Marine Sanctuaries Conservation Series ONMS-10-02

Examples of Ecosystem-Based Management in National Marine Sanctuaries: Moving from Theory to Practice

U.S. Department of Commerce
National Oceanic and Atmospheric Administration
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Office of Ocean and Coastal Resource Management
Office of National Marine Sanctuaries

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About the Marine Sanctuaries Conservation Series

The National Oceanic and Atmospheric Administration's Office of National Marine Sanctuaries (ONMS) administers the National Marine Sanctuary Program. Its mission is to identify, designate, protect and manage the ecological, recreational, research, educational, historical, and aesthetic resources and qualities of nationally significant coastal and marine areas. The existing marine sanctuaries differ widely in their natural and historical resources and include nearshore and open ocean areas ranging in size from less than one to over 5,000 square miles. Protected habitats include rocky coasts, kelp forests, coral reefs, sea grass beds, estuarine habitats, hard and soft bottom habitats, segments of whale migration routes, and shipwrecks.

Because of considerable differences in settings, resources, and threats, each marine sanctuary has a tailored management plan. Conservation, education, research, monitoring and enforcement programs vary accordingly. The integration of these programs is fundamental to marine protected area management. The Marine Sanctuaries Conservation Series reflects and supports this integration by providing a forum for publication and discussion of the complex issues currently facing the National Marine Sanctuary Program. Topics of published reports vary substantially and may include descriptions of educational programs, discussions on resource management issues, and results of scientific research and monitoring projects. The series facilitates integration of natural sciences, socioeconomic and cultural sciences, education, and policy development to accomplish the diverse needs of NOAA's resource protection mandate.

Examples of Ecosystem-based Management in National Marine Sanctuaries: Moving from Theory to Practice

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COVER

Rockfish sitting at the base of a soft coral in the Monterey Bay National Marine Sanctuary. Photo IfAME/MBNMS/MARE

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EXECUTIVE SUMMARY

In the fall of 2008, graduate students from eight universities—California State University Monterey Bay, University of California Santa Barbara, University of Connecticut, University of Hawai'i, University of Michigan, University of New Hampshire, University of South Florida, University of Washington—participated in a "Distributed Graduate Seminar" (DGS) at the National Center for Ecological Analysis and Synthesis (NCEAS) at the University of California Santa Barbara. The goal of the semester-long seminar was to examine the role of the Office of National Marine Sanctuaries (ONMS) in implementing ecosystem-based management (EBM) at the sites that make up the National Marine Sanctuary system. Each university collaborated with one or more Sanctuaries to conduct a case study based on a core set of questions regarding EBM. The products of these case studies encompassed a wide-range of topics, including detailed summaries of existing management strategies and original quantitative analyses and tools for implementing EBM within sanctuary boundaries. The Sanctuary Program's important role as a facilitator of management action was an emergent property of the case studies. They also found that facilitating management actions and engagement of partners is effectively used by sanctuaries and more common than regulatory actions. In April 2009, NCEAS hosted a "Synthesis Working Group" that brought together representative graduate students and faculty from seven of the eight universities and ONMS staff to examine their case studies and share findings and establish commonalities amongst all Sanctuaries. The following is a synthesis produced at the April meeting of the Seminar case study materials.

KEY WORDS

Ecosystem-based management, marine protected areas, national marine sanctuaries.

TABLE OF CONTENTS

Executive Summary 1

Key Words 1

Table of Contents 2

List of Figures 3

List of Tables 4

Introduction 5

I. Examples of EBM within ONMS 8

A. EBM in Policy Language: Case Study: Stellwagen Bank National Marine Sanctuary 8
B. Co-management Strategies 11
Case Study: Thunder Bay National Marine Sanctuary 11
Case Study: Olympic Coast National Marine Sanctuary 12
C. Stakeholder Involvement 14
Case Study: Hawaiian Islands Humpback Whales National Marine Sanctuary 14
D. Marine Zoning 16
Case Study: The Channel Islands National Marine Sanctuary 17
Case Study: The Florida Keys National Marine Sanctuary 19

II. Emerging Tools for EBM implementation 21
Case Study: Papahanumokuakea Marine National Monument 21
Case Study: The Channel Islands National Marine Sanctuary (CINMS) 24
Case Study: Monterey Bay National Marine Sanctuary 26

Conclusions 28

References 30

Appendix A 35

LIST OF FIGURES

Figure 1: The locations managed by the Office of National Marine Sanctuaries..........6

Figure 2: Map of Stellwagen Bank National Marine Sanctuary and surrounding environs. 8

Figure 3: Map of Thunder Bay National Marine Sanctuary and surrounding environs. 11

Figure 4: Map of Olympic Coast National Marine Sanctuary and surrounding environs. 13

