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Marine ecosystem approaches to management: challenges and lessons in the United States

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Abstract

This study examined how the United States' largest marine resource management agency, the National Oceanic and Atmospheric Administration (NOAA), has begun to change its management strategy away from traditional marine resource management approaches towards an Ecosystem Approach to Management (EAM). Surveys were conducted with 57 NOAA scientists and resource managers in nine NOAA programs in 8 different geographic regions across the United States in 2005. A qualitative analysis examined the attitudes and experiences of participants with respect to implementing EAM and identified four major challenges to enhancing cooperation and understanding of EAM. We conclude with recommendations for concrete initiatives that future efforts in EAM that any management agency can undertake to facilitate further ecosystem management opportunities.

Keywords: Marine policy; Ecosystem management; NOAA; Ecosystem; Management strategies; Ocean policy

1. Introduction

Ecosystem approaches to management (EAM) has been heralded as the expansive, holistic method needed to manage natural resources in an increasingly stressed natural world [1,2]. Although the concept of ecosystem management continues to evolve, the main thrust of this strategy is the inclusion of humans in an integrated view of managing resources while sustaining ecological integrity [3,4]. The challenge in implementing EAM is how to accommodate competing interests while sustaining productive, resilient, and healthy marine ecosystems [2,5]. The practical applications of this strategy are not yet completely defined, but the philosophical shift towards EAM has begun. EAM requires looking at the big picture, beyond traditional management agency boundaries, and working closely with other resource managers, both public and private. It requires addressing the long-term consequences of today's decisions, and it means thinking of various resources as interrelating parts of systems rather than as individual components to be separately managed. It means awareness of many scales of effect, from local and national to international and even global.

The United States' National Oceanic and Atmospheric Administration (NOAA), a federal science agency located within the US Department of Commerce, conducts research and gathers data about the global oceans, atmosphere, space, and sun. The United States (US) has an ocean territory of over 4 million square miles making it the largest in the world. NOAA was established in 1970 in response to the United States' need for "exploration and development leading to the intelligent use of our marine resources—we must understand the nature of these resources, and assure their development without either contaminating the marine environment or upsetting its balance" [6]. Although the idea of managing entire ecosystems is not new [1], official adoption of this strategy amongst US federal agencies has only occurred more recently. NOAA officially adopted an EAM after a 1992 Interagency Task Force recommended that government agencies adopt it to more effectively manage the resources for which it is responsible [7]. NOAA's implementation of

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EAM would represent not only a shift in the tools and techniques used to manage marine resources, but also a complete reorientation of NOAA's collaboration with other agencies and partners. The difficulty in this shift is at least partially due to the fact that NOAA, like many US federal and state agencies, is a mission-driven agency with diverse responsibilities ranging from preserving and conserving resources, to regulating and promoting commerce. Although much of the experience of regional planning and management of ecosystems has not taken place under the banner of EAM, there are many positive examples and efforts from which to learn. In this paper we use NOAA as an example of how a large federal organization within the United States has transitioned to operationalize EAM. The challenges and lessons learned by this agency are immediately relevant to any large government or non-government agency wishing to develop an EAM strategy. As noted by others [8], EAM policy adoption is not the same as policy implementation, and NOAA has, like others, faced challenges in incorporating new practices in its management style and on-the-ground policy approaches.

Under the Oceans Act of 2000 (P.L. 106–256), a16-member US Commission on Ocean Policy (USCOP) was established with the goal of making recommendations to the President and Congress for a national ocean policy for the United States. The USCOP's Policy recommendations were written in the form of the United States Ocean Action Plan (USOAP) [9]. In 2004, NOAA began a renewed transition towards EAM after the USOAP firmly endorsed the importance of focusing on EAM. Specifically, the USOAP called for a more integrated, comprehensive approach to management of our nation's coasts and oceans. Paramount among the report's recommendations was a movement toward ecosystem-based management of coastal and marine resources. In accordance with the USOAP, NOAA developed a Strategic Plan (2004) that incorporated specific guidance for an EAM approach. NOAA defines an ecosystem approach to management (EAM) as:

> An ecosystem approach to management (EAM) is one that provides a comprehensive framework for living resource decision marking. In contrast to individual species or single issue management, EAM considers a wider range of relevant ecological, environmental, and human factors bearing a 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 [10,11].

Ecosystem science in NOAA is comprised of a broad set of monitoring, research, and advisory services, implemented to meet the many statutory mandates for aquatic resource and coastal management for which NOAA is responsible. As EAM becomes more commonplace and better integrated into the management strategies within NOAA, a better balance in resource management, ecosystem integrity, and commerce continues evolve. NOAA's progress towards implementing EAM more effectively provides insight for local, regional and international agencies interested in natural resource management into the challenges and lessons learned by a multidisciplinary and multifaceted agency. The lessons learned from this survey and NOAA's experience might prove useful to agencies that are currently adopting an EAM as well as those that might choose to do so in the future.

As EAM evolves within NOAA's organization, it continues to work towards better integrating its' dual responsibilities of protecting ecosystem integrity while also promoting commerce. The balance between the management strategies used to meet these goals continues to be defined, debated, and refined. The goal of our study was to identify the challenges NOAA faces in implementing EAM, to gauge its progress towards implementing this policy, and to provide examples of some of the policy tools and lessons learned during its implementation.

2. Methodology

In 2005, NOAA asked the nine programs uniquely associated with ecosystem science and management within NOAA to participate in a survey of the initiatives that constitute EAM. The survey was composed of 12 open ended questions and one categorically based question directed to managers and field scientists involved in integrated management. At the time of the survey, NOAA did not have a written EAM execution policy on how to plan or implement ecosystem approaches. Therefore, the survey participants were provided with the working NOAA definition of EAM and asked to submit input on efforts which involve "the integration of various components of EAM while taking a holistic view of a specified geographic area, involving multiple disciplines, sectors (e.g. fisheries, coastal management, water quality, habitat, etc.) and partners". Survey responses ($n = 66$) were included based on the respondent's judgment that their reported activities truly reflected an ecosystem approach.

The survey questions solicited information specific to NOAA's ecosystem-related activities that met the current NOAA EAM definition, or activities utilizing many of the

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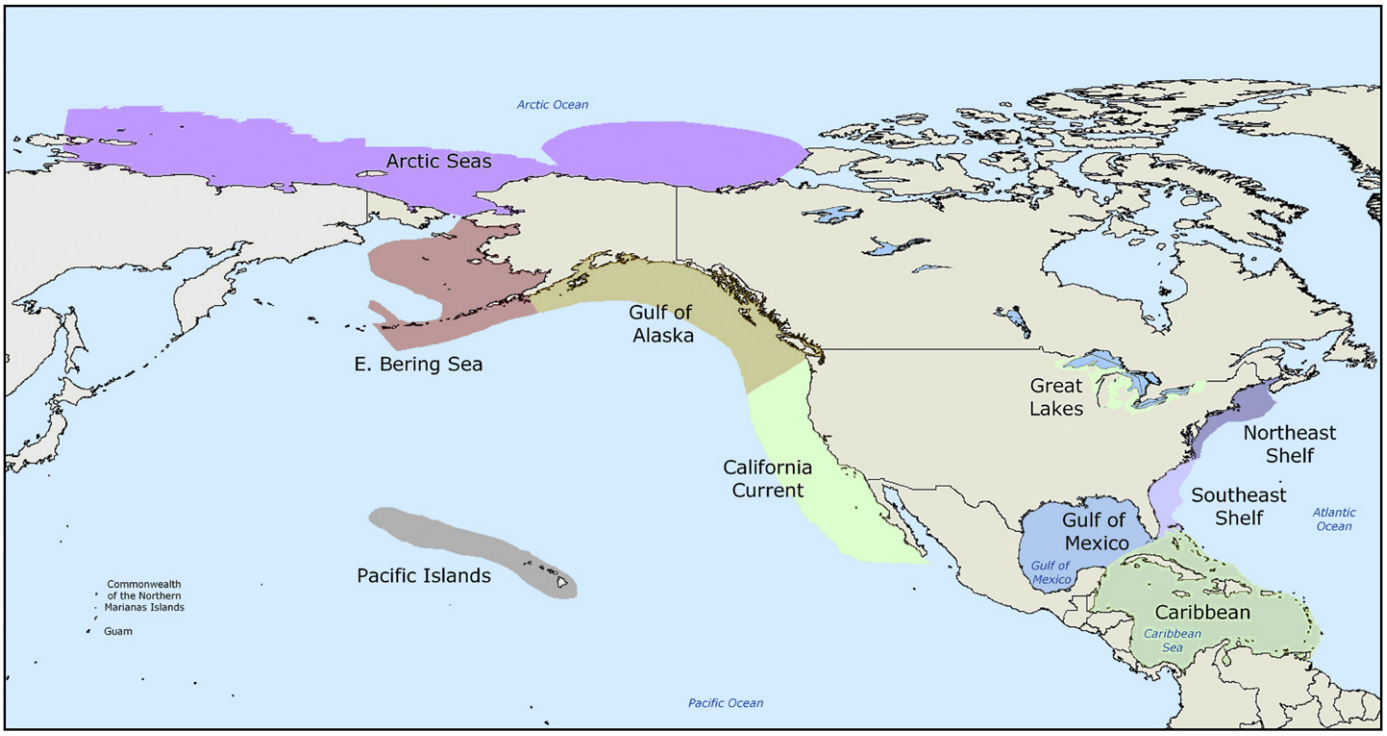

Fig. 1. NOAA Ecosystems of the United States.

characteristics of EAM as defined by NOAA. The survey sought to:

1. identify actions used in implementing EAM,
2. quantify and highlight the challenges that NOAA faces in implementing EAM,
3. identify which programs would benefit most from additional resources to advance EAM activities, and
4. qualify and describe the lessons learned from NOAA's past and present experiences in implementing EAM.

A content analysis of key words/phrases from the survey responses was performed in order to group responses by reported "challenges" faced in implementing an EAM project. In collaboration with academic, NGO, And US federal and state partners; NOAA delineated 8 regional ecosystems that represent geographically specified management areas [12]. The 8 geographic regions included in the survey were the: Northeast US continental shelf, Southeast continental shelf, Gulf of Mexico, California current, Alaska ecosystem complex, Pacific Islands, Great Lakes, and the Caribbean ecosystem (Fig. 1)

3. Results and discussion

3.1. Challenges to implementing EAM

A content analysis identified 4 challenges to enhancing cooperation and understanding of EAM consistently reported throughout different levels of management and various geographic regions. The four challenging factors identified were: (1) integrating varying forms of science ($n = 30$), (2) encouraging and managing partnerships ($n = 35$), (3) funding restraints ($n = 35$) and 4) lack of "big-picture" thinking ($n = 20$). We describe and analyze these issues in terms of determining common policy goals and management priorities while developing a communication system between collaborators.

3.1.1. Challenge 1: integrating the science

Respondents reported a dual concern with respect to the integration of varying forms of science into EAM. The first challenge identified was the need to more successfully integrate the social aspects of resource management with its already strong natural science capabilities. Although NOAA is progressing rapidly in developing ecosystem tools and products to facilitate improved ecosystem management capabilities, the development of social science capabilities has moved at a slower pace. The human dimension of governing ecosystems and conducting ecosystem research is an important factor in ensuring comprehensive understanding of any ecosystem [10,13].

NOAA, like many natural resource agencies, lacks a strong social science arm that effectively advises natural resource managers how to integrate social aspects into its marine policy. There is a strong need to incorporate societal objectives into policy, implementation, and management decisions [11], and a corresponding need for more active constituent involvement in establishing priorities in order to encourage sustainability and create consensual stewardship behaviors [11].

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The other aspect of integrating science is a lack of synthesis of the science being conducted amongst multiple disciplines that contribute to ecosystem management. NOAA has begun to address this problem by adopting Integrated Ecosystem Assessments (IEA) as a way to compile large, complex data sets from both natural and social scientists into a single assessment, while involving multiple internally and externally generated sciences. The products from an IEA include ecosystem models and forecasts (e.g. food web dynamics and species interactions, population dynamic models, risk assessment and management strategy evaluations). One large benefit of an IEA is that it establishes target levels and thresholds for important ecosystem components while also serving as a tool to evaluate the impacts of management options and risks of not attaining target ecosystem states. Reporting on the status and update of the IEA process informs managers, stakeholders and the public on the state of ecosystems and management options for achieving societal goals and values.

A successful example of a NOAA implemented IEA is the Gulf of Mexico Hypoxia Assessment, which has resulted in a better understanding of the scale of nutrient overloading and environmental contamination within the Mississippi–Atchafalaya River Basin. The goals of this assessment are to document both ecological and economic characteristics of hypoxia and compile existing information on nutrient sources, identify alternatives for reducing nutrient inputs, and examine the costs and benefits associated with reducing the nutrient loads to surface waters. Integrated assessment methodology has been the best tool to defend this intricate social, economic, and political situation in a non-biased manner. The integrated assessment options encourage considerable scientific evaluation and interpretation prior to decision-making. This form of adaptive management is an extremely important tool for EAM because it allows policy makers to make the best decision possible with research based upon the best available scientific experiments/models.

3.1.2. Challenges 2: encouraging partnerships

An institutional feeling of "protectiveness" or overlapping jurisdictions within a geographic area has been a traditional problem for resource management. In addition, the dynamic nature of ecosystems makes it difficult for rigid guidelines on either ecosystem classification or boundary delineation. While scientists may define boundaries based on ecological criteria, the geopolitical or management boundaries must also be taken into account in EAM [14].

An important component in solving the problem of integrating social and natural science includes promoting collaborations between internal and external partners. Survey respondents noted that collaboration has been difficult to implement in an atmosphere of limited funding and time, and within an organizational structure of employees spanning the United States. Adding to this problem is the fact that multiple divisions within NOAA overlap on research projects without full exchange or dialogue. For example, harmful algal blooms (HABs) may be studied by external researchers who are granted research funding from NOAA, while there is currently no formal structure for communicating these results directly to NOAA's own internal HAB research.

Internal cooperation might be improved with greater level of centralized coordination amongst management. Additionally, a better application of matrix management may help streamline some of the barriers to organizational challenges. Strategic planning and matrix management cross traditional organizational boundaries by the assembly of teams to look at complex crosscutting issues for a more integrated organization.

3.1.3. Challenge 3: funding restraints

A third major challenge reported by respondents was a lack of financial resources to pursue EAM projects. Partnering agencies have been willing to offer their support for an EAM project, but funding restraints have hindered success. Limited funding for travel has furthermore delayed or eliminated the opportunity for face-to-face meetings.

The importance of allowing unfettered communication and access to key project players cannot be underestimated. Encouraging access to member teams of EAM projects affords the opportunity to leverage an immense amount of expertise and resources that no one agency could offer independently. Although reports and databases of projects are helpful, these tools are not nearly as helpful as gathering together knowledgeable people to describe their efforts, ask questions, and attempt to understand the common threads. A lack of funding for these efforts appears to be directly linked to the fact that no formal legislation exists to force NOAA to completely enact EAM, and thus in times of reduced funding, resources are often focused on those responsibilities that NOAA must legally comply with (e.g., US Endangered Species Act).

Incorporating resources to facilitate meetings with managers from other EAM projects and other agencies would provide a different perspective on some of the challenges NOAA faces in implementing an EAM strategy. An increased utilization of Memorandums of Understanding (MOU) with other agencies to support travel and subsistence for project personnel would ease this difficulty. One such MOU is the Cooperative Ecosystem Studies Unit (CESU). Each CESU is composed of federal agencies, a host university, and partner institutions with the CESU organized around biogeographic areas. CESU's provide research, technical assistance and education to federal land management, environmental and research agencies and their partners. Membership in a CESU facilitates collaborative efforts and increases the value obtained from science dollars. The agreement reduces the time and paperwork involved in acquiring services and expertise from member universities and NGOs. An additional advantage of participating in a CESU includes

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some level of cost sharing of the project, while linking several institutions to increase access to expertise and facilities.

3.1.4. Challenge 4: "big picture" decision making

Survey respondents noted an absence of staff time to pursue tools to help agencies understand EAM principles. Survey participants also expressed the need to help other agencies see each agency's role and opportunities in addressing concerns within the ecosystem context. Portraying the picture that EAM fosters a holistic view for man in the environment and that collaboration will equal a greater summation than each individual project is an ongoing struggle in maintaining momentum during the process. Working together, communities have a greater chance to save money, pool resources, promote community quality and improve quality of life for all. A success story includes NOAA's involvement with the US Coral Reef Task Force (CRTF) which adopted a resolution in 2002 calling for the development of Local Action Strategies (LAS) by each of the seven member participants (Florida, US Virgin Islands, Puerto Rico, Hawaii, Guam, American Samoa, and the Commonwealth of the Northern Mariana Islands). The LAS are locally driven road maps for cooperative action among federal, state, territory, and non-governmental partners that identify and implement the locally relevant priority actions required to reduce key threats to valuable coral reef ecosystems. A CRTF component connects local priorities to national goals and coordinates agency actions to better support each local jurisdiction's resource management. This 'ecosystem-level' or 'big picture' thinking changes the way participants interact. Big picture decision making leads to improved community-level understanding of the potential stresses a rising population poses to the territory's coral reef health and its relation to the overall health of the community.

In addition to a broader management focus, technological advances for monitoring and managing of ecosystem variables are increasingly important. Several respondents suggested that NOAA should consider at least partially releasing its current ecosystem monitoring capabilities to collaborating universities/agencies so that it can focus on developing technologies toward increasing the efficiency of managing and conducting scientific research in these ecosystems. Technological shortfalls are inevitable as we explore dynamic ecosystems. Support for new technology may be considered a risk during limited budgets. The question is whether funds should go toward developing new technology and reliable models for improved decision making or whether projects should continue the status quo. A respondent provided an example of the danger of waiting for enough science before making decisions. "Implementation cannot wait for acquisition of scientific information because project delays erode the land area available to enable construction projects such as reservoirs, stormwater treatment areas, and restored or recreated wetlands. Each day [without a decision] there is a loss of opportunity to make the land acquisition to support project designs." Adaptive management, realistic timetables and flexibility in project design can serve as a remedy for uncertainty in decision making.

3.2. Future directions and conclusions

Our results indicate progress in putting EAM principles into practice, but implementation needs to be much greater. Ecosystem management strategies require more consideration of social/cultural conditions, population dynamics, and socio-economic factors. Ecosystem management principles are embedded in many of the 90 separate pieces of US federal legislation that gives NOAA its stewardship authorities. The evolution of EAM has become better understood in the last few years amongst resource managers and policy makers. As respondents mentioned in the survey, the collection and coordination of vast amounts of ecosystem data is needed in order to make informed ecosystem management decisions. The collection of this data is a monumental endeavor and should be primary in ecosystem management decisions. Along with coordinating people and information, leveraging funding to support the science is complicated by NOAA's complex organizational and budgeting structure. Another concern is how to operationalize ecosystem approaches across NOAA's within legislative authorities (e.g., Magnuson Stevens Fishery Management Act, Endangered Species Act, etc). We believe these problems arise from a disconnect in the various phases of the planning, programming, budgeting, and ultimately, in the overall execution of the EAM project.

One of the conclusions of NOAA's EAM project review is that many of the challenges might be rectified by identifying and strengthening the needed capabilities to deliver ecosystem science. Empirical research has stated that increased knowledge alone is not enough to ensure change [15], nor is knowledge of ecosystem approaches a means to declare EAM a success. Sound science is the cornerstone for EAM, but unless the science can be articulated and packaged in a manner to guide policy then we risk missing a chance to fully operationalize and reap the benefits of EAM implementation. The cornerstone of future success is an adaptive governance structure in which ecosystem management understanding is operationalized in day-to-day activities. In summary, three elements to foster that adaptive governance includes (1) an EAM commitment from all levels of management, (2) EAM given equal priority with legal mandates, and (3) decision-making on a broader ecosystem-level context.

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References

[1] Leopold A. A sand county almanac. New York: Oxford University Press; 1949.
[2] Grumbine RE. What is ecosystem management? Conservation Biology 1994;8:27–38.
[3] Larkin P. Concepts and issues in marine ecosystem management. Review in Fish Biology and Fisheries 1996;6:139–64.
[4] Brunner RD, Clark T. A practice-based approach to ecosystem management. Conservation Biology 1997;11:48–58.
[5] Pirot JY, Meynell PJ, Elder D. Ecosystem management: lessons from around the world. A guide for development and conservation practitioners. Gland, Switzerland and Cambridge, UK: IUCN; 2000.
[6] Nixon RM. Statement to Congress accompanying Reorganization Plan number 4 of 1970. Washington, DC: Office of the White House Press Secretary; 1970.
[7] Gore A. Reinventing environmental management. Accompanying report of the national performance review. Washington, DC: US Government Printing Office; 1993.
[8] Butler KF, Koontz TM. Theory into practice: Implementing ecosystem management objectives in the USDA Forest Service. Environmental Management 2005;35:138–50.
[9] US Ocean Action Plan (USOAP). The Bush Administration's response to the US Commission on Ocean Policy. Washington, DC: Executive Office of the President; 2004.
[10] National Oceanic and Atmospheric Administration (NOAA) Strategic Plan 2006–2011: New priorities for the 21st century. Washington, DC: U.S Department of Commerce; 2005.
[11] Murawski SA. Top 10 myths concerning ecosystem approaches to ocean resource management. Seventh meeting, United Nations open-ended informal consultative process on oceans and the law of the sea, panel discussion: "Demystifying Ecosystem Approaches and Oceans," New York: US Department of Commerce; June 12–16, 2006. 5p.
[12] National Oceanic and Atmospheric Administration, NOAA workshop on delineation of regional ecosystems. Charleston, SC; 2004. Available online 〈http://ecosystems.noaa.gov/noaa_workshop_delineation_final.htm〉
[13] US Commission on Ocean Policy (USCOP). An ocean blueprint for the 21st century. Washington, DC: US Commission on Ocean Policy; 2004. Available at: 〈www.oceancommission.gov/〉.
[14] Omernik JM. Ecoregions: A spatial framework for environmental management. In: Davis WS, Simon TS, editors. Biological assessment and criteria: tools for water resource planning and decision making. Boca Raton, FL: Lewis Publishers; 1995.
[15] Hanna JC, Moote MA. Politics of ecosystem management. Washington, DC: Island Press; 1999.

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