents (e.g., managed species) depends on the societal goals that management and policy are supporting, and the nature of the threats and activities being managed. For abundant populations with few interactions with other species, simple models may suffice. Single species assessments are likely to remain to primary tool for fisheries management but will be supplemented by multi-species and ecosystem modeling to address key questions about interactions.

Habitat

In marine fisheries assessments habitat usually receives little attention. However, assessments of habitat degradation or enhancement have been important for diadromous, estuarine and coastal species. In integrated regional ecosystem assessments, habitat dynamics become a central component of the assessments, forming a foundation for the biological community changes and mediating many of the human interactions with the rest of the ecosystem.

To analyze the dynamics of habitat over space and time physical and biological oceanographers and marine geologists have to interact regularly and have current data on the state of ecosystem components in which they specialize. To link the dynamics of aquatic habitats to the integrated regional assessments, these specialists have to interact routinely with population dynamics experts as well the supporting researchers in fields like marine botany, fish behavior, community ecology, and animal physiology. To varying degrees all these experts need to reorient their thinking and analytical approaches to have a greater spatial emphasis. Finally, the experts on the habitat components need regular interaction with experts working on the levels and spatial patterns of human activities, so that the assessments can capture the habitat-mediated impacts of the human activities.

Social and Economic Factors

Applying an ecosystem approach to management of coastal and ocean resources requires an understanding of the mechanisms that drive human behavior, as well as more specific knowledge of how humans use marine ecosystems directly and indirectly for social, cultural, and economic benefits. Some of the more salient factors are demographic (population size and structure), social (perceptions, attitudes, values), economic (markets, production, consumption), and governance (laws, regulations, processes). To properly investigate these influencing factors, not only must data gaps be filled but NOAA must address gaps in research expertise in areas of demography, sociology and anthropology, political science, and economics – expertise that focuses on attempting to understand the spatial and temporal variations in human activities that affect, and that are affected by ecosystem resources. NOS and NMFS have become more active in these fields through the work of centers like the Coastal Services Center, the NMFS Economic and Social Programs, and collaborations with universities, but these programs need substantial augmentation to contribute fully to the integrated regional assessments. Specifically, NOAA should have the following core analytical capabilities for assessing the status and spatial and temporal variations of human activities in each region:

- Social science capacity to analyze the spatial and temporal variations in the uses of the principal ecosystem resources (e.g., land use, extraction of living marine resources, recreation and tourism) in each region;
- Social science capacity to assess the market and non-market value of human uses of, and the natural services of ecosystems in each region;
- Social science capacity to assess the benefits and costs of protecting and/or restoring ecosystem resources (e.g., habitat, marine mammals) in each region;
- Social science capacity to assess the sociocultural values of the uses of ecosystem resources and services in each region.

RECOMMENDATION 11: The capabilities to analyze status and trends in populations, habitats, and human activities need to be sustained and expanded at the regional scale.

V.A.3 Integration and Forecasting

Much of the science support for management is needed to forecast the trajectory of ecosystems under different scenarios for management actions, environmental variability, and human actions. Such projections are made with models ranging from conceptual, through statistical and theoretical. All approaches require integrative studies and forecasts to support an ecosystem approach to science and management.

Physical-Chemical-Biological Interactions

For some individual marine populations, assessments and management strategies are beginning to take account of environmental forcing. However understanding of causes and consequences of extreme weather, climate variability, pollution, and habitat change is still far from complete. Because climate variability is predictable for many months, its impacts are particularly important for forecasting ecosystem change and assessing management risks. As management becomes increasingly accountable for the status of habitats of species as well the populations, there will be increasing need to model and explore scenarios of how abiotic and biotic components of habitat may change as part of, or in response to, natural or anthropogenic changes in the ocean's physical, chemical, and biological features.

Combining models that are used to predict ocean climate variability with biological models presents no conceptual difficulties but there are three fundamental hurdles to be overcome. First, the spatial resolution of ocean climate models must be increased substantially to describe the small-scale processes, like eddies, fronts and upwelling that affect biological communities. Achieving this will require a commitment by climate modelers to address the issues important to marine ecosystems. Second, as biology is added to climate models the complexity grows dramatically and the need for empirical information to establish interaction rates grows commensurately. This is a problem for all ecosystem models and some fundamental and very creative research on how to use observations to train these models is required. Third, many of the processes and linkages between ecosystem components are neither recognized nor understood. Processes that regulate community structure and composition, for example, change in yearly to decadal time scales, and our inadequate observing systems do not provide sufficient insights to develop numerical models of these processes.

The large range of scales and regionally important processes that physical-chemical-biological models must encompass should be dealt with using a two-pronged approach. First, a center of experts in large-scale climate modeling and forecasting, such as Geophysical Fluid Dynamics Laboratory, should expand basin-scale physical-climate models to include chemical factors and the lowest trophic levels. Then different local models should be nested within this basin-scale model to describe hundreds of kilometers of coast at higher resolution or to focus on specific protected areas, estuaries or other features of localized interest. The basis for such regional and local models already exists in portfolio of the Coastal Services Center and at various academic institutions.

Biological Components

Integrated assessments attempt to capture the interactions that occur in the regional ecosystems, rather than viewing the dynamics of each population in isolation. To further develop such assessment tools requires teams of experts with excellent quantitative skills and knowledge of oceanography, population dynamics, community ecology and other fields. They need to interact regularly to share approaches and concepts, and access to high level analytical tools.

A major function of the integrated assessments will be for exploring scenarios to investigate the sustainability of different combinations of human activities in the same area or how different management options may perform under a range of hypotheses about future states of nature. These uses all involve not just assessing the current status and recent trends in the ecosystem components and interactions, but forecasting future trajectories of the ecosystem components and benefits to humans under different hypothesised scenarios. Such forecasts will be highly uncertain and must be tested for robustness to many assumptions. Capacity to conduct such modeling must be increased, and the experts in ecosystem modelling must work with experts in economic modelling and forecasting, as well as ocean climate forecasting.

Human Uses of Marine Ecosystems

As the ecosystem approach to management is applied to coastal and marine ecosystems, there will be increased demand by managers for spatially- and temporally-dynamic models of human activities that are explicitly linked to the natural components of those ecosystems. The integration of human activities with the biological, chemical and physical components of marine ecosystems will face many of the same modeling challenges to be faced by experts in population dynamics and oceanography in terms of complexity and resolution. To support EAM, bio-economic and demographic models will need to be nested within larger and more complex ecosystem models, and linked dynamically to key ecosystem components. Bioeconomic models of fishing activity, for example, can be linked to models of climate variability to demonstrate how climate-driven changes in fish resources may affect fisheries and fishing communities. Because the feedback does not necessarily stop with the fishing community, the bioeconomic model could be linked to models of land use and other human activities in coastal watersheds – which, when varied, will affect the coastal environment in different ways.

For an ecosystem approach to be implemented in the management of any human activity, knowledge is needed of how that activity changes the ecosystem in which it occurs, the consequences of the changes, and if needed, how to mitigate the effects. In assessing **impacts of human activities on the ecosystem,** knowledge of ecosystem effects of even well-studied human activities such as fishing and coastal nutrient enrichment is still incomplete, and findings are hotly debated among experts. Studies of the ecosystem effects of many other human activities in the sea, such as ecosystem effects of sound due to seismic exploration, shipping and military uses, are still in their early stages.

There have been few formal tests of the **effectiveness of specific management measures** at keeping the impacts of a given human activity on marine ecosystems sustainable while allowing extraction of social, economic, and cultural benefits. The data bases and analytic and modeling tools to conduct such performance evaluations of management measures to mitigate ecosystem effects of human activities, and to function in complementary ways in integrated management, are all currently inadequate. This is another essential capability for NOAA's ecosystem science that requires augmentation.

RECOMMENDATION 12: NOAA should expand capacity in forecasting trajectories of ecosystem components under different hypotheses for environmental and anthropogenic forcing and in linking these forecasts to potential consequences for resource users, coastal residents, and management options**.**

Forecasting is necessary for provision of integrated ecosystem advice for policy and management. There is evidence that there is some predictability on at least medium-term time scales, but the forecasts will be highly uncertain, and management and policy need to be informed of the nature and implications of the uncertainties.

V.B Additional Capabilities Needed in NOAA to Deliver Effective Ecosystem Science

NOAA needs additional capabilities to deliver effective ecosystem science. This section addresses capabilities that do not need to be reproduced in each region, either because they are too exploratory for expansion or because that centralization is needed for efficiency. These capabilities might be successfully developed in a few Centers of Specialized Expertise where a critical mass of personnel and equipment could be developed or where the environment – human resources and partnering institutions – are especially favorable. Further investigation led by NOAA EGT could reveal whether other types of centralization would be beneficial to NOAA's ecosystem science enterprise.

V.B.1 Building New Tools (Modeling and Forecasting)

Contemporary single-species assessment models allow stock-specific experts to take a flexible modelling framework and adapt it to the biological traits and information strengths and weaknesses of the specific stock being assessed. Development of such flexible analytical models was a highly specialized task, done most efficiently by a small, skilled team of experts, with an eye to routine use of the resultant assessment modelling tools. The complete toolbox of assessment methods was developed with such an approach, and has served both the broad NOAA fisheries assessment and the wider community of clients of the assessments well.

A similar approach can be developed for the necessarily complex ecosystem assessment and forecasting tools. Each regional center must have the expertise to adapt, apply and interpret such models. However development of ecosystem assessment and forecasting tools that are reliable enough to be credible and flexible enough to be useful will require a set of world-class experts dedicated to the task of tool development. Co-location would be important to speed progress and obtain synergies among different experts, and a critical mass is needed to ensure that new ideas get a rigorous examination prior to adoption.

These experts also would need first-hand familiarity with the real-world problems faced in each region, as they undertake the ecosystem assessments and scenario forecasting. Such experience is necessary to avoid developing models either divorced from application or tailored to a set of issues unique to a single region. Experts in the Center of Specialized Expertise must have regular interactions with the regional experts adapting and using the tools and the regional groups need some presence in the periodic assessment reviews of these centers. Such interactions both reduce the risk of development drifting away from useful application and facilitate uptake of innovations by regional experts once innovations are validated.

Similarly, new instruments are needed to monitor the ocean and components of the ecosystem, as well as to probe specific interactions among species in an ecosystem. For example, new methods are making large-scale in-situ monitoring cost effective and advances in genetic and biological techniques are opening new possibilities for observing marine communities. Such instruments will best be developed and tested in Centers of Specialized Expertise, with strong ties to academic and other expertise. It will be essential that these experts work closely with regional experts from multiple regions to keep products broadly useful and to ensure rapid uptake of technologies.

V.B.2 Develop Social Science Methods for Linking Ecosystem Science to Governance

Governance processes produce government policies, regulations, and incentives: the principal mechanisms for managing human behavior. By encouraging certain behavioral patterns and discouraging others, governance is a matter of central importance to managing human behavior in an ecosystem context. To implement an ecosystem approach to management, experts must apply the common tools of governance and socio-economic analysis to analyze how government policies, regulations, and management services are produced, and to ask what conditions lead to government successes and failures. With such analysis and understanding, it is possible to prescribe ways to correct the obstacles in the public sector that lead to failures of government processes and policies. These obstacles are expected to be common when governments are faced with the complex trade-offs inherent in ecosystem approaches to integrated management.

It will also be necessary to increase capacity to obtain useful information on public priorities and preferences that can be used in EAM decision making, both through greater use of opinion polls and general attitude surveys on ecosystem resource issues, and more labor-intensive ethnographic fieldwork to provide in-depth assessment of values and the degree to which they are strongly or weakly held. One or more Centers of Specialized Expertise should be formed to develop the social science (political science, public administration, or legal) capacity to assess how government (through its laws, regulations, processes) influences the uses of ecosystem resources and services, to diagnose sources of governance failure, and to identify the necessary and sufficient conditions for producing successful EAM policies.

V.B.3 Understanding Society and its Response to Changing Ecosystem Components

Human populations both affect the status of marine ecosystems and respond to changes in the status of marine ecosystem components. Changes in the natural components of coastal and Great Lakes ecosystems will likely induce human responses that have significant consequences for population size and composition, types of economic activities, and distribution of incomes in coastal areas. Other responses, such as in perceptions, values, laws and other institutions, also shape the overall well-being of society and humans attitudes towards the environment. These human responses tend to occur over large spatial and long temporal scales and, therefore, are best examined by a large, diverse community of scholars. The expertise required for such investigations include demography (population size and structure), sociology (perceptions, attitudes, values), economics (market and non-market outcomes), and political science and law (laws, regulations, processes). Centers (physical and/or virtual) of Expertise in the spatial dynamics of human responses to ecosystem components should be formed to develop and apply tools for analyzing the large spatial and temporal scales of human responses to changes in the natural components of large marine ecosystems.

V.B.4 Ecosystem Structure and Function

All regional centers would be expected to conduct high-level process-based research on aspects of ecosystem structure and function important to understanding the dynamics of the regional aquatic ecosystems and the impacts of human activities on them. However, a Center focusing on global aspects of these issues and on synthesis of the rapidly expanding knowledge of ecosystem structure and function is essential for several reasons. Findings about specific ecosystems need to be viewed in more general contexts and by independent minds, so the features that emerge as crucial to specific aquatic ecosystems get integrated appropriately into the more general conceptual and operational frameworks in which NOAA scientists and partners are working. Another reason is the sheer rate of growth of this field internationally, such that dedicated experts are needed if NOAA is to stay current with developments. Yet another reason for such a Center is that implementing an ecosystem approach as the core of NOAA science's service to applied clients will require triage – selecting specific parts of the ecosystem on which to focus effort both in research and in assessment, modeling, and advice, and giving less attention to the other parts. Whenever applied science is selective about what receives focus and what does not, the science is vulnerable to criticism that the choices were wrong. For NOAA's choices to be credible, they must be informed by a full mastery of developments in ecosystem science nationally and internationally, and an ability to justify regional differences in choices within a consistent national context.

The Centers of Specialized Expertise in ecosystem structure and function would have a mix of disciplinary experts from ocean physics to biological systems. Their unifying traits would be interdisciplinary thinking and familiarity with the needs of the users of NOAA science. The former would ensure that the groups would focus appropriately on those features of ecosystem structure and function that are most important for management. The latter would ensure that the centers did not let interesting theoretical and conceptual challenges take their efforts so far from applications that their insights and discoveries could not be used to improve the support provided to the users of NOAA science.

V.B.5 Ecosystem Impacts of Specific Human Activities

There is a need for increased knowledge of how human activities affect marine ecosystems, and how effective specific management measures are at keeping human uses of marine ecosystems sustainable. Much of the associated research is most logically done in regional centers, integrated with implementation of management plans, monitoring compliance with the plans, and assessing the state of the ecosystem in the areas where the activity is occurring. However, the knowledge acquired will have broad implications for other regions, and synergies will be gained by combining the results of different case-specific studies. A Center of Specialized Expertise in impacts of specific human activities could develop methods and approaches for assessing and mitigating these effects, accumulate knowledge, communicate emergent insights, and provide specialized expertise back to regional centers. The latter role would be particularly helpful in highly specialized fields such as the effects of introduced sound on marine organisms, and in assessing effectiveness of technical or economic management instruments.

V.B.6 Technical Analyses (Contaminants, Toxicology, Etc.)

NOAA maintains a number of specific programs dedicated to monitoring and/or assessing toxic contaminants in the marine and coastal environment, their effects on biota, and implications for humans (Appendix 6). Although these programs address specific issues and circumstances in non-point source pollution monitoring, seafood safety surveillance, and broader ocean and human health, it is nevertheless appropriate to examine them to determine if there would be synergies and gains in efficiency from reorganization or central coordination. These programs require state of the art facilities, access to expensive testing equipment and exacting procedures, and some centralization of analysis capacity is probably warranted. The centralization should be tempered by the need for multiple site-redundant capabilities to assure that if one critical facility is disrupted, the critical functions are maintained, as was the case after Hurricane Katrina destroyed one such facility. Further, assessment of toxicology and contamination programs in NOAA should be conducted with respect to their organization and functions to provide for essential services in support of its many trust missions, including the Oceans and Human Health Initiative. The amount of current and required coordination among programs and benefits and costs of reorganization should be the major focus of this review. This review should consider ongoing access to appropriate technologies as well as site redundancy to maintain essential services.

V.B.7 Biodiversity and Taxonomy

Important parts of the research and management associated with supporting an ecosystem approach will require considering species of less or without commercial importance. Such concerns are central in issues such as threats posed by invasive species and conservation of biodiversity, but can be important in other applied areas of ecosystem science as well. NOAA needs access to expertise in new research techniques and management methods focused specifically on the conservation and protection of biodiversity, but it lacks a clear view of its current expertise and investments in this area. A focus for these scientists could be biodiversity science and management, in which results would be disseminated rapidly and effectively to regional centers. A Working Group of experts including but not limited to NOAA scientists should prepare an inventory of the biodiversity science activities currently on-going in NOAA facilities and by partners. This would include, *inter alia*, work directly in support of United Nations debates on High Seas Biodiversity under the Convention on Biological Diversity, bio-prospecting, and invasive species. The Working Group should be asked for a projection of how demands for such biodiversity science will change over the next 5 years and 20 years.

These needs also show that the NOAA ecosystem science enterprise will need access to taxonomic experts in most marine taxa, whether for identification of specimens that may be new species to an area or for ensuring reliable inventories of biodiversity. In recent years support and funding for taxonomy has been limited. Therefore, NOAA needs to provide support for taxonomic services, but it may not be possible to have experts in all regions. It should be sufficient to have the taxonomic support available as needed, in a few centers. To ensure efficient access to this expertise an inventory of taxonomic experts in NOAA facilities should be established and kept up to date.

V.B.8 Data Archiving and Integration

NOAA has identified many types of data relevant to ecological systems that are part of its long-term architecture for data. Traditionally, data sets used for a variety of ecological purposes have been locally developed, restricted in content, representing short time series, and archived with a wide variety of data management protocols. Consequently, it has been difficult to make these data available in a common format and spatially disaggregated forms that can be used to address more than the original purposes for which the data were collected. To support complex research on factors influencing ecosystems and for producing integrated ecosystem assessments, consistent data archival and integration protocols should be implemented. NOAA and other agencies (e.g., NASA, USGS) are devoting increased attention to the data management and communication activities. For example, much of the activity currently supported by IOOS funds have been to develop and implement more transparent and easy to use standardized data management and archiving for its ecological data.

Two aspects are critical for improving data archiving and integration. First, in supporting the regional ecosystem activities for the eight regions, data management and archiving protocols and standardization must be developed in concert among the various NOAA LOs and other entities including the IOOS Regional Associations, state and local partners, academic institutions, private corporations and other federal agencies. Second, to produce integrated assessments of all US marine ecosystems, there must be national compatibility across the regional ecosystems, to allow expertise and advances to be disseminated efficiently. NOAA needs a clear plan to ensure both of these needs, regional and national, are met.

It is important to note that the private sector is rapidly developing standard protocols and tools for manipulating and displaying geospatial information. Google Earth and Microsoft Virtual Earth are just two of the open frameworks that could be utilized to display and distribute geospatial information. NOAA should investigate the opportunities to leverage these commercial standards rather than relying solely on in-house development teams.

RECOMMENDATION 13. NOAA and its partners in the ecosystem science enterprise should develop or designate Centers of Specialized Expertise to:

1. build new tools for modeling and forecasting, and new observation instruments;
2. develop social science capacity for linking with ecosystems governance;
3. develop an understanding of society and its response to changing ecosystem components;
4. identify changes in ecosystem structure and function;
5. quantify effects of human activities on the ecosystem.

This list is meant to be indicative of some critical areas that occurred to the Committee and is not exhaustive. Other Centers could be developed, should additional needs become apparent as the Recommendations in this Report are implemented.

RECOMMENDATION 14. NOAA should consider whether consolidation of efforts should occur and should develop plans for efficient regional and inter-regional coordination in the following areas:

1. technical analyses on contaminants and toxicology;
2. biodiversity and taxonomy;
3. data archiving and integration.

VI HOW TO MAKE THE TRANSITION

NOAA must do more than dictate that groups assemble in order to have an effective ecosystem science enterprise. It must have incentives to make the parts interact, common products on which they structure their collaboration, and mechanisms to oversee and be accountable for the integration across LOs and with partners at the regional level. It must also have mechanisms at the NOAA-wide level to ensure coordination among regional ecosystem science enterprises, and between these regional enterprises and the national centers. It also needs a plan for where it is going, what path it plans to take to get there, and what pace it expects to maintain.

VI.A Implement Regional Ecosystem Science Boards

As described above, NOAA LOs conduct or contribute to extensive ecosystem science in support of their diverse mandates, and must work together to produce the key ecosystem science products. Despite individual cases of effective coordination across LOs and with partners, formal mechanisms do not exist to assure that NOAA's ecosystem science conducted at the regional level is coordinated, efficient, or integrated across LOs and partners. In order to better serve its clients for integrated ecosystem products, NOAA needs such mechanisms, to overcome the current lack of consistent regional organizational structures among the lines and the fact that none of the LOs can provide comprehensive national ecosystem science services.

Line Offices expanding the scope of their activities will not, in itself, produce integration of ecosystem-based science and management activities. As NOAA LOs and partners place their management and regulatory roles on an ecosystem basis, a successful ecosystem approach must view the management of human activities in an integrated way. It is not enough to manage each sectoral activity in a broader ecosystem context without consideration of other management activities or plans for other sectors. Each management activity in an ecosystem can affect the success of every other action. The linkages among the consequences of management choices in different sectors makes integrated management a necessary companion to adopting an ecosystem approach to sector management.

This necessary partnership between sector and ecosystem approaches does <u>not</u> mean that the actual management agencies must be integrated in terms of jurisdiction and authority. It <u>does</u> mean that their planning strategies and management choices have to be conducted in full knowledge of the options being considered by the other agencies. It also means that the various agencies need to start from a common factual basis for accommodating the effects of various natural and human forcers, and for evaluating the consequences of all the human activities in the shared ecosystem. Without full information sharing among agencies in planning and choosing management options, individual sectors may be led to prefer alternatives that would fail to be sustainable or to provide the expected benefits due to the consequence of other activities in the same area. Without a common scientific basis for accommodating forcers and evaluating ecosystem effects of human activities, the choices made in one sector can thwart achievement of the management goals of another sector.

In order to provide comprehensive and coordinated ecosystem science at the regional level, NOAA has three choices.

Option 1: Adopt a consistent regional management structure among its LOs and common standards for supporting the ecosystem science enterprise. For example, NMFS employs a regional structure for its six science centers and management offices, roughly corresponding to the eight regional ecosystems identified by the goal team. However, not all LOs may have the resources to do this or sufficient scientific investment in one or more of the regions to justify such a change.

Option 2: Re-organize all NOAA's ecosystem activities into a single LO with a comprehensive regional structure. This option provides an organizational structure with clear authority and accountability for the ecosystem science enterprise at the regional scale. However, even if it were implemented, there would still be a need for regional collaborations that extend beyond the ecosystem "office", for example, to access critical ecosystem observations from buoys maintained by NWS and satellites maintained by NESDIS. The need for effective collaborations with non-NOAA agencies, academia and other groups, would also not be resolved by this Option.

Option 3: Enable regional integration of NOAA's ecosystem science enterprise through formation of Regional Ecosystem Science Boards. These Boards, with mandatory representation from all relevant LOs, and often with members from partners providing key science capabilities in the Region, would be responsible for a variety of tasks related to planning, assessment, and the provision of ecosystem-level management advice. Duties of these Boards would include developing coordinated ecosystem science plans for each region, providing a focus for supporting integrated ocean observing systems, producing and updating Integrated Ecosystem Assessments, coordinating new science initiatives for use in NOAA's PPBES process, and developing the science advisory entities to inform ocean and coastal management and governance bodies.

Although Option 2 (a central LO) provides the greatest accountability, there are significant costs (monetary, personnel, and institutional) associated with such a major realignment, and such an alignment would not solve all the coordination problems. The eETT does support focused realignment of some programs (Section V.B), but concludes that a more practical approach for coordinating regional ecosystem science activities appears to be Option 3 (establishment of Regional Ecosystem Science Boards). Most LOs have regional resources that are obvious entities for such coordination, even if some LOs lack centers in some regions. Resources such as OAR Cooperative Institutes do not have the same direct accountability to NOAA as do formal regional centers such as PMEL and AOML, but they include a significant amount of the ecosystem science expertise supported by NOAA, and would be part of the coordinated ecosystem science enterprise.

RECOMMENDATION 15. NOAA should develop a series of Regional Ecosystem Science Boards consistent with the eight national regional ecosystems identified by the EGT plus the Antarctic. Each of these regional boards should be chaired by an SES-level manager, and include formal representation by all LOs providing ecosystem sciences in that regional ecosystem.

Duties of these Regional Ecosystem Science Boards should include planning, coordinating and executing comprehensive plans of marine ecosystem science, and oversight for the production of integrated ecosystem assessments.

Operation of the Regional Ecosystem Science Boards

The Senior Executive Service level person leading each **Regional Ecosystem Science Board** (RESB) should have a demonstrated ability to work across line organization to produce results requiring participation by multidisciplinary teams. This SES-level individual would be responsible to convene the other executive level individuals representing the NOAA core capacities in each region, comprising the Regional Ecosystem Science Board. The primary efforts of the RESB would be to:

- develop mechanisms for exchange of information and data,
- coordinate scientific research across LOs and with partners in each region,
- oversee preparation of the Integrated Ecosystem Assessments,
- identify science objectives and prioritize among competing demands by the users of NOAA ecosystem science,
- identify priority needs for direct support from the national Centers of Specialized Expertise (Section V.B),
- coordinate the provision of experts and independent scientific advice to support users of NOAA ecosystem science,
- be the main point of contact with the EGT in its national coordination role for Ecosystem Science, and link the ecosystem science enterprise to the other NOAA goals teams.

The Regional Ecosystem Science Boards can only fulfill their potential with a significant infusion of new funding. Absent such funding the benefits of using an integrated ecosystem approach would justify serious consideration by the RESB of what existing activities would have to decrease or stop in order to fund EAM. This transition from existing patterns would be performed using a process of decision-making that would involve NOAA internal organs as well as constituencies for NOAA products and advice.

Oversight for the implementation of RESBs should occur at a level above the NOAA EGT to provide authoritative resolution of any problems encountered with implementation. This would include as appropriate, NOAA Research Council, NOAA Ocean Council, etc. as well as NOAA Executive Council. NOAA SAB would review implementation in two years.

Estimating the **timeframe to implement** the RESB and commence regional research coordination and development of an IEA is difficult. Developing the RESB under a fast track implementation is necessary to keep up with the developments in regional ocean governance and public expectations raised in part by the recommendations of prominent commissions. A proposed fast track timeline is:

Start – after NOAA SAB approves report and submits to NOAA Administrator

Months 0-6. Preparatory Phase. NOAA Administrator considers recommendations and modifies them if necessary. Appointment of SES RESB leads and initial members. NOAA EGT in consultation with RESB leads, outlines charter development, develops IEA guidelines. Preliminary meetings of RESBs. Notice to constituencies (internal and external) about possible changes in NOAA services.

Months 7-12. Launch Phase. Planning research coordination and IEA scoping, e.g., identifying data and other region-specific information available to respond to EGT guidelines. With initial plans, priority data and information would be categorized to focus on 1) what NOAA can do well; 2) what NOAA can do relatively credibly and 3) what cannot be done or known now. This would involve NOAA constituencies.

Months 13-18. Initial work phase. Get the data and information into comprehensive archives and check for consistency. NOAA constituencies would be kept informed.

Months 19-24. Integrated Analysis and Reporting Phase. Perform first integrated assessments and report on them. Communication with, and feedback from, constituencies.

VI.B Enhance the Role of EGT and PPBES to Coordinate the Ecosystem Science Enterprise Nationally

NOAA and its partners intend to place management and regulatory roles on an ecosystem basis (II.E), and LOs are reorganizing their science enterprise to provide a stronger ecosystem basis for policy and management. NOAA correspondingly has given prominence to the Ecosystem Goal Team (EGT), whose purpose is to coordinate ecosystem science planning across LOs. The EGT operates largely through the Planning, Programming, Budgeting, and Execution System (PPBES), which provides a matrix structure for linking the theme (Ecosystems) to the agents (LOs). However, the PPBES system is necessarily a high-level and central coordinating body, working at a national scale and several budget cycles ahead. There are significant regional coordination needs for ecosystem science for management across LOs and external partners.

The eETT has several concerns with this situation. First, the planning range is so great that it is difficult for the EGT to inventory all ecosystem science planned in each program and LO regional center each year. At the same time, at the regional level infrastructure (e.g., ship scheduling) requests must be made long before the funding and personnel to use them are in place. Second, the difficulty of getting the necessary information compresses the time the EGT has to prepare plans, reducing its effectiveness in coordinating the associated planning and budgeting. Third, transitioning from NOAA’s traditional LO organization to a theme orientation requires the coordinating structure to have authority or resources to encourage LO participation. It is early in the process, but our impression is that the Goal Teams must shape their programs to meet the interests of the LOs and, because they play little role in evaluating performance, have limited ability shape the programs they plan. Combining multiple LOs and diverse single-sectoral mandate orientations is a process that will take place slowly unless leadership is consistent and authoritative, agency personnel endorse the direction and process of change, and the external environment is supportive of the direction and process of change.

The implementation of NOAA’s matrix model and PPBES has provided considerably more formal coordination and transparency in budgeting decision-making. The eETT cannot make a compelling case for or against the PPBES approach. However, enthusiasm for the approach is low because of the problems above. Most individuals associated with the PPBES process acknowledge that there is a steep learning curve for how to use the process most effectively and the process is still in an adaptive mode. This provides opportunities for NOAA and its EGT to devise ways to expand and integrate ecosystem assessments into NOAA's management approach at the regional level. These concerns seem to be well-appreciated by the PPBES leadership.

RECOMMENDATION 16. The PPBES process, supported by the EGT, should identify and adopt timelines for both annual and multi-year planning, considering particularly the sequencing of timeframes for planning and coordinating of scientific research across LOs within Regions. The timelines should facilitate coordination among NOAA entities and their partners for ecosystem science and research, particularly at the regional scale (IV) and relative to the activities of the national centers (V).

The EGT should have a key role, in collaboration with the RESBs, in developing a common set of objectives for all regions, a set of guidelines for the IEAs, and **regional charters** for the operations of the RESBs. Theses charters would recognize the need to have common approaches to operations for all regions but differences that reflect the regional marine environment, resources, cultures and preferences. The RESB charters would identify the tasks and contributions of each LO and how the regional ecosystem science enterprises would link to other NOAA goals, such as Climate and Weather. Each Charter would also identify partnership arrangements with CI/JI, Regional Associations, IOOS, and federal and state agencies with interests contributing to NOAA's missions. The NOAA EGT, RESB leads, and selected experts would also develop an initial set of guidelines for development of IEAs, outlining common elements in each regional IEA, with the expectation that the RESB would adjust the IEA to regional conditions.

The Ecosystem Goal Team also would serve as a support and coordination mechanism for the RESBs. The EGT would convene regular meeting of the leads from each of the eight RESBs to compare approaches, coordinate needs for expertise and support from the Centers of Expertise and other regions, discuss how to solve common problems, and share lessons learned.

VI.C Use the IEAS to Provide Incentives for Ecosystem Science Across LOs

Cooperation among different LOs and partners in the ecosystem science enterprise will be facilitated by the need to produce IEAs as a common priority, requiring input from the diverse expertise within each Region. The IEAs are the cornerstone for NOAA to maximize efficiencies and synergies in providing a single integrated science product from which advice and support to different management and policy clients can be derived, and they provide a practical focus for promoting an integrated NOAA ecosystem science enterprise. However, IEAs will demand resources to produce. To succeed as a key activity for integrating across LOs, the work must be perceived as an opportunity for obtaining resources, not as yet another unfunded mandate added onto the LO responsibilities.

We envision that each Regional Ecosystem Science Board will develop a program to meet to its regional science and management needs. This program will identify key services that could be provided by various LOs and programs within NOAA, and each Board will solicit LO participation through a competitive proposal process. Each Board will evaluate the responses from LOs and program elements to assemble an integrated program. As the programs are implemented, regular reviews and progress assessments will be conducted for each regional science/management plan.

Recommendation 17: Fund the preparation of the IEAs and other key ecosystem science products through a process that is competitive among teams of LOs and partners.

VII RESPONSE TO NOAA'S STATEMENT OF TASK FOR THE EETT

The eETT has undertaken a fairly general assessment of NOAA's ecosystem science enterprise. Given the complexity of the question of what comprises "ecosystem science in support of management and policy", the size and diversity of NOAA and its partners, and the many changes ongoing in the NOAA ecosystem science enterprise, our recommendations provide direction for guiding change, but not a fully developed plan and schedule. We cannot produce a program-by-program, Line Office-by-Line Office or location-by-location response to the questions posed. The eETT anticipates that by providing independent perspectives on agency processes, it can stimulate NOAA to act through its existing EGT or ad hoc bodies where detailed assessments are required. Like the RRT report that initiated this review, the eETT recommends that NOAA's SAB, in conjunction with the NEC, review implementation progress after two years to evaluate responses to the our recommendations.

NOAA asked two multipart questions, "**Is the mix of scientific activities conducted and/or sponsored by NOAA appropriate for its mission needs, including its legislative and regulatory requirements**/" and **"How should NOAA organize it ecosystem research and science enterprise?"** Our response is developed in sections III-VI above. Here we respond to the questions in the order they were presented, including intentional redundancies between this section and earlier ones to avoid inconsistencies.

VII.A Is the mix of scientific activities conducted and/or sponsored by NOAA appropriate for its mission needs, including its legislative and regulatory requirements?

The mix of activities is, of course, not optimal. There is significant demand for more activity in many areas. The greatest need is to integrate current products to encompass more components of the ecosystem (including humans) and to address the interaction of management actions in different sectors. We stress that the current products are of high scientific merit and do serve important uses, such that there would be significant costs if most existing programs were curtailed to allow new "ecosystem" programs to be instituted.
Three general types of change are recommended:

1. There are opportunities to organize activities to be more effective and reflective of evolving priorities, building on the work of the EGT. Integrated regional ecosystem assessments and advice are called for in IV and specific capabilities needed to do this are discussed in V.
2. Clients of NOAA science products and advice must be convinced that integrated advice will allow them to deal with new problems, to deal with many existing ones more effectively, and where there will be changes in products and services the short-term coasts to adapt are outweighed by the medium-term benefits. This is consistent with the concepts of both the ecosystem approach and integrated management. This is discussed in Section III.
3. As both the US COP and Pew Ocean Commission noted, additional resources will be needed for NOAA to deliver effective ecosystem science in support of management and policy. Progress on the recommendations of the eETT will be subject to availability of resources to support or provide incentives for change.

In general, today more high quality science is available than currently is used in making management decisions. This gap highlights the need to continually work on effective provision of scientific decision support services, communication of science, and ensuring ways to obtain feedback on the scientific questions that managers and society want answered. It is equally important to educate or train managers on how to use ecosystem information.

With regard to subject matter, within each region NOAA has developed core capacities in the foundations of integrated ecosystem assessments: monitoring, assessing status and trends, and integrating relationships and forecasting trends (V.A). These must be maintained and enhanced, to support Integrated Ecosystems Assessments. As part of the integrated ecosystem assessments, linking environmental (including climate) forcing to effects on biological communities and societal needs appear to be is one key element. Forcing through anthropogenic effects like pollution, harvest management, harmful algal bloom forecasting, etc. is another (V.A). With respect to specific capacities, NOAA needs to strengthen analytical capacities to model and forecast, social science methods to link ecosystem science to governance and identify how humans respond to changing ecosystem components, track ecosystem structure and function, perform technical analysis of toxics and contaminants in the ecosystem, track biodiversity and taxonomy to support an ecosystem approach, and archive and integrate data on ecosystems and the impacts of human activities (V.B).

Distribution along the continuum from long term research to products for immediate use?

The intimate connection between ecosystem science and various mandates to provide science advice for management and other legal activities makes ecosystem science somewhat different from much of NOAA's physical science enterprise. Both long-range research and immediate product production are needed in the ecosystem science enterprise, and the interactions are networked among physical, biological and anthropogenic factors, rather than sequential. Budgetary factors affect the balance between basic research and product generation, but within the present framework we did not see a problem with the distribution of time-to-fruition in the mix of ecosystem science.

Internal and external (to NOAA) balance?

The eETT did not find an answer to this question, and *one* may not exist. Responses to the eETT from the academic community were predictably that they would like to see more external funding for ecosystem science and concern was expressed over loss of continuity during uncertain fiscal situations. Clearly NOAA has benefited by having the resources to sponsor external science and research though contracts, Cooperative and Joint Institutes, etc. The choice to develop internal versus external arrangements for ecosystem research appears to have been opportunistic, to take advantage of the circumstances as they present themselves. It is difficult for us to advance definitive, systematic guidelines that would serve NOAA better than current practice. We recommend regional coordination of the ecosystem science enterprise (IV.D) and the optimal balance might be best set at these scales. We do recommend that where NOAA is dependent on external institutions for meeting core capacities for monitoring, assessment or status and trends, and integration and forecasting, these relationships should be formalized (V.A).

Links to international science programs?

Most of the developed world is moving in the same direction, and in some areas where NOAA is constrained by litigation and legislative mandates, other jurisdictions may have made more progress. As NOAA integrates around science for an ecosystem approach to management, there may be opportunities to make stronger connections with the different international scientific bodies to better integrate the science, rationalize the observing systems, improve data sharing and archiving protocols, etc. It is also important to NOAA consider ways to collaborate with other agencies to assist developing countries, in particular, with developing scientific and management capacity and scientific literacy.

VII.B How Should NOAA Organize its Ecosystem Research and Science Enterprise?

The eETT recommends that the eight regions as defined by NOAA as the LMEs within the US jurisdiction and the Antarctic become the focal points for organizing and locating scientific core capacities (IV). Such a regional organization maps fairly well on the current location of NOAA's assets to provide core capacity for scientific decision support services in these regions. Within each region and at the national level, the eETT recommends that NOAA develop a much stronger collaborative approach to ecosystem science. Within NOAA itself the Ecosystem Goal Team and other coordinating mechanisms are working, but often have difficulty attracting or maintaining LO interest. At the regional level, the eETT recommends that NOAA work with other local, state and regional interests and agencies to develop a coordinated ecosystem research plan (IV.B, VI.A) and that NOAA develop Regional Ecosystem Science Boards to coordinate across LOs and with research and management partners in order to utilize respective authorities, expertise and assets more effectively in understanding and supporting management in the region (VI.C). The starting point for this regional coordination is recommended to be the development of an Integrated Ecosystem Assessment for the region, responsive to various regional science and management needs (IV.B). Some types of ecosystem science support should be provided at the regional level (V.A), whereas other specialized types of expertise may be best centralized, with clear mandates and mechanisms to ensure that they support the regional teams when and as needed (V.B).

This regional focus reflects the eETT belief that there are significant benefits to regional flexibility in addressing local needs, determined by the interactions between society and watersheds, coastal and offshore environments. On the other hand, although it is impractical to manage the entire ecosystem science enterprise centrally, the EGT should have sufficient authority to ensure coherence in the implementation of national policies, and scientific consistency in the regional activities.

The relationship to non-ecosystem science activities?

The eETT agrees with NOAA that branding weather and climate as non-ecosystem components is an artificial separation. Both weather and climate are key forcing elements in biological and anthropogenic systems, making these activities crucial for the Ecosystem Goal at present. Cooperation and collaboration in scientific research will accentuate their roles in the future, and better understanding of the influences is critical. The rationale for administrative separation of Climate Goal and Weather and Water Goal from the Ecosystem Goal is less important than ensuring productive cross Goal working relationships.

Conventional mapping of the sea floor for navigation and security purposes also will gain an additional function as ecosystem assessments and ecosystem approaches to management are inherently spatial (V.A.2).

The continuum from long term research to information products for immediate use (including mandated scientific advice)?

At the level of detail the eETT concentrated, we have recommended that there are specific core capacities that need to exist at the regional level (V.A), and that NOAA examine how actual or virtual groups could be established to advance development of more specialized methods and techniques (V.B). Although the Physical and Social Science Task Team recommended that short-term research, i.e., less than five years to fruition, be located in NOS whereas longer term research would be done through OAR, the eETT did not see the same value, and saw considerable risks, in a similar division in ecosystem science and research. Rather we found that most ecosystem science is a cumulative process that can yield information and advice on management and policy on seasonal, annual, and multi-annual scales. Thus, for the eETT a "time to fruition" approach was not compelling as a criterion for location of ecosystem research.

Line office distribution?

Line Office distribution with respect to the Ecosystem Goal has been dictated largely by legislative mandates. Absent a move by Congress to amend these mandates greatly, and require a restructuring such as recommended by the US COP and the Pew Commission, the eETT does not propose radical administrative reorganization. Rather, the eETT sees that over the next three to five years, mandated activities will necessarily expand their ecosystem scope to improve management and policy, and to better comply with NEPA. Already, there is a demonstrated expansion of management concerns across LOs, federal, state and local partners (Appendix 5). However, without effective integration by empowered coordinators, this expansion will create both gaps and redundancies, neither of which NOAA or its clients can afford (IV-D). **We assume that the form of institutions will follow function, such that in 5-10 years further organizational changes may be required to better implement an ecosystem basis for the NOAA science enterprise. The key here is for NOAA and its EGT to get on with the task of expanding and integrating ecosystem assessments into NOAA's management approach at the regional level now, rather than waiting for legislation or regulatory changes to make some specific organizational structure necessary.**

Program structure used in NOAA's Planning Programming Budgeting and Execution System?

The implementation of NOAA's matrix and PPBES has provided considerably more formal coordination and transparency in budgeting decision-making. The preponderance of sentiment in responses to eETT inquiry were resignation and cautious optimism, but little enthusiasm. The eETT cannot make a compelling case for or against the approach; however, there appear to be two legitimate and difficult issues with some salience. First, a fair number of respondents had problems not with the need to plan and coordinate with other program managers, but with the compressed time frame for key parts of the PPBES process which was, they felt, an impediment to performing those activities as part of the process. The second issue concerns long-term planning commitments, like assignment of ship time and how the PPBES process may force commitments ahead of the ability to assure funding, project personnel, etc. In this regard, the eETT recommends that the PPBES process consider what timelines for both annual and multi-year planning best facilitate coordination among NOAA entities and their partners, and adapt them as needed.

The theme of this report is that a regional organization would best provide the research and applied science support to comprise the scientific basis for ecosystem based management. This approach fits the nature and role of ecosystem science much better than any we can envision, particularly better than disciplinary, time-to-fruition, internal vs. external, or management-sector orientations.

GLOSSARY

CI	Cooperative Institute
CSE	Center of Specialized Expertise
eETT	external Ecosystem Task Team
HAB	Harmful Algal Bloom
IEA	Integrated Ecosystem Assessment
iETT	internal Ecosystem Task Team
IOOS	Integrated Ocean Observing System
JI	Joint Institute
LO	Line Office
NCCOS	National Centers for Coastal Ocean Science
NMFS	National Marine Fisheries Service [NOAA Fisheries]
NMSP	National Marine Sanctuary Program
NOS	National Ocean Service
NOAA	National Oceanic and Atmospheric Administration
OAR	NOAA Office of Oceanic and Atmospheric Research
PacOOS	Pacific Ocean Observing System
RESB	Regional Ecosystem Science Board
RRT	Research Review Team
SAB	NOAA's Science Advisory Board

APPENDICES

APPENDIX 1. EETT TERMS OF REFERENCE

EXTERNAL ECOSYSTEM TASK TEAM: TERMS OF REFERENCE FRAMEWORK FOR AN EXTERNAL REVIEW OF NOAA's ECOSYSTEM RESEARCH AND SCIENCE ENTERPRISE

Prepared by the NOAA Internal Ecosystem Research and Science Task Team[1]

Background:

The NOAA Research Review Team (RRT), under the auspices of the NOAA Science Advisory Board, conducted a "Review of the Organization and Management of Research in NOAA." The team's report, along with the SAB transmittal letter accompanying the report, is posted at http://www.sab.noaa.gov/Reports/Reports.html.

The RRT report questions where ecosystem research activity is located in NOAA. It contains the following recommendation:

> *"…NOAA should establish an external Task Team to evaluate and strengthen the structure and function of ecosystem research in, and sponsored by, NMFS, NOS and OAR."*

Extracts from NOAA Research Review Team's report relevant to the location of ecosystem research are given in Annex I (from pages 16-18 of the Report).

NOAA agrees with the recommendation of the RRT for an external review on ecosystems. NOAA has decided that the review should be broad enough to address the entire ecosystem research and science enterprise[2].

NOAA conducts mission oriented research and scientific activities on a diverse range of topics, on time scales ranging from decadal scale studies of system processes to short term studies for immediate application. NOAA's entire ecosystems research and science enterprise includes:

- Scientific advice and information products tailored to user needs,

[1]The NOAA Internal Ecosystem Research and Science Task Team was established by the NOAA Research Council. Its members are Michael Sissenwine (chair), Peter Ortner, Jean Snider, Sennen Salapare, John Janowiak (Melvyn Gelman, alternate), and Michael Ford.

[2] The NOAA ecosystem research and science enterprise is the set of NOAA supported activities (internal and external) that adds to the body of scientific knowledge and translates it into products and services that support the Agency's mission.

- Observational systems to assess and characterize changes in ecosystems and ecosystem uses,
- Applied research (not tied to immediate user needs) to better understand processes in order to improve the capability of observing systems and the quality of information products (including scientific advice),
- Development based on results of applied research, of new science tools, conservation technologies, and production technologies.

Annex II elaborates on these categories of scientific activity.

The NOAA ecosystem research and science enterprise needs to support the NOAA Strategic Plan (http://www.spo.noaa.gov/pdfs/NOAA%20Strategic%20Plan.pdf), which is based on stakeholder input and internal assessments of NOAA's mandates and mission. The Strategic Plan has four mission goals including an Ecosystem Goal to "Protect, restore, and manage the use of coastal and ocean resources through an ecosystem approach." To fulfill the Strategic Plan, NOAA adopted a Planning, Programming, Budgeting, and Execution System (PPBES, https://www.ppbs.noaa.gov/about.html). NOAA organized its activities into forty four Programs (https://www.ppbs.noaa.gov/PDFs/program_manager_list.pdf), including nine Programs that address the Ecosystem Goal (1) ecosystem research, (2) ecosystem observation, (3) protected species, (4) fisheries management, (5) aquaculture, (6) coastal and marine resources, (7) habitat, (8) corals, and (9) enforcement. Some of the Programs are managed by a single NOAA Line Office (for the LO structure see http://www.noaa.gov/pdf/noaa-org-chart030804.pdf), while others are "matrix managed" across LOs. Most of the NOAA's Ecosystem Research and Science Enterprise is within the Ecosystem Goal. However, the Ecosystem Goal benefits from scientific activities of other Strategic Plan Goals, which, for example, provide environmental information that, can be used to help predict ecosystem changes.

What is an ecosystem?

For NOAA's purposes, an ecosystem is defined as a geographically specified system of organisms (including humans), the environment, and the processes that control its dynamics.

What is an ecosystem approach to management?

For NOAA's purposes, and ecosystem approach to management is management that is adaptive, specified geographically, takes into account ecosystem knowledge and uncertainties, considers multiple external influences, and strives to balance diverse social objectives.

This document offers a framework for conducting the external review. It suggests:

- Terms of Reference,
- Size of the review team and reviewer qualifications,
- A method for selecting review team members,
- An approach for conducting the review.

Terms of Reference

The purpose of the review is to answer the following questions:

Is the mix of scientific activities conducted and/or sponsored by NOAA appropriate for its mission needs, including its legislative and regulatory requirements, in terms of

- Subject matter,
- Distribution along the continuum from long term research to products for immediate use (including mandated scientific advice),
- Internal and external (to NOAA) balance?
- Links to international science programs?

How should NOAA organize its ecosystem research and science enterprise, in terms of:

- The relationship to non-ecosystem science activities (e.g., weather, climate or mapping), which is in part an artificial separation,
- The continuum from long term research to information products for immediate use (including mandated scientific advice),
- Line Office distribution,
- Program Structure used in NOAA's Planning, Programming, Budgeting, and Execution System,
- Other categorization schemes, such as by scientific discipline, mission area or mandate (implicitly including all sectors that are users of science advice), ecosystem or region, internal/external, etc.

In answering these questions, the review should include the following:

- Strengths and weaknesses of existing organizational structures used by NOAA, and by other entities with missions similar to NOAA's (domestic, foreign and multinational).

- Advantages and disadvantages of requiring that all scientific activity within a category of research, (e.g., long term or short term) be organized in the same way.

- How well organizational structures and approaches facilitate the transition from research to operations and information products,

- How well organizational structures and approaches facilitate the transition from research to operations and information products.

- How well organizational structures and approaches enhance the relevance, responsiveness, quality and credibility of scientific advice and products.

- Cost implications of organizational structures, including the transition costs of change,

- Ecosystem related implications of the report of the report of the US Commission on Ocean Policy and the President's Ocean Action Plan.

- Ecosystem implications of international agencies of which the US is a member (groups including but not limited to regional fisheries management organizations, such as ICES, PICES, CITES, and various UN agencies such as FAO and UNESCO).

I. Size of the review team and reviewer qualifications

NOAA's ecosystem research and science enterprise is large and diverse. Thus it requires a relatively large review team to do justice to the Terms of Reference. The review team should have at least seven members with a variety of backgrounds (recognizing that even with seven reviewers, it will not be practical to have all backgrounds represented), such as:

1. Scientific disciplines of physical sciences, biological sciences including fisheries science, and social sciences,

2. Experience in academia, within mission oriented government agencies, Non-Governmental Organizations (NGOs), and the private sector,

3. Familiarity with NOAA's mandates,

4. Being a science provider to key generic groups of stakeholders, science interpreter to groups of stakeholders, science user, or .stakeholder with a history of interaction with science providers.

The reviewers should have the following qualifications:

1. National and international professional recognition,

2. Knowledge of the scientific information needs to support NOAA's ecosystem stewardship missions, coupled with broad familiarity with NOAA's total mission,

3. Knowledge of, and experience with, the organization and management of complex mission oriented scientific programs,

4. No perceived or actual vested interest or conflict of interest that might undermine the credibility of the review.

It is of note here that except for qualification criteria 4, the criteria are not absolute requirements. The qualifications of some individuals are expected to be outstanding enough with respect to one or more of the criteria, that being unqualified with respect to other criteria, would not necessarily make them ineligible. Because of the limited size of the review panel, management organization expertise must include expertise on ecosystem science or the very special features of science applied to government decision-making.

II. A method for selecting review team members

Nominations should be submitted to the NOAA Science Advisory Board (SAB) with justifications that address the candidate's background and qualifications (specifically for the categories above). The nominations should indicate if the candidate has expressed a willingness to serve, if selected.

The results of the review have the potential of being controversial because the results of the review (if implemented) may have direct consequences on social and economic opportunities and/or quality of life of some of NOAA's stakeholders. This is a key reason for providing stakeholders the opportunity to nominate review team members. Moreover, it is important that stakeholders have the opportunity to provide input to the review team, and that the process of selecting reviewers be transparent. Accordingly, nominations will be solicited by a notice in the Federal Register, which summarizes the information in this document. Anyone (from within or outside NOAA) should be eligible to nominate. Individuals may self nominate. However, employees of NOAA or persons currently funded by NOAA should be ineligible to serve as a review team member.

It will be up to the SAB to evaluate the nominees and select the review team members. The intent is to select from the nominees. However, the SAB should retain the prerogative to name people to the review team that were not nominated if it deems it necessary to achieve the desired

III. The SAB will post the review panel, with abridged resumes, for public information, to close the loop on transparency and develop an approach for conducting the review.

IV. Review Approach

There are several aspects of the review approach that need to be specified, including:

1. Role of the NOAA Internal Ecosystem Research and Science Task Team,

2. Source of data about NOAA's ecosystem research and science enterprise, how it is organized and how other Agencies (US and foreign) organize similar types of scientific activities,

3. Site visits,

4. Mechanism for public input,

5. "Ground truthing" the review,

6. Timetable.

These aspects are addressed below.

Role of the NOAA Internal Ecosystem Research and Science Task Team: The internal task team will work with the Ecosystem Research and Science Review Team to facilitate gathering data and arrangements for review activity, as one source of ideas and insights, and to act as a sounding board for ideas. The communications between the Internal and External teams should be two-way. A "sounding board" suggests the internal team merely responds to ideas from the external team; whereas it is expected that the internal team already has enormous expertise regarding the issues specified in the Terms of Reference. The internal team will be encouraged to propose ideas (about both problems and potential solutions), not just respond to ideas from then external team. However, it will be solely the role of the "External Ecosystem Research and Science Review Team" to formulate conclusions and recommendations.

Source of data about NOAA's ecosystem research and science enterprise: how it is organized and how other Agencies (US and foreign) organize similar types of scientific activities: Data assembled for the NOAA Research Review (http://review.oar.noaa.gov/) will be updated and refined to serve the specific needs of an ecosystem review. The data will include descriptions of:

1. Ecosystem research and science program elements including budgets and staffing levels,
2. Current organizational structures,
3. Partnerships including university relationships,
4. Scientific activities by facility (e.g., laboratory) and organizational structure,
5. Science user needs, given that the needs of users of "ecosystem science" are expected to be a complex issue.
6. Government Performance and Results Act (GPRA) requirements,
7. Planning and programming documents (e.g., 5-Year Research Plan, 20-Year Vision, Program Baseline Assessments),
8. Other subjects of interest to the External Ecosystem Research and Science Review Team.

It is also important for the Review Team to gather information about organizational approaches of other organizations that have similar missions to NOAA's ecosystem stewardship mission. This might be done by sampling websites (which usually describe organizations), conducting a survey, and/or by interviewing leaders of organizations other organizations. The international experience is particularly important. It is likely that NOAA can profit by learning how other national and multi-national groups are successfully conducting applied marine ecosystem science.

Site visits: The Review Team should make site visits to representative locations (e.g., in terms of Line Office activities, mission areas, scientific disciplines) where ecosystem research and science activities are conducted. These visits should sample activities of NMFS, NOS and OAR. Seattle and South Florida are obvious candidates to be visited, as these are areas where ecosystem sciences are concentrated. Given the relatively large number of NMFS facilities, additional site visits to key facilities are suggested (Woods Hole and La Jolla are good candidates). Charleston is a location where NOS ecosystem science activity is concentrated such that it is a good candidate for a site visit.

Opportunity for public input: Meetings should be arranged with stakeholders, Congressional staff and officials of the Office of Management and Budget. It should be feasible to coordinate stakeholder meetings with the aforementioned facility site visits. Written input might also be solicited by Federal Register Notice. Phone interviews of key constituency spokespersons might be conducted. The draft report will be made available for public comment by publishing it in the Federal Register.

"Ground truthing" the review: There is always a risk that the external review team will come to conclusions or make recommendations that are clearly invalid or unworkable. This usually occurs because the reviewers lack some information or background. Unfortunately, such situations tend to discredit reviews and they are used to dismiss even sound conclusions and recommendations. Therefore, it is prudent to have a knowledgeable group provide feedback on conclusions and recommendations before the report of the review is finalized. This is a role that the Internal Task Team can fulfill at the discretion of the external review team. The external review team may also seek feedback from elsewhere. Ultimately, the conclusions and recommendations must be solely the responsibility of the external review team.

Timetable: The External Review of NOAA's Ecosystem Research and Science Enterprise should be conducted according to the following schedule:

1. Review "clock" starts when SAB agrees to Framework for the review;

2. By day 10, Federal Register Notice (FRN) soliciting nominations published;

3. By day 30, nominations due to SAB;

4. By day 45, members of the external review team selected;

5. By day 75, initial meeting of external review to become familiar with their charge, and to decide on a course of action;

6. Approximately every 45 days after the initial meeting throughout the period of the review, external review team meetings. The internal task team will be available to participate;

7. By day 100, data about NOAA's ecosystem research and science enterprise collected;

8. By day 150, information on organizational structures used by other entities with similar ecosystem stewardship missions to NOAA's collected;

9. By day150, site visits and constituency input sessions have been conducted,

10. By day 150, progress report submitted to SAB;

11. By day 180, interim report submitted to SAB;

12. By day 195, interim report made available in Federal Register for public comment;

13. By day 215, FRN public comments due;

14. By day 230, feedback from SAB to external review team;

15. By day 260, external review team finalizes its report, including "ground truthing;"

16. By day 285, SAB reviews and approves report;

17. Days 286-300, set aside as a contingency in case of unavoidable delays.

If the "clock starts" by the end of November 2004, the review should be complete by the end of the fourth quarter of FY 2005, as called for in the NOAA response to the RRT report. However, the schedule is extremely tight, such that delays in starting the clock will make it unrealistic to complete the review by the deadline without seriously jeopardizing quality.

Annex 1 Extracts from NOAA Research Review Team report relevant to the location of ecosystem research

"We also find that there is a difference between operational responsibilities and regulatory responsibilities. …In mission areas like fisheries, coastal zone management, or more generally ecosystem-based management, NOAA must provide the best advice on which to base management and regulatory decisions. This scientific advice (e.g. fisheries stock assessment) is best based on work in a research environment. … NOAA must exercise caution to ensure that the research program is not unduly influenced by regulatory responsibilities, but at same time, it is essential to ensure that the best science is available and responsive to policy and management needs including the regulatory process."

"Maintaining the research program within NOS and NMFS with appropriate safeguards for the higher-risk, more basic research efforts can do this. It can also be accomplished by having the research in a separate organizational structure with clear and unambiguous responsibility to meet management and regulatory needs. The Review Team notes that the former approach facilitates the provision of scientific advice for management, but the latter approach may provide a more integrated research effort and enhance extramural involvement."

"…we note that the research being conducted in NMFS and NOS could migrate to OAR, but only if the scientific advice associated with ecosystem-based regulatory responsibilities went with the research role."

"NMFS organization into regional fisheries Science Centers is a useful model for interaction and management of laboratories within regions. In each of the fisheries Science Centers there are several laboratories, each with a specific focus area, but they are managed and administered collectively through the Center. This model could, also, be an effective means of integrating the science and research efforts across the line offices."

Annex 2 Categories of scientific activity

Observational systems: Ecological observations are the core of the research and science enterprise. They are reoccurring measurements of ecosystem variables (which throughout this document should be understood to including the human dimension) that build time series. Standard procedures (including protocols for quality assurance and data management) are in place for research and scientific activity in this category. The data is used for a variety of purposes, such as input into advice on resource management decisions. While some of the data is used for documents published in the scientific literature, it is also found in advisory products aimed a decision makers, distributed in technical reports, and made accessible in databases.

Scientific advice and information products: These are science-based analyses (both qualitative and quantitative) aimed at reporting on the state of ecosystem variables, the consequence of human activities, and the implications of alternative management decisions. Generally, assessments are tailored to the needs of non-scientific users. They depend heavily on observations and understanding of ecosystem processes obtained through applied research. Assessment results are usually reported in technical documents tailored to user needs. They are also used by researchers conducting syntheses on the state of ecosystems and case studies on the performance of resource management.

Applied Research: This research is mission inspired even though it may be long term without an immediate connection to non-scientific users. It is aimed at advancing understanding of aspects of marine ecosystems with a view at enhancing the capability give scientific advice and provides information products. This research tends to focus on processes that govern populations and ecosystems. It also includes research that improves understanding of technologies, thus leading to development that supports the mission. The primary outlet for this research is the scientific literature. Other scientists are typically the users.

Development: This activity uses the increased understanding produced by the Agency’s applied research, and any other pertinent research, to create new tools or methods to increase the capability and/or capacity to provide scientific advice and services to non-researchers. Nevertheless, successful development is usually documented in the scientific literature. It does not include development primarily aimed at research applications (this activity is part of strategic research). There are three subcategories of Development:

- Development of Science Tools: Development of science tools provides new applications of technology for observing or new methods (such as models) for assessments.

- Development of Conservation Technologies: This development is of new technologies that help to minimize undesirable impacts of human activities on marine ecosystems. This development provides new options for regulating human activities to achieve conservation objectives, without undue negative impact on benefits from the regulated activities.

- Development of Production Technologies: This activity provides new options for deriving benefits from human activities associated marine ecosystems. If successful, these technologies will be adopted by the private sector without regulatory requirements (e.g., the private sector has an economic incentive to use the technologies

APPENDIX 2. EETT WHITE PAPERS - ECOSYSTEM SCIENCE CAPABILITIES REQUIRED TO SUPPORT NOAA'S MISSION IN THE YEAR 2020

Overview: Ecosystem Science Capabilities Required to Support NOAA's Mission in the Year 2020

The National Oceanic and Atmospheric Administration -- NOAA-- has as its stated mission "*To understand and predict changes in the Earth's environment and conserve and manage coastal and marine resources to meet our nation's economic, social and environmental needs*"(NOAA 2004). In meeting its marine stewardship responsibilities, NOAA seeks to "*Ensure the sustainable use of resources and balance competing uses of coastal and marine ecosystems, recognizing both their human and natural components".* Authorities for executing these responsibilities come from over 90 separate pieces of federal legislation, each with unique requirements and responsibilities to the nation. Few of these acts explicitly mandate ecosystem approaches to management (EAM) or its supporting science. However, it is obvious to many resource managers, the science community, and, increasingly, the public, that these stewardship responsibilities require significantly greater connectedness among the scientific disciplines supporting management (Browman and Stergiou 2004; 2005). Neither NOAA nor any other science agency can possibly meet the increasing demand for ecosystem science products addressing each of its mandates individually. Even if they could, doing so would not provide the integration necessary to solve the increasingly complex array of management issues. This focus on the integration of science and management responsibilities into an ecosystem theme is one of the center pieces of the U.S. Ocean Commission's Report (USCOP 2004), and the Administration's response through the U.S. Ocean Action Plan (CEQ 2004).

Acting through its Ecosystem Goal Team (**http://.ecosystems.noaa.gov**), NOAA has begun to better integrate the ecological research, observing and forecasting components undertaken by its "line Offices" (e.g., National Marine Fisheries Service, National Ocean Service, Office of Oceanic and Atmospheric Research, National Environmental Satellite, Data and Information Service, and National Weather Service). The NOAA 5-year research plan (NOAA 2005a) emphasizes how the Agency will better integrate its current activities, using as a framework the Goal Team structure. In contrast, its 20-year *vision* for science and research (NOAA 2005b) sets broad themes for the Agency in meeting its ecosystem stewardship responsibilities, e.g., "*NOAA will provide the scientific underpinnings for an ecosystem approach to management of coastal and ocean resources, so that complex societal choices are informed by comprehensive and reliable scientific information*".

The Agency needs to understand what types of science, skills and products will be necessary to inform emerging ecosystem management challenges if it is to move from simply better integrating its current activities to an ability to meet its strategic 20-year research vision. This document was developed to identify a strategic portfolio of research, monitoring, data integration, and decision support capabilities underpinning more holistic approaches to NOAA's stewardship and management of coastal and ocean resources.

What are the characteristics of EAM for which NOAA must provide science support?

For its purposes, NOAA defines EAM as:

> *An ecosystem[3] approach to management (EAM) is one that provides a comprehensive framework for living 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.*
>
> *EAM is differentiated from more narrowly focused management by a number of defining characteristics. EAM is: (1) geographically specified, (2) adaptive in its development over time as new information becomes available or as circumstances change, (3) takes into account ecosystem knowledge and uncertainties, (4) considers the fact that multiple simultaneous factors may influence the outcomes of management (particularly those external to the ecosystem), and (5) strives to balance diverse societal objectives that result from resource decision making and allocation. Additionally, because of its complexity and emphasis on stakeholder involvement, the process of implementing EAM needs to be (6) incremental and (7) collaborative* (Murawski 2006).

Ecosystem science supporting these characteristics must therefore be integrated on appropriate geographic scales relevant to the particular problem or issue being addressed. Some of these management foci will be local (a bay or estuary), many will scale upwards, including global. All will require greater integration of ecosystem knowledge across traditional disciplines that can be easily re-assembled at problem-relevant time and space scales. Given the wider diversity of stakeholder groups that will participate in ecosystem-level problem solving, new information products, including those that integrate and simultaneously interpret biological, social and physical trends must emerge. Finally, new management (governance) institutions will also likely emerge – evolved from those currently in existence, or yet to be formed – that will require the use of natural and social science information that will inform the difficult choices that must be made in managing coastal and ocean ecosystems. One of the vexing issues these institutions will face is the divergent value systems held by stakeholder groups (e.g., utilitarian vs. preservation views of marine ecosystems). Our institutions and science support systems must be prepared to evaluate management from these diverse perspectives.

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[3] An ecosystem is a geographically specified system of organisms (including humans), the environment[2], and the processes that control its dynamics.

[3] The environment is the biological, chemical, physical, and social conditions that surround organisms. When appropriate, the term environment should be qualified as biological, chemical, and/or social.

The set of "white papers" (available at **http://spo.nmfs.noaa.gov/tm/**; look for NOAA TM NMFS-F/SPO-74 dated July 2006) is not intended to be comprehensive with respect to all of the existing and emerging issues, but rather, to focus on a few priority topics that researchers and coastal managers have identified as multidisciplinary themes of EAM requiring NOAA's attention. These themes were assigned to senior scientists and research managers in NOAA who are at the forefront of these issues, and who represent a cross-section of the various line offices within the agency collaborating on them. This examination of pivotal issues requiring greater emphasis will help NOAA, its partners, and stakeholders more fully implement an ecosystem approach to management. It will contribute to how NOAA organizes itself and manages its activities, and how it will interact with other federal, state and local management jurisdictions. Most importantly, these papers will inform long-term research planning activities of the Agency.

The six white papers consider the following ecosystem-related themes:

1. Ecosystem Responses to Climate Variability
2. Management of Living Marine Resources in an Ecosystem Context
3. Freshwater Issues
4. Marine Zoning and Coastal Zone Management
5. Ecological Forecasting
6. Science Requirements to Identify and Balance Societal Objectives

Of course, better science capabilities alone will not be sufficient for meeting the increasing challenges we face in managing the nation's coastal and ocean ecosystems. However, ocean governance systems have not been static. Even within traditional use sectors (e.g., fisheries, energy exploration and recovery) there is an evolution towards broadening mandates to consider their interactions with other sectors and issues. In fact, there is a growing demand from these current institutions for ecosystem-level information and advice for which science is not yet fully equipped to provide (Rice 2005). Thus, there is an urgent need to address these issues and priorities.

Finally, this exercise in futurism is not the first, and will not be the last to consider emerging marine science and policy "mega-trends". In 1984 the Intergovernmental Oceanographic Commission (IOC) posited a vision of emerging themes by the year 2000 (IOC 1984). Chief among their predictions were the increased importance of interdisciplinary approaches to climate research and ecosystem studies (Field et al. 2005). More recently, in visioning ocean science for 2020, Field et al. (2005) provide a number of tantalizing predictions for science and management challenges for which science must prepare, including: (1) the increased reliance on more capable remote sensing, (2) the importance of the information revolution to ocean science, (3) the "globalization" of modeling capacity, (4) discovering functional biodiversity (molecular ecology), (5) increased emphasis on global climate change, (6) waste disposal in the oceans, (6) understanding of the deep sea floor biosphere, (8) the emerging importance of the land-sea interface and the coasts, (9) the growth if interdisciplinary sciences, (10) greater involvement of society in managing the ocean's limited resources, (11) transitioning to sustainable fisheries, and (12) capacity building in marine science in both the developing and developed world. This volume provides a NOAA-centric view of important challenges for ecosystem management and the role that its science can play in informing and helping to create a sustainable future for our nation's ocean and coastal ecosystems.

For further information, please see NOAA Technical Memorandum NMFS-F/SPO-74, dated July 2006, available at the website: **http://spo.nmfs.noaa.gov/tm/**.

The authors acknowledge and appreciate the efforts of the numerous individuals who reviewed these white papers, and particularly those of Ms. Lynn Dancy.

References

Browman, H.I., and K.I. Stergiou. 2004. Perspectives on ecosystem-based approaches to the management of marine resources. Marine Ecology Progress Series 274: 269-303.

Browman, H.I., and K.I. Stergiou. 2005. Politics and socio-economics of ecosystem-based approaches to the management of marine resources. Marine Ecology Progress Series 275: 241-296.

Executive Office of the President, Council on Environmental Quality [CEQ]. 2004. U.S. Ocean Action Plan: The Bush Administration's Response to the U.S. Commission on Ocean Policy, 39 pp. http://ocean.ceq.gov/actionplan.pdf

Field, J.G., G.Hempel, and C.P. Summerhayes. 2002. Oceans 2020: Science, Trends, and the Challenge of Sustainability. Island Press, Washington, D.C. 365 pp.

Intergovernmental Oceanographic Commission [IOC]. 1984. Ocean Science for the Year 2000. Paris: Intergovernmental Oceanographic Commission, UNESCO.

Murawski, S.A. 2006. Top 10 Myths Concerning Ecosystem Approaches to Ocean Resource Management. 7th Meeting, United Nations Open-Ended Informal Consultative Process on Oceans and the Law of the Sea, Panel Discussion: "Demystifying Ecosystem Approaches and Oceans" June 12-16, 2006, New York. 5 pp.

National Oceanic and Atmospheric Administration [NOAA]. 2004. New Priorities for the 21st Century- NOAA's Strategic Plan: Updated for FY 2005- FY 2010, 28 pp.

National Oceanic and Atmospheric Administration [NOAA]. 2005. Research in NOAA: Towards Understanding and Predicting Earth's environment – A five-year plan: Fiscal years 2005-2009, 54 pp.

Rice, J.C. 2005. Implementation of the Ecosystem Approach to Fisheries Management – Asynchronous co-evolution at the Interface Between Science and Policy. In: Browman, H.I., and K.I. Stergiou. (eds.) Politics and socio-economics of ecosystem-based approaches to the management of marine resources. Marine Ecology Progress Series 275: 265-270.

U.S. Commission on Ocean Policy [USCOP]. 2004. An Ocean Blueprint for the 21st Century, 676 pp.
http://oceancommission.gov/documents/full_color_rpt/welcome.html#full

APPENDIX 3. EETT/IETT MEMBERS AND LIST OF PERSONS CONTACTED AND MEETINGS ATTENDED

A. List of eETT and iETT Members

eETT Members	***iETT Members***
Dave Fluharty - chair	Steve Murawski - chair
Jake Rice - rapporteur	Peter Ortner – vice chair
Mark Abbott	Gary Matlock - NOS
Mike Donahue	Kristen Koch, - OAR
Russ Davis	Mark Holliday - NMFS
Stephanie Madsen	Mel Gelman - NWS
Jon Sutinen	Mike Ford – PPI
Terry Quinn	Erik Cornellier – PA&E

Staff: Kirsten Larsen, NMFS.
Laura Bozzi, SAB [Knauss Fellow]
Kristen Laursen [Knauss Fellow]

B. List of Contacts

The eETT members appreciate the time that NOAA people and others gave us as we tried to take the pulse of a very large agency. Due to time and schedule constraints it was not possible to perform a systematic set of site visits nor were we able to sample all programs in NOAA. Anyone who reviews the list below will discover that it is an eclectic mix of people we identify. Still it is consistent with the request of NOAA to sample its vast enterprise, consult with partners and to explore external perspectives at the international level and the academic and stakeholder level. Many more contacts were made than reported here but mostly on an informal basis.

A contact as defined for this list is a meeting or telephone conversation specific to the task of the eETT between one or more respondents and one or more Task Team members. These contacts ranged from as little as 15 minutes to several hours. Most were based on a formal set of questions but informal interactions around these themes also yielded important information.

In addition to the individual contacts, eETT members attended a number of professional meetings and were invited to attend meetings of various NOAA components. It was invaluable to see how NOAA presents itself at professional meetings and to observe how the nitty-gritty of agency planning actually takes place. At some of these meetings it was possible to make presentations of the work of the eETT. Work in progress is not as interesting as final results in terms of catching public sentiment. Further, there is not a lot of excitement generated by reviewing organization charts among the public, however, there is a lot of excitement among those whose careers are built by knowing how an agency is organized and who care deeply about better ways to meet NOAA's multiple ecosystem science responsibilities.

The list is organized alphabetically for lack of another rationale. We identify the NOAA Line Office and program wherever possible but not necessarily the title of the position. This is because we want to emphasize that input from the bench-level scientist as well as the boss is needed for development of our perspective. Any titles used are those at the time of the contact in recognition that a number of the contacts have moved to other positions over the course of this review. In this regard, we want to thank again the iETT members and the NOAA authors and reviewers of the White Papers (Appendix 2). We apologize in advance to anyone who may have participated in a meeting or on a conference call whose contribution is not noted below.

Susan Abbott-Jamieson, NMFS, Fisheries Statistics and Economics Division
Tundi Agardy, Sound Seas, Washington, DC
Jackie Alder, University of British Columbia, Sea Around Us Project, Vancouver, CAN
Michael Belaev, PICES, National Marine Resources Committee, Moscow, Russia
Heather Brandon, Ocean Policy Coordinator, Office of the Governor, Alaska
Douglas Brown, NOS, Coasts and Marine Resources Program
Leon Cammen, OAR
Marie Colton, NOS, Technical Director
Ned Cyr, NOAA Climate/Fisheries
Penny Dalton, previously CORE, Washington Sea Grant
Douglas DeMaster, NMFS, Alaska Fishery Science Center
William J. Douros, NOS, Monterey Bay National Marine Sanctuary
Michael J. Dowgiallo, NOS, NCCOS
Louie Echols, Washington Sea Grant
William Fox, NMFS, Southwest Fishery Science Center
Beth Fulton, CSIRO Marine Research, Australia
Michael H. Fulton, NOS, Center for Coastal Environmental Health and Biomolecular Research
Marc Hershman, US Commission on Ocean Policy, School of Marine Affairs, University of Washington
Molly McCammon, AOOS
Steve Gittings, NOS, Marine Sanctuaries Division
Mary Glackin, Assistant Administrator for Program Planning and Integration at NOAA
Alf Håkon Hoel, University of Tromsø, Norway
David Jansen, House Resources Committee, Fisheries and Oceans Subcommittee
David Johnson, NOS, Center for Coastal Fisheries Habitat Research
James Kendall, DOI, Minerals Management Service
Gene Kim, Knauss Fellow, House Resources Committee

Suam Kim, PICES, Pukyong National University, Pusan, Korea
Chester J. Koblinsky, OAR, Climate Program
Ants Leetma, OAR, GFDL
Sandy MacDonald, OAR Executive
Robert E. Magnien, Director, Center for Sponsored Coastal Ocean Research
James Mahoney, Assistant Secretary of Commerce for Oceans and Atmosphere and NOAA Deputy Administrator
Garry Mayer, NMFS, Habitat Conservation Program [NOS, Coral Advisory Bd.]
Ana Parma, Centro Nacional Patagonico, Argentina
Clarence Pautzke, North Pacific Research Board
Robert Pavia, NOS, Special Assignment, West Coast Ecosystems
R. Ian Perry, PICES Secretariat
Richard Rosen, Assistant Administrator for Oceanic and Atmospheric Research and Chair NOAA Research Council
Mary Ruckelshaus, NMFS, Northwest Fishery Science Center
Paul Sandifer, US Commission on Ocean Policy
Edward Sarachik, University of Washington, JISAO, Seattle
Kitty Simonds, Executive Director, Western Pacific Fishery Management Council
Richard Spinrad, OAR Executive
John Stein, NMFS, Northwest Fishery Science Center
Kevin Stokes, Chief Scientist, Seafood Industry Council, New Zealand
Ole Tougaard, Fisheries Directorate, European Union, Brussels
Usha Varanasi, NMFS, Director, Northwest Fishery Science Center
Charles Wahle, NOS, MPA Science Center
David Whaley, House Resources Committee, Fisheries and Oceans Subcommittee
David Witherell, Deputy Director, North Pacific Fishery Management Council
Emily Woglom, Office of Management and Budget
Warren Wooster, Professor Emeritus, School of Marine Affairs, University of Washington
Ruth Yender, NOS
Konstantin Zgurovsky, WWF, Far Eastern Branch, Vladivostok
Chang Ik Zhang, Presidential Commission on Policy Planning and Pukyong University, Korea

C. List of Meetings

Coastal Zone 05, New Orleans 2005
American Fisheries Society, Anchorage, 2005
NPFMC Ecosystem Committee, Scientific and Statistical Committee
NAS Ocean Studies Board Meeting, Woods Hole, 2005
NMFS Science Board, Pacific Grove 2005
NMFS Fishery Science Laboratory Deputy Directors, Seattle 2005
PICES Vladivostok 2005
NMSP/NCCOS Meeting, Monterey 2005
NOAA Science Advisory Board, June, August, November 2005
NOAA SAB Research Review Team 2005

APPENDIX 4. PARTIAL LISTING OF LEGISLATIVE REQUIREMENTS MANDATING NOAA'S ECOSYSTEM SCIENCE PROGRAMS

- Magnuson-Stevens Fishery Conservation and Management Act (1976, 1996)
- Marine Mammal Protection Act
- Endangered Species Act
- National Marine Sanctuary Act
- Coastal Zone Management Act of 1972, Coastal Zone Act Amendments of 1990
- Coral Reef Conservation Act of 2000
- Clean Water Act
- National Environmental Policy Act
- Harmful Algal Bloom and Hypoxia Research and Control Act of 1998
- Comprehensive Environmental Response, Compensation, and Liability Act
- Energy Policy Act of 2005
- Information Quality Act
- Estuary Restoration Act of 2000 (ERA):
- National Sea Grant College Program Act
- Oceans and Human Health Act
- National Aquaculture Act of 1980
- Ocean Dumping Act (Title II of the Marine Protection, Research, and Sanctuaries Act)
- National Coastal Monitoring Act
- Water Resources Development Act of 1992
- Coastal Wetlands Planning, Protection, and Restoration Act
- Pollution Prevention and Control Act
- Federal Power Act
- Fish and Wildlife Coordination Act
- Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990
- Whaling Convention Act
- Coastal Ocean Program, § 201(c) of Public Law 102-567
- Government Performance and Results Act
- Global Change Research Act
- National Materials and Minerals Policy Research and Development Act
- Oil Pollution Act
- Atlantic Coastal Fishery Cooperative Management Act
- Northern Pacific Halibut Act
- Atlantic Tunas Convention / International Convention for the Conservation of Atlantic Tunas
- Interjurisdictional Fisheries Act of 1986 / Anadromous Fish Conservation Act 1965 (AFCA)
- High Seas Fishing Compliance Act
- Tuna Conventions Act of 1950 Agreement on the International Dolphin Conservation Program
- Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR)
- PICES Treaty (North Pacific Marine Science Organization), ratified December 6, 1991
- ICES Treaty
- NAFO Treaty
- USA-Canada Whiting Treaty
- North Atlantic Salmon Conservation Organization Treaty
- International Whaling Commission Treaty
- Convention on Conservation and Management of Pollock Resources in the Central Bering Sea
- Pacific Salmon Treaty Act of 1985
- National Oceanic and Atmospheric Administration Authorization Act of 1992

APPENDIX 5. NOAA'S INTEGRATED ASSESSMENTS AND ECOSYSTEM APPROACHES

INTEGRATED ASSESSMENTS

These are illustrations of the work being done now to place assessments of specific ecosystem features into greater ecosystem contents. Although these fall short of the integrated ecosystem assessments envisioned by the eETT they illustrate that process of moving assessments to a greater ecosystem scope are already underway in NOAA.

Gulf of Mexico

An Integrated Assessment of Hypoxia in the Northern Gulf of Mexico
This assessment summarizes the state of knowledge of the extent, characteristics, causes, and effects of hypoxia in the northern Gulf of Mexico. It outlines a range of approaches for reducing those effects and examines the costs and benefits associated with those approaches. It also describes additional research and monitoring needed to reduce uncertainties, to track progress following any mitigation efforts, and to identify potential future adjustments to any initial actions that may be taken to reduce hypoxia and improve water quality. Source -- http://www.nos.noaa.gov/products/pubs_hypox.html#fia

National Coastal Condition Report II (2005): Chapter 9 – Health of Galveston Bay for Human Use
This final chapter of the NCCR assesses the health of an estuary based on its ability to meet society's desired uses. Using Galveston Bay (the largest estuary on the Texas coast) as an example, this chapter examines the following questions: 1) What are society's stated uses for this system; 2) How well are those uses being met; 3) In instances in which a particular use is not being achieved to the desired level, are there relationships between the impairment and the NCCR indicators? If so, how might improving one or more of the indicators affect a particular use? Addressing estuarine health in this manner can help researchers interpret existing data in terms of an estuary's ability to meet society's desired uses, as well as drive the collection of new data directly related to perceived problems. Source --
http://www.epa.gov/owowwtr1/oceans/nccr/2005/Chapter9_GalvestonBay.pdf

Southeast

An Integrated Assessment of the Introduction of Lionfish (Pterois volitans/miles complex) to the Western Atlantic Ocean
This assessment summarizes what is known about the introduction of lionfish, to identify the potential effects on marine ecosystems, to discuss management and policies related to the introduction of lionfish, and more generally, to address the threat of marine fish invasive species. Source -- http://coastalscience.noaa.gov/documents/lionfish_ia.pdf

National

An Assessment of Coastal Hypoxia and Eutrophication in U.S. Waters
The assessment examines the ecological and economic consequences of hypoxia in United States coastal waters; alternatives for reducing, mitigating, and controlling hypoxia; and the social and economic costs and benefits of such alternatives. Source -- http://coastalscience.noaa.gov/documents/coastalhypoxia.pdf

The State of Coral Reef Ecosystems of the United States and Pacific Freely Associated States 2002
In response to growing concerns about the condition of reefs, the United States Coral Reef Task Force (USCRTF) called for a nationally-coordinated mapping and monitoring program to help track and evaluate the condition of U.S. coral reefs and report to the Nation every two years. This report is the first effort to collect consistent, comparable scientific information to assess the status of coral reef health. This report assesses the condition of reef resources, ranks the relative importance of environmental pressures that have degraded reefs, highlights significant actions taken by USCRTF agencies to conserve coral reef ecosystems, and provides recommendations from coral reef managers to fill information gaps. It forms a baseline against which future assessments will be compared, allowing scientists to track and ultimately predict changes in reef conditions. Source -- http://coastalscience.noaa.gov/documents/status_coralreef.pdf

The State of Coral Reef Ecosystems of the United States and Pacific Freely Associated States: 2005
The purpose of this report is to provide an assessment of the current condition of coral reef ecosystems in U.S. jurisdictions. The report focuses primarily on shallow-water portions of these states and territories, from the shoreline to the maximum depth at which sunlight dependent corals can survive. Information is provided on the geographic distribution of reefs; the understanding of the 13 key natural and anthropogenic threats; existing monitoring programs, methodologies, and data; current management actions; and summary of the status each jurisdiction's coral reef ecosystems. Source -- http://ccma.nos.noaa.gov/ecosystems/coralreef/coral_report_2005/

National Assessment of Harmful Algal Blooms in US Waters
The assessment presents a synthesis of current research and management expertise on the causes, consequences, and current status of harmful algal blooms (HABs) nationwide and presents alternatives and recommendations for addressing HABs and their impacts. This assessment was developed by the Task Force on Harmful Bloom and Hypoxia under the National Science and Technology Council (NSTC) Committee on Environment and Natural Resources (CENR). It was a multi-agency, multi-disciplinary effort that included input from States, Indian tribes, industry, nonprofit organizations, and other stakeholders. Source -- http://www.cop.noaa.gov/pubs/habhrca/Nat_Assess_HABs.pdf

ECOSYSTEM APPROACHES

The incorporation of more general ecosystem principles into traditional management approaches for coastal and marine issues has progressed substantially in recent years. In particular, ecosystem approaches to fisheries management have progressed from the theoretical to the implementation stage. This has occurred because of the growing realization that fisheries management is imbedded in a larger set of ocean policy decision making involving living marine resources and attributes of their supporting ecosystems. Efforts to include ecosystem attributes in fisheries are occurring world-wide, and "best practices" are being shared among programs operating in the eastern and western Atlantic oceans, the north and western Pacific, in Antarctica, and elsewhere. General principles, goals, and objectives for the inclusion of ecosystem considerations in fisheries have been articulated at the international level (e.g., by the United Nations Food and Agriculture Organization [FAO], and other regional bodies including ICES, PICES and others). In the United States, numerous national and regional efforts have begun that have articulated the general approaches and are beginning to adapt them to particular fishery applications (See White Paper 2 in Appendix 2). Highlighted below are a few recent examples of the incorporation of ecosystem considerations in management.