Figure 5: Map of Hawaiian Islands Humpback Whale National Marine Sanctuary and surrounding environs..........15

Figure 6: Map of the Channel Islands National Marine Sanctuary and surrounding environs, including the network of State Marine Reserves and Conservation Areas..........17

Figure 7: Diagram of the collaborative federal/state process for MPA design in the CINMS. 18

Figure 8: Map of the Florida Keys National Marine Sanctuary and surrounding environs, including elements of marine zoning..........20

Figure 9: Map of the Papahanaumokuakea Marine National Monument and surrounding environs..........22

Figure 10: Map of percent change in impact per pixel for Management Option 2.. 25

Figure 11: Map of the Monterey Bay National Marine Sanctuary and surrounding environs. 27

Figure 12: Cartogram depicting the relative influence of “relevance factors” in the implementation of EBM in the Monterey Bay National Marine Sanctuary..28

LIST OF TABLES

Table 1: The date established, location, and area for each National Marine Sanctuary that collaborated with a University participant in the Distributed Graduate Seminar. 7

Table 2: Key elements of ecosystem-based management as articulated by the U.S. Commission on Ocean Policy and the Pew Oceans Commission, and described by Communication Partnership for Science and the Sea (COMPASS). 9

Table 3: Example of an ecosystem-based resource list for the Papahanaumokuakea Marine National Monument. 23

INTRODUCTION

In the last two decades, ecosystem-based management (EBM) emerged as a compelling alternative to traditional single-species approaches for effective management of marine and coastal resources. Christensen et al. (1996) defined ecosystem management as "management driven by explicit goals, executed by policies, protocols, and practices, and made adaptable by monitoring and research based on our best understanding of the ecological interactions and processes necessary to sustain ecosystem composition, structure, and function." Ecosystem-based management integrates many sectors and stakeholders, considers cumulative impacts, explicitly includes humans as integral to the system, and preserves important services for humans as goals for management (McLeod et al. 2005). The Pew Oceans Commission and the US Commission on Ocean Policy both articulated the scientific community's support for EBM and identified it as a necessary element of effective resource management (Pew Oceans Commission 2003, US Commission on Ocean Policy 2004).

The National Oceanic and Atmospheric Administration's Office of National Marine Sanctuaries (ONMS) manages more than 150,000 mi^2 (388,498 km^2) of marine and freshwater systems in 13 National Marine Sanctuaries and 1 Marine National Monument (Figure 1). These locations have important "conservation, recreational, ecological, historical, cultural, archeological, scientific, educational, or esthetic qualities" (NMSA 2000, Sec 301). A legal textual analysis of the National Marine Sanctuaries Act (NMSA) completed during the Distributed Graduate Seminar (DGS) reveals neither an explicit mandate for, nor a prohibition of, the use of EBM in Sanctuaries (Carden, unpublished). However, sections of the legislation are consistent with EBM. For example, the NMSA seeks to "maintain natural biological communities … and [to] protect, and, where appropriate, restore and enhance natural habitats, populations, and ecological processes" 16 U.S.C.§§1431(b)(3). To achieve this goal, the Secretary of Commerce is authorized to "develop and test methods to enhance degraded habitats or restore damaged, injured, or lost sanctuary resources" Id. at § 1440(b)(1)(B). In addition, the NMSA requires the ONMS to enhance conservation and management, encourage sustainable use, improve public awareness, and maintain "for future generations the habitat, and ecological services, of the... living resources that inhabit [the Sanctuaries]" (NMSA 2000, Section 301).

In the fall of 2008, graduate students from seven universities (Table 1) participated in a DGS with support from the National Center for Ecological Analysis and Synthesis (NCEAS) at the University of California, Santa Barbara and in collaboration with NOAA's Office of National Marine Sanctuaries. The seminar's goal was to examine the role of U.S. marine protected areas as tools for EBM. Because National Marine Sanctuaries are the most significant single MPA management program in the United States, they received particular emphasis in the seminars. Seminar participants examined how our growing scientific understanding of ecosystem processes within MPAs and evolving ocean-observing capabilities, can allow us to manage MPAs as integral components of the ecosystems in which they reside.

Each of the seminar groups considered five questions for examination and chose one or more of them to incorporate into a case study. The seminar participants were give considerable leeway to develop their own perspective on how to address the questions in the context of their case study. The questions were:

1. Does place-based management of MPAs create conflicts with species-based approaches that reduce the effectiveness of both?
2. Should MPAs be integrated into larger scale ecosystem management approaches or managed as individual entities?
3. Are existing legal and jurisdictional authorities sufficient to integrate MPAs into ecosystem based management efforts at local and regional scales?
4. Can National Marine Sanctuaries effectively implