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Confronting the challenges of implementing marine ecosystem-based management

Heather M Leslie[1,2*] and Karen L McLeod[3]

Many services provided by coastal and marine ecosystems are in decline. Awareness of these declines and the need to improve existing management has led to a shift toward ecosystem-based approaches to marine management and conservation, both in the US and elsewhere. Marine ecosystem-based management (EBM) involves recognizing and addressing interactions among different spatial and temporal scales, within and among ecological and social systems, and among stakeholder groups and communities interested in the health and stewardship of coastal and marine areas. We discuss some overarching principles of marine EBM and highlight key challenges facing implementation. We then recommend ways in which natural and social scientists can advance implementation of ecosystem-based approaches in the oceans by addressing key research needs, building interdisciplinary scientific capacity, and synthesizing and communicating scientific knowledge to policy makers, managers, and other stakeholders.

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As highlighted recently by the Millennium Ecosystem Assessment (MA 2005), many ecosystem services provided by coastal and marine ecosystems are in decline (Figure 1). Functioning coastal and marine ecosystems provide services, such as food, fuel, timber, mineral resources, and pharmaceuticals, and play key regulating and supporting roles (eg climate regulation, nutrient cycling, and storm protection). These systems also provide opportunities for trade, recreation, tourism, research, and education, and have considerable cultural, aesthetic, and spiritual value (Figure 2).

In a nutshell:

- Marine ecosystem-based management offers an approach that can reverse the severe, widespread declines in coastal and ocean ecosystems
- Putting the concept into practice involves defining a common vision, developing appropriate governance frameworks, identifying examples of success, and evaluating when the goals of ecosystem-based management have been achieved
- Key research needs for marine ecosystem-based management include understanding the individual and cumulative impacts of disturbances on human communities and marine ecosystems and the contexts in which learning and adaptation can occur
- Tools to support marine ecosystem-based management are needed to better evaluate the impacts of human activities on marine ecosystems and to assess trade-offs among different activities and ecosystem services
- In addition to conducting new research, it is vital to synthesize existing knowledge and develop mechanisms to more effectively connect emerging science to management and policy processes

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Our understanding of the value of oceans continues to grow, as evinced by recent reports from the Pew Oceans Commission (POC 2003) and the US Commission on Ocean Policy (USCOP 2004). Both commissions emphasized the importance of moving beyond species or sector-based management and adopting a more comprehensive, ecosystem-based approach to managing coastal and ocean systems. Other countries – notably Australia, Canada, and the United Kingdom – have also recognized the inadequacy of continuing to manage oceans in a piecemeal fashion, and have begun implementing ecosystem-based approaches. At the global level, the 2002 World Summit on Sustainable Development affirmed the international community's commitment to more comprehensive, holistic approaches to marine management (WSSD 2002).

Ecosystem-based management (EBM) is an integrated approach that considers the entire ecosystem, including humans (POC 2003; USCOP 2004; McLeod *et al.* 2005). Marine EBM differs from current approaches that usually focus on a single species or sector, and includes consideration of the interactions among ecosystem components and the cumulative impacts of multiple activities. Approaches to implementing marine EBM vary, but all focus on protecting ecosystem structure, function, and key processes. There are two primary reasons why ecosystem-based approaches are preferable to the status quo. First, scientists have found overwhelming evidence that ecological interactions in coastal and ocean systems are vital to the resilience and health of these systems. When these connections are broken or severely degraded – through species loss or decline, destruction of key habitats, or change in disturbance regimes – the ability of

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coastal and marine systems to recover from disturbances, and to continue providing valued services, declines (Paine *et al.* 1998; Steneck *et al.* 2004; Hughes *et al.* 2005). Second, the current ocean management regime in the US and elsewhere has not adequately sustained coastal and ocean resources (POC 2003; USCOP 2004).

■ General principles of marine EBM

Marine EBM is about interactions: interactions among different spatial and temporal scales, within and among ecological and social systems, and among stakeholder groups and communities interested in the present and future health of coastal and marine areas. During a number of recent meetings focused on marine EBM, four key principles have been broadly agreed upon by both academics and practitioners.

Figure 1. Among the most important services provided by coastal and marine ecosystems are (a) habitat for biodiversity (including the intertidal communities that support this seastar, Pisaster ochraceus*), (b) recreational opportunities, (c) nutrient cycling, and (d) food.*

First, it is necessary to address multiple spatial and temporal scales in the design and implementation of EBM efforts. Humans use coastal and ocean resources at multiple spatial scales, and recognition of the social and biogeophysical interactions that operate across different spatial scales is vital to effective management. The same is true of temporal scales; historical use of marine ecosystems, as well as variability in environmental conditions, can have a tremendous influence on the current structure and functioning of ecological communities, and generate ecological legacies that extend into the future (Dayton *et al.* 1999; Jackson *et al.* 2001; Figure 3). Institutional legacies may be equally robust, and can set constraints on what management actions are possible in a given sociopolitical context (Folke 2006). Finally, interactions at one level can influence the dynamics at a higher level of organization, leading to surprising and sometimes unpredictable management outcomes (Levin 2006).

Second, there is increasing recognition of the linkages among marine ecosystems and the human communities that depend on these systems. Such linkages are particularly visible in coastal and nearshore areas, in the form of coastal development, tourism and recreation, and fishing. Yet even in the coastal areas with which people are most familiar, there are many "hidden" connections between humans and marine ecosystems, including key ecosystem services that tend to be overlooked. Many of these services are not directly valued or are highly undervalued by markets; nonetheless, they contribute substantially to human well-being (MA 2005). For example, the December 2004 tsunami in the Indian Ocean and Hurricane Katrina in the US highlighted the role of coastal wetlands in protecting human lives and infrastructure from storm damage (Danielsen *et al.* 2005).

Third, ocean management efforts do not begin at the "low-water mark"; it is essential to connect environmental policy and management efforts across air, land, and sea boundaries. In Chesapeake Bay, for example, this has entailed discussion not only of how the terrestrial activities in the Bay's expansive watershed impact its coastal ecosystems, but also of how the anthropogenic influences on the Bay's airshed – an atmospheric region 6.5 times the size of the watershed – contribute to water quality and other key elements of the Bay's ecosystem health (CBF 2006).

Finally, meaningful engagement with stakeholders is needed to create management initiatives that are credi-

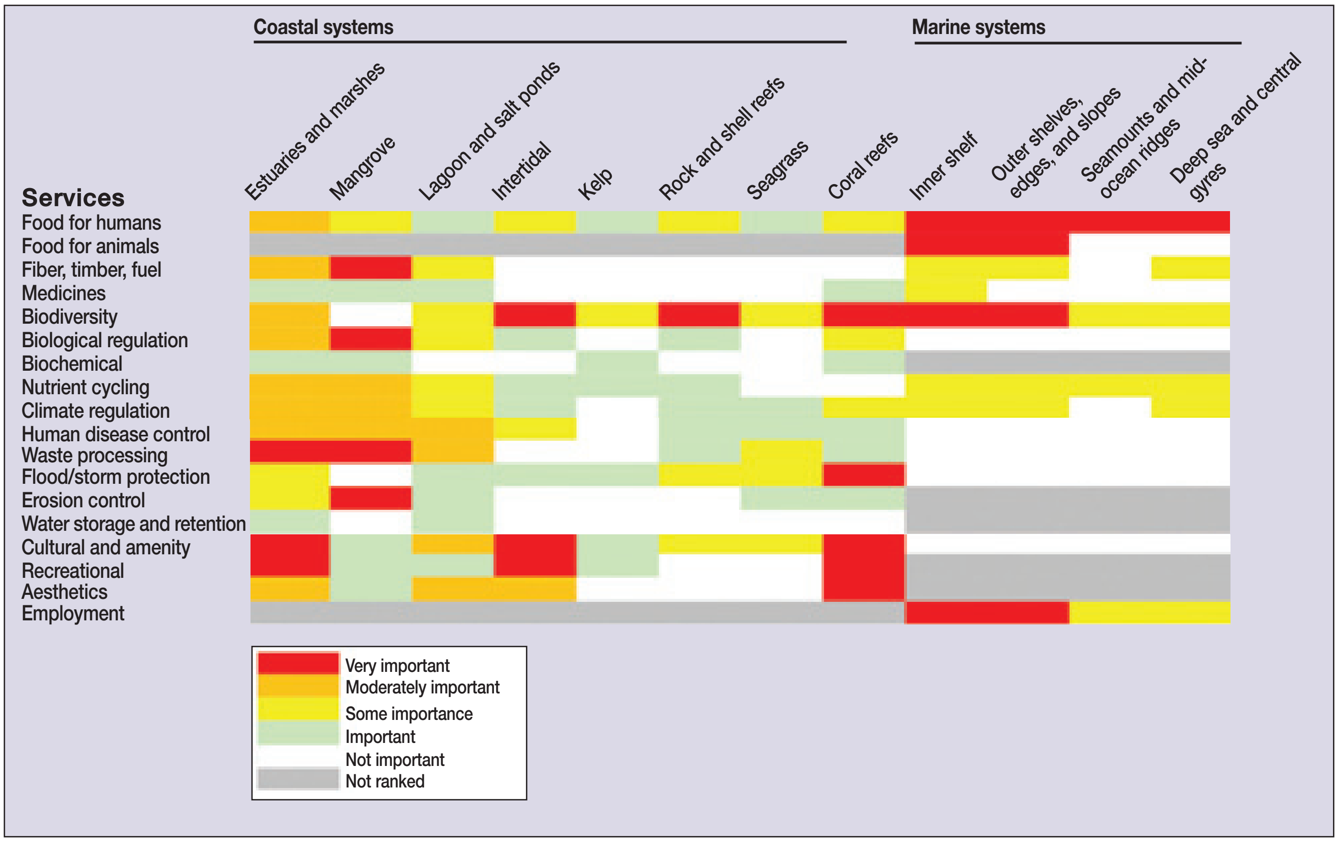

Figure 2. Ecosystem services provided by coastal and marine ecosystems. This figure is adapted with permission from Tables 18.2 and 19.2 of the Millennium Ecosystem Assessment (MA 2005). The original tables had two different ranking systems. We converted them to a comparable numeric system and translated the numeric scale (0–4) to colors for visualization purposes.

ble, enforceable, and realistic. The form of such engagement varies, but it can be useful to think of stakeholders as agents within dynamic networks that are linked to the environment at multiple spatial scales, rather than as static, well-defined groups (Berkes 2004). In many cases, ocean management is viewed as part of the public trust, which means that managers must consider the interests of all citizens, not just those who have a specific material interest (POC 2003; USCOP 2004). Engagement with resource users and other interested parties at the community level is particularly important, as local engagement can make the difference between a successful and a failed management effort (Brown *et al.* 2002; Christie 2004).

Although the US lacks a comprehensive framework for marine EBM, different aspects of the above principles have been touched upon, often within a single sector (Pikitch *et al.* 2004) or specific goal (Rosenberg and McLeod 2005). Coastal zone management, integrated coastal management, and terrestrial management professionals have been wrestling with many of these issues for decades, and there is certainly a great deal that can be learned from their experiences. Until recently, however, ecosystem-based approaches have rarely been pursued in a coordinated manner at the local or regional scale – the scales at which people are most intimately linked to, and reliant upon, coastal and marine ecosystems.

■ Challenges of implementing marine EBM

Four core imperatives face those working to implement ecosystem-based approaches to coastal and ocean management. Each of these challenges includes scientific aspects as well as others that reach beyond the realm of science.

(1) There is a need to define a common vision, including objectives for marine EBM and for the social and ecological states and services that people are most interested in maintaining or restoring. While the details of a vision will vary with the spatial and temporal scale of a particular effort, in all cases, a dialogue is needed among managers, resource users, scientists, and other stakeholders, in order to determine what ecosystem services people need or want from the marine environment and what components of ecosystem structure and functioning need to be in place in order to provide those key services. Creating the institutional spaces for such conversations is difficult, but possible, as is initiating the processes of consensus-building and compromise that follow (Brown *et al.* 2002).

We have observed that when groups of stakeholders work to define such visions, this leads to debate over whether to emphasize ecosystem health or human well-being. This tension is inevitable and indeed essential to developing a vision that resonates with

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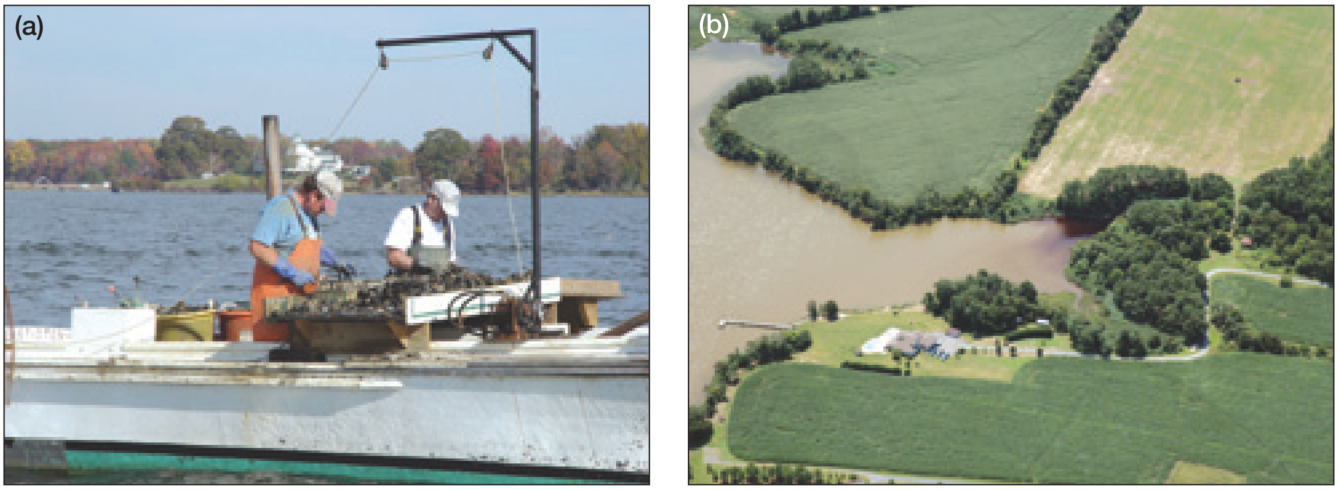


Courtesy of the Chesapeake Bay Foundation

Courtesy of J Thomas, IAN Image Library

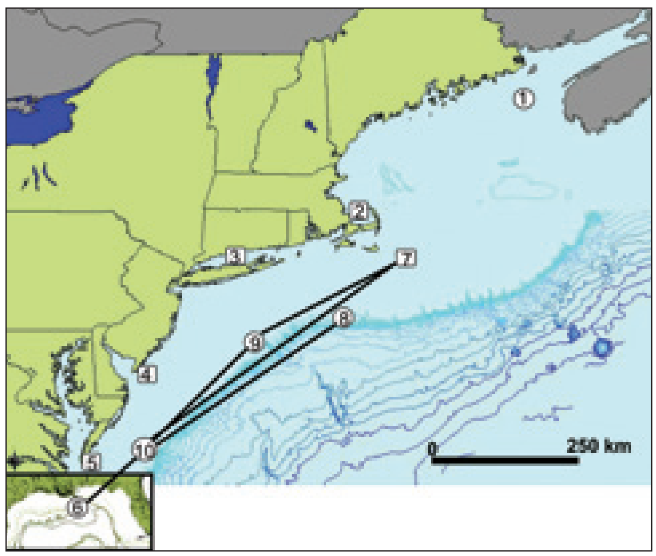
Figure 3. The integrity and resilience of the Chesapeake Bay ecosystem has been impacted by the cumulative and synergistic effects of multiple human activities that span centuries, including (a) fishing and (b) increased nutrient and sediment loading due to land-use change.

the entire community of stakeholders. Whether the priority is ecosystems or people greatly influences stakeholders' assessment of desirable ecological and social states. Marine EBM can facilitate this dialogue, given that a central tenet of EBM is that people are part of coastal and marine ecosystems (POC 2003; USCOP 2004; McLeod *et al.* 2005).

(2) Ocean governance frameworks that enable people to implement marine EBM must be developed. Such frameworks should include the web of formal and informal arrangements, institutions, and norms that control how resources and the environment are used, what behavior is deemed acceptable, and what rules and sanctions are applied to affect patterns of use (Juda 2003). Coastal and ocean-related activities are regulated by dozens of agencies in the US, some of which actually have conflicting and overlapping mandates (JOCI 2006). Moreover, the current structure often does not correspond well with the scales at which key ecological, social, and economic dynamics are operating (Wilson 2006; Figure 4). Yet resource management institutions that operate on multiple, nested spatial and organizational scales can be extremely effective (Dietz *et al.* 2003).

(3) We need to identify examples of success, in which visions grounded in ecosystem-based management have actually led to changes in coastal and marine management practices and outcomes. There is widespread agreement on the importance of integrating knowledge of the connections discussed above into management; the real challenges come in moving beyond concepts toward implementation in specific settings. In fact, there are a number of cases in which ecosystem-based approaches are being employed, although few, if any, constitute a fully ecosystem-based strategy (Guerry 2005; Arkema *et al.* 2006). These "partial" examples are still notable, however, as they can help illustrate the use of key elements of an ecosystem-based approach (eg fully protected marine reserves, ocean zoning, habitat restoration, establishment of cross-jurisdictional management goals). Moreover, there are a number of relevant terrestrial cases upon which to develop coastal and marine ecosystem-based approaches (see Meffe *et al.* [2005] for an overview).

(4) We need to evaluate when the goals and other elements of the vision have been achieved. This involves developing and tracking a range of metrics,



Courtesy of K Buresch and R Hanlon

Figure 4. The Northwest Atlantic longfin squid fishery is managed as though the squid (Loligo pealeii) *belong to a single, homogenous stock, even though a recent study indicates that there are multiple, genetically distinct populations. Most inshore populations sampled in the summer (squares) were genetically distinct from one another, while most offshore populations sampled in the winter (circles) exhibited high gene flow, as indicated by the connected lines. Figure redrawn from Buresch* et al. *(2006) with permission.*

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Panel 1. A research agenda for marine EBM

In April 2005, 27 natural and social scientists gathered at Princeton University to identify areas of broad agreement as well as challenges to implementing marine EBM. Several priority research needs emerged.

Natural science:
- Gather and synthesize information on how systems are changing and on the drivers of these changes, especially over long time scales.
- Further understanding of the context and impacts of exogenous and endogenous perturbations.
- Develop and apply models for marine EBM that deal explicitly with uncertainty.
- Clarify the relationships among biodiversity, ecosystem functioning, and ecosystem services.

Social science:
- Assess diverse examples of marine EBM at multiple spatial scales, and study how these efforts interact across scales.
- Synthesize data on public attitudes toward the ocean.
- Investigate how people learn and adapt in response to social and ecological perturbations.
- Perform economic valuation of restored, intact, and degraded ecosystems and the services they provide.

A number of interdisciplinary research needs were also identified. In many cases, stakeholder involvement in the research process would strengthen the development and impact of the work:
- Develop one or more demonstration projects for marine EBM within a large marine ecosystem in US waters.
- Map ecological and human-use characteristics of coastal and marine areas.
- Conduct a comparative analysis of terrestrial and marine EBM approaches, as well as other solutions to common resource management problems.
- Develop decision-support tools to aid in marine EBM, including ones that would:
    - Explore the linkages and feedbacks between social and marine ecological systems, particularly across different geographic scales.
    - Describe the interactions among different human activities and evaluate their cumulative impacts.
    - Evaluate trade-offs between different human activities and among different ecosystem services.

encompassing ecological, economic, social, and institutional elements of the system of interest. Ideally, these indicators will be considered from the beginning, as part of the development of the vision. Increasingly, managers and other practitioners recognize the value of adaptive management (Walters 1997). Through adaptive management, managers engage in a deliberate, structured process of formulating and testing hypotheses about how ecological and social systems interact, and then evaluate the outcomes of management "experiments" in order to improve management in the future. Initiatives grounded in adaptive management (eg Gunderson 1999; Sainsbury *et al.* 2000) provide a framework for implementing management actions in ways that incorporate uncertainty and enable learning. However, before engaging in adaptive management, it is vital that participants agree on the outstanding questions that need to be answered (Lee 1999). In addition, it is important to realize that EBM is an iterative process that requires flexibility and adaptation, since both knowledge and systems change over time. The dynamic nature of both ecological and social systems requires that we manage these systems around dynamic end-points, analogous to the way in which we maintain physical and financial capital (B Gold pers comm). In other words, we should apply our knowledge of the multiple states in which both social and ecological systems can exist to develop indicators of shifts in state. This will help us to help forecast likely impacts on both ecosystems and associated human communities, and to structure management interventions accordingly (Folke *et al.* 2002).

What can the scientific community do?

Natural and social scientists can respond to these challenges in a multitude of ways. Here, we highlight three key approaches: addressing crucial research needs, building interdisciplinary scientific capacity, and synthesizing and communicating scientific knowledge.

Research

We need to understand how the world works in order to manage human activities and maintain or, in some cases, restore the ecosystem services that people value. Relevant scientific investigations may be classified into three categories: efforts to understand the social and ecological dynamics of coastal and marine systems, monitoring of those dynamics, and the development of tools that enable learning and adaptive management. Setting priorities within and among these three research areas is critical, and requires collaboration among scientists, practitioners, and other stakeholders.

Investigations of system dynamics may employ quantitative or qualitative approaches, including case studies, experiments, and models, or a combination of these and other methods. Developing an integrated understanding of the dynamics of coupled social and ecological systems requires bridging these approaches and extending them to broader geographic scales. One means of doing so is through adaptive management: models are developed to answer outstanding research questions that cannot be directly addressed by field investigations; these models, in turn, inform large-scale "experiments" that integrate ecological, economic, and social issues. While such experiments will be specific to a given context, there are a num-

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ber of areas where targeted research is likely to yield particularly valuable scientific and policy dividends (Panel 1). Natural science research must include assessment of the individual and cumulative ecological impacts of different types of disturbances – from changing political regimes to climatic change – and how human communities adapt to these different perturbations, and must examine how marine EBM principles are being implemented at different geographic scales. We are just beginning to understand how social and ecological processes interact across spatial and temporal scales (eg the ecological, economic, and social dimensions of coastal marine fisheries), and particularly how they respond to multiple types of disturbance (Folke 2006). Moreover, the relationships between biological diversity, ecological processes, and the generation of ecosystem services on scales relevant to management and conservation have not been well explored. For example, in controlled experiments in marine settings, increased diversity has been shown to lead to increases in ecosystem function, such as biomass production, resource use, and nutrient cycling (Worm *et al.* 2006). In general, however, these studies have been conducted at small spatial scales. In an analysis of marine fisheries collapses worldwide, Worm *et al.* (2006) found that such collapses occurred at a higher rate in marine ecosystems with fewer fish species than in those that were species-rich. Further investigations of this kind – linking diversity, functioning, and marine ecosystem services – are needed. Case studies assessing the value of key marine ecosystem services are increasingly available, but how to generalize these examples to unstudied contexts remains an open question. Similarly, meta-analyses of the social and institutional features that contribute to successful implementation of ecosystem-based approaches to coastal and ocean management are lacking.

Effective monitoring requires the development of a full suite of ecological, economic, social, and institutional indicators, so that we have a comprehensive view of how a system is changing through time in response to different disturbances and management strategies (Panel 2). Economic indicators should include what people value, what trade-offs among services people are willing to make, and measures of human well-being. Developing appropriate economic measures of the value of ecosystem services will require different approaches for different services. For provisioning and cultural services, values may be measured directly, whereas for regulating and supporting services, they need to be measured indirectly (Farber *et al.* 2006). Social indicators should include stakeholder perceptions, the topology and degree of connectivity within social networks, the roles of leadership and history in changing system resilience, and the mechanisms by which ideas spread and social norms are changed. Ecological indicators should include measures of ecological structure, processes, legacies, and feedbacks, particularly in response to anthropogenic and natural perturbations. Also, better indicators of the linkages between ecological structure and processes and ecosystem services are needed. Institutional indicators should be developed to measure the social system's response to anthropogenic and natural perturbations and policy changes. Moreover, indicators of the magnitude and degree of linkages and feedbacks between social and ecological systems are needed. While developing and maintaining such a monitoring program is a major endeavor, it also benefits scientists and managers; managers will gain information vital to determining the efficacy of their efforts and scientists will obtain data that can be used to resolve outstanding scientific questions and inform future research.

Panel 2. Monitoring for resilience

There is growing interest in developing management strategies that maintain the resilience of coupled ecological and social systems, so that they are better able to respond to both natural and anthropogenic disturbances (Folke *et al.* 2002; Hughes *et al.* 2005). With mounting awareness of the complexity and dynamic nature of ecological and social systems (Levin 2006), scientists and practitioners increasingly recognize that the monitoring toolbox should include indicators of processes as well as patterns. In the ecological context, it is not enough to measure the abundance and distribution of species (although this is certainly very important to advance understanding of how ecological communities are changing through time); assessing reproduction and recruitment rates of key marine species (eg keystone, strongly interacting, and habitat-forming species) provides insight into the ability of biological populations and communities to persist. The same is true for social systems; in addition to understanding how household, community, and institutional structures contribute to individual and community-level well-being, we need information on the social and economic processes (eg demographic change, changing technologies, and access to credit or new markets) that influence the resilience and adaptive capacity of human communities.

Finally, scientists can contribute to the research needs for marine EBM by developing tools that policy makers and the public can use to advance understanding and adaptive management of marine systems. Comparative analysis of case studies (Arkema *et al.* 2006), ecosystem service valuation (Daily *et al.* 2000), scenario development (Bennett *et al.* 2003), ecosystem models (Christensen and Walters 2004), reserve selection algorithms (Margules and Pressey 2000), and trade-off analysis (Brown *et al.* 2002) are just some of the relevant tools that have been developed to date. Another example comes from the non-governmental organization Ecotrust, where practitioners have created a decision-support tool called OCEAN (Ocean Communities Equity/Ecology/ Economy Analysis Network; www.ecotrust.org/knowledgesystems/ocean.html), that integrates geographic information systems (GIS), databases, and analytical tools to aid decision makers in understanding the spatial distribution of fish and fishermen, and how changes in each influence the resilience of coastal communities (Scholz *et al.* 2006; Figure 5). The Nature Conservancy

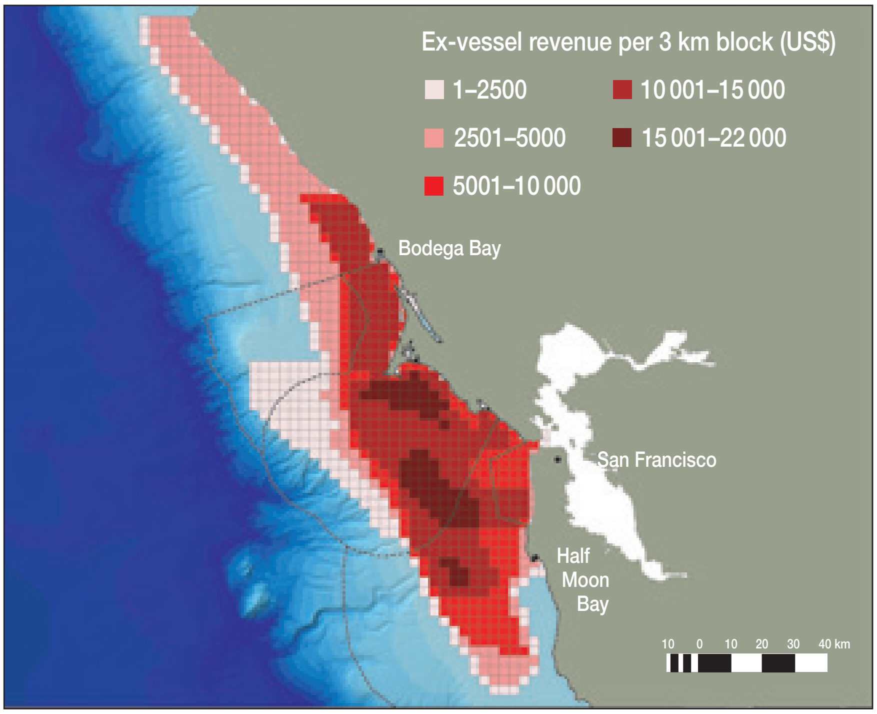

Figure 5. *Average ex-vessel revenues derived from California Dungeness crab landing receipts, 1997–2003. Dungeness crab fishing grounds off the north-central California coast were delineated based on fishermen's local knowledge, using the OCEAN decision-support tool. Figure adapted from Scholz* et al. *(2006) with permission.*

and partners recently launched a web-based marine EBM "toolkit", to support managers and EBM practitioners working to address multiple ocean management objectives related to conservation, fisheries, and coastal hazards (see www.marineebm.org). Another non-governmental organization, Nature-Serve, is coordinating an "EBM Tools Network" to provide training and support for such tools in coastal and marine areas (see www.ebmtools.org).

Building interdisciplinary capacity

There is a tremendous need to build bridges among disciplines, particularly between the natural and social sciences. This is no small endeavor, given the time and effort required to learn multiple vocabularies and develop understanding that transcends individual disciplines, the traditional structure of universities, and the standard reward system for academic scientists (NRC 2004). Nonetheless, encouraging signs from both the scientific community (Carpenter and Folke 2006) and funding agencies (eg NSF's IGERT program) suggest that interdisciplinary research will soon be a respected approach to scientific inquiry, if not the norm. Like any productive collaboration, an interdisciplinary partnership takes time to develop and to yield results. People need to learn how to understand each other's perspectives and the intellectually challenging questions in a given area, and to develop a research plan of mutual interest. In our own experience, this initial "start-up" time is often underestimated. The more that academic, non-governmental, and governmental institutions can do to promote this groundwork (eg through funding and technical support), the more likely it is that natural and social scientists will be in a position to contribute to substantive interdisciplinary efforts.

Synthesis, translation, and communication

While research is absolutely essential, this alone is not sufficient to ensure that managers, policy makers, and stakeholders have access to the knowledge and tools they need to design and implement marine EBM efforts. For this access to occur, synthesis of existing information (Guerry 2005) and communication of this knowledge in relevant, legitimate, and credible contexts is of paramount importance (Lubchenco 1998; Cash *et al.* 2003). Scientists can engage in synthesis and communication activities in a number of ways (eg via one-on-one interactions and collaborative research with conservation and management professionals and stakeholders, service on scientific advisory boards and expert review panels, submission of public comment, publications in newspapers and other media). Often, scientific understanding among decision makers, managers, and communities of stakeholders can be facilitated through boundary organizations. These institutions work at the interface of science and politics, translating knowledge and actively mediating conflicts between different groups. They are able to do this effectively in part because they are responsive and accountable to multiple communities (Cash *et al.* 2003). One marine-related example is COMPASS (Communi-cation Partnership for Science and the Sea), a collaborative effort to advance and communicate marine conservation science to policy makers, marine resource managers, journalists, and the public (www.compassonline.org).

■ Recent progress toward implementing EBM

Scientists, practitioners, and policy makers are already tackling the challenges discussed above at multiple geographic scales and in many different fora. For example, in 2005, COMPASS released a scientific consensus statement on marine EBM, which was signed by over 200 academic scientists and policy experts (McLeod *et al.* 2005). The National Center for Ecological Analysis and Synthesis (NCEAS) coordinated a comparative analysis of marine EBM case studies (Arkema *et al.* 2006) as part of a larger, ongoing EBM research effort. A number of

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Figure 6. *Morro Bay, California, is the focus of a regional initiative in coastal marine ecosystem-based management funded by a variety of private and public sources, including the David and Lucile Packard Foundation, the Resources Legacy Fund Foundation, and the California Ocean Protection Council. Since 2003, stakeholders have worked collaboratively to integrate local knowledge, research, and monitoring data to guide and evaluate marine resource management in the region.*

symposia focused on the science and implementation of marine EBM have been held at recent scientific meetings, including the American Association for Advancement of Science, the American Society of Limnology and Oceanography, the American Fisheries Society, and the Society for Conservation Biology.

The US is showing forward progress in legislating aspects of EBM. For example, key EBM provisions were incorporated into the reauthorization of the Magnuson-Stevens Fishery Conservation and Management Reauthorization Act passed at the close of 2006. The 110th Congress is also showing promise in this regard. The 2007 session began with the introduction of Oceans-21, a bipartisan bill that would establish a comprehensive national oceans policy, in the House of Representatives. Other opportunities over the next two years include the Coral Reef Ecosystem Conservation Amendment Act, reauthorization of the National Marine Sanctuaries Act, laying groundwork for reauthorization of the Coastal Zone Management Act, and renewed possibility that the US will ratify the United Nations Convention on the Law of the Sea. Moreover, the Joint Ocean Commission Initiative – led by Commissioners from both national commissions – is working with Congress, state governments, and non-governmental organizations to create meaningful ocean policy reform. A number of states, including Massachusetts, New Jersey, New York, and California, have passed legislation or taken other actions to introduce more ecosystem-based approaches into their coastal and ocean management efforts. Non-governmental organizations and foundations also are increasingly engaged in marine EBM efforts, by supporting demonstration projects and related research at the local, national, and international levels (Figure 6). Nonetheless, there is still a great deal that could be done at the state and regional levels. For example, representation of diverse interests (and values) in fisheries management decisions, particularly through the regional fisheries management council processes, is still largely confined to the fisheries industry itself. Establishment of regional ecosystem councils, as suggested by the Pew Oceans Commission (2003), would address this imbalance.

International efforts in this area could comprise a whole series of papers (see Browman and Stergiou [2005] for a recent summary), but it is worth noting that both Canada (via the Oceans Act) and Australia (via the Oceans Policy) have governance frameworks in place that mandate integrated and comprehensive management of human impacts on coastal and ocean ecosystems. This is a direction in which the US needs to move. Also at the international level, the United Nations Environment Programme recently published a framework for assessing progress toward ecosystem-based management in coastal and river basin systems (UNEP/GPA 2006), which could be used to develop monitoring programs for marine EBM initiatives in the US and elsewhere.

Given the strong interest of policy makers and the public, there are considerable prospects for scientists to contribute to the implementation of marine EBM approaches through research, development of scientific capacity, and scientific communication and synthesis. While there will always be opportunities to increase our understanding of the ecological and social dynamics of particular systems, sufficient information and experience already exist to move forward with implementation of ecosystem-based approaches in marine systems. We hope that this paper will spur further dialogue and substantive contributions to EBM of our coasts and oceans by both natural and social scientists.

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