Ecosystem Approaches at the International Level

The Food and Agriculture Organization of the UN has actively pursued the establishment of guidelines to implement ecosystem approaches to management as part of its oversight of regional fishery management organizations. These principles are consistent with those recommended above for the USA national level. As part of the United Nations Food and Agriculture Organization's (FAO) long-term planning for ecosystem approaches, they have provided various documents aimed at technical experts and a variety of lay audiences to encourage the concepts. Consistent with recommendations in our report, FAO notes that key research requirements for an ecosystem approach include: (1) conducting fishery and ecosystem impact assessments, (2) evaluating socio-economic considerations, (3) assessment of the efficacy of proposed management measures, (4) assessment and improvement of management measures, and (5) long-term monitoring including practical sets of indicators and reference points.
http://www.fao.org/fi/nems/news/detail_news.asp?lang=en&event_id=34029

Ecosystem Approaches at the National Level (US)

Ecosystem Principles US

The re-authorization of the Magnuson-Stevens Fishery Conservation and Management Act in 1996 required NOAA to compile a report assessing the extent to which ecosystem principles have been used in fisheries management and how such principles can be further implement to improve management of living marine resources. The full report, published in 1999 emphasized the importance of compiling explicit ecosystem plans underpinning fishery management programs, and described six actions to implement such plans, including: (1) encouraging managers to apply ecosystem principles, goals, and policies, (2) providing training to managers and staff, (3) preparing guidelines for fishery ecosystem plans, (4) developing pilot programs, (5) providing oversight to ensure development and compliance, and (6) enacting legislation enabling fishery ecosystem plans. The ecosystem principles are described in detail in: http://www.st.nmfs.gov/st7/documents/epap_report.pdf

Our Living Oceans

Periodically, NMFS releases a comprehensive assessment of the status of fishery populations and protected species assessed by the Agency. This report provides a comprehensive assessment of the status of biological populations, in relation to a number of human factors such as fishing, habitat change and ocean variability that influenced biological resources. http://www.st.nmfs.gov/st2/pdf.htm

Ecosystem Approaches at the Regional Level US

There is a growing body of regional applications of ecosystem principles in fisheries management in various parts of the United States. Some of these are occurring at the federal level, and many at the state or inter-state level. Below are a few examples of ecosystem principles being incorporated in domestic management.

Chesapeake Bay

States bordering the Chesapeake Bay have long noted the interrelationships among commercial species in the Chesapeake Bay, including oysters, blue crab, striped bass, menhaden, and other species. The world's largest estuary is home to a variety of life stages of these and numerous other species. Predator prey relationships among the species are critical characteristics of the ecosystem. Optimal management of the Bay's resources will increasingly depend on understanding the trophic dynamics among the managed species and other biota. As well, the bay watershed drains immense agricultural and urban areas. Nutrient pollution is a significant issue, and so ecosystem principles underpinning integrated management of the Bay's resources are critical components of balancing human and resource needs. NOAA's Chesapeake Bay office, using a broad scientific and stakeholder process developed a prototype fisheries ecosystem plan as a means to focus discussion of using current understanding of the Chesapeake Bay ecosystem http://noaa.chesapeakebay.net/docs/FEP_DRAFT.pdf.

Puget Sound Ecosystem Research Plan Initiative

The ecosystem of Puget Sound is home to a vast array of living resources, including indigenous runs of salmonids, marine mammal populations, including killer whales, and numerous other populations of finfishes, invertebrates, and mammals. Given the growing human population adjacent to the sound, and the land-based resource industries (agriculture and forestry), shoreline modification and other activities serious declines have been noted in conditions for sustaining the living resources of Puget Sound. Integrated assessment and management of the Sound's resources is seen as imperative. To address these needs, a number of state and federal agencies and local conservation organizations and municipalities have been developing ecosystem approaches to conservation planning in the Sound, e.g. the Shared Strategy for Salmon Recovery (http://www.nwr.noaa.gov/Salmon-Recovery-Planning/ESA-Recovery-Plans/Draft-Plans.cfm), Governor's Puget Sound Partnership http://www.psat.wa.gov and the Nearshore Strategy Initiative. These efforts will integrate endangered species recovery planning in the matrix of multiple use planning for the area. NOAA is contributing to these efforts in a variety of ways but most directly it is taking the lead through its Northwest Fishery Science Center to convene regional science and management agencies and groups develop a synthesis document for ecological and socio-economic information as a starting point for diagnosing problems and solution and developing an ecosystem research plan (http://www.nwfsc.noaa.gov). Academic institutions have developed other synthetic data sets on which and ecosystem approach can be built, e.g., PRISM(http://www.prism.washington.edu/regionalissues/category.jsp?keywords=REGNLS&category=Ecosystem%20Research%20and%20Management.

Western Pacific Fishery Management Council
The Western Pacific Council (responsible for the Hawaiian Islands and a variety of island archipelagos in the Pacific) is in the process of developing archipelagic fishery ecosystem plans that would eventually replace its separate Pacific-wide fishery management plans for coral reef fish, precious corals, bottomfish, seamount groundfish, and crustaceans. These plans outline how bottomfish, coral conservation, and socio-economic considerations can be integrated in a geographically explicit series of plans (e.g., for the Mariana Archipelago, the Hawaiian Island Archipelago, Samoa Islands, Guam, and the Pacific Remote Islands). Large pelagics would continue to be managed on a Pacific-wide basis given the scale of their ecosystem migrations http://www.wpcouncil.org/.

Alaska Region
The North Pacific Fishery Management Council has been at the forefront of implementing ecosystem considerations into its fishery management plans (See Appendix 2 White Paper 2). In particular, the NPFMC has incorporated conservation of cold water coral habitats by implementing fishery closed areas explicitly to protect these fragile habitats. Other habitats of particular concern have been reserved from fishing activities, for various purposes including integrated management of protected species including sea lions and other mammals. Multiple ecosystem-based measures including reduction of bycatch, accounting for trophic relationships among species, and conservative long-term management approaches have been part of its ecosystem approach. The Council routinely summarized a wide variety of ecosystem data and indicators as part of its annual groundfish management planning. More recently, the Council, in concert with the State of Alaska and stakeholder groups, has been considering how to implement area-based ecosystem plans (e.g., for the Aleutians and other defined areas) http://www.fakr.noaa.gov/npfmc/current_issues/ecosystem/Ecosystem.htm

Atlantic Seaboard and Gulf of Mexico
As part of the 2004 NOAA budget, Congress included $2 million to advance ecosystem approaches for the four fishery management councils in the Atlantic and Gulf. As part of this project each of four councils (New England, Middle Atlantic, South Atlantic, and Gulf of Mexico) were provided funding to survey and understand ecosystem issues

relevant to their activities. These reports are being compiled by the various Councils now, and identify the particular issues in their respective areas requiring ecosystem approaches to management. Ongoing work in the Gulf of Mexico as part of this project is described in:
http://www.gulfcouncil.org/downloads/GMFMC%20Ecosystem%20Fisheries%20Management%20Report.pdf

Northeast
In the Northeast, the NMFS Northeast Fisheries Science Center has produced periodic assessments of a variety of ecosystem indicators, and is conducting research on the adequacy of indicators for determining the status of the NE shelf ecosystem : http://www.nefsc.noaa.gov/nefsc/publications/crd/crd0211/

These few examples cited above are not meant to be a comprehensive assessment of the state of implementation of ecosystem approaches to fisheries management either nationally or internationally. They do illustrate, however, as a sector, that fisheries has embraced the concepts inherent in ecosystem approaches and that fisheries managers are attempting to develop these concepts into workable regional implementations.

APPENDIX 6. TECHNICAL ANALYSES: NOAA TOXICOLOGY AND CONTAMINANTS EXPERTISE

NMFS: Three Science Centers have ecotoxicology or marine chemistry programs to provide a variety of services, including:

The Northwest Fisheries Science Center (Seattle) program assesses various problems associated with urbanized coastal areas, harmful algal blooms, and monitoring following specific events such as Exxon Valdez and Katrina:
http://www.nwfsc.noaa.gov/research/divisions/ec/index.cfm
http://www.nwfsc.noaa.gov/research/divisions/ec/ecotox/index.cfm

Auke Bay (Alaska) Laboratory of Alaska Fisheries Science Center provides ongoing surveillance for Exxon Valdez and various habitat conservation programs:
http://www.afsc.noaa.gov/abl/OilSpill/oilspill.htm

The Northeast Fisheries Science Center, Highlands NJ Laboratory maintains a marine chemistry program assessing problems of urban contamination, ocean dumping effects and habitat issues
http://www.nefsc.noaa.gov/epd/marchem/

National Seafood Inspection Laboratory (located prior to hurricane Katrina at the Pascagoula Fisheries Laboratory, provides a variety of technical monitoring functions supporting seafood safety
http://www.nmfs.noaa.gov/sfa/sfweb/nsil/index.htm

Aquatic animal health is a program maintained by the Protected Resources Office and focuses on contamination effects related to protected species recovery
http://www.nmfs.noaa.gov/pr/health/

NOS: Multiple NOS programs focus on marine contamination programs related to coastal runoff, habitat quality, general surveillance, and oceans and human health. Additionally, harmful algal blooms and other toxic event sampling are a significant focus of these programs:
http://0-oceanservice.noaa.gov.library.unl.edu/topics/coasts/contaminants/welcome.html

The Center for Coastal Monitoring and Assessment supports the National Status and Trends Program, which includes the Mussel Watch and Benthic Surveillance programs:
http://ccma.nos.noaa.gov/cit/data/ These programs provide long-term monitoring for contamination, as well as additional sampling when specific events occur. It is important to have such baselines in order to measure success of pollution abatement programs.

NOS's Office of Response and Restoration (OR&R) protects the coastal environment from oil spills and hazardous waste sites, and restores damaged natural resources.
http://0-response.restoration.noaa.gov.library.unl.edu/

OAR: OAR's Great Lakes Environmental Research Laboratory (GLERL) supports a variety of programs focused contamination issues both in the Great Lakes, and elsewhere, including Chesapeake Bay:
http://www.glerl.noaa.gov/res/Programs/aqmain.html

Additionally, OAR provides support for air borne sources of contamination through its Air Resources Laboratory

Sea Grant: Individual Sea Grant programs have a focus which includes emphasis on toxicology and contamination programs, for example:
http://www.seagrant.sunysb.edu/HEP/library.htm

Additionally, OAR provides support for air borne sources of contamination through its Air Resources Laboratory:
http://www.arl.noaa.gov/research/programs/airmon.html

Cross NOAA Programs:

A recent large scale initiative related to Oceans and Human Health (OHHI) has brought three line offices together to provide institutional coordination, including NOS (Charleston), OAR (GLERL, Ann Arbor), and NMFS (NWFSC, Seattle):
http://www.ogp.noaa.gov/mpe/ohi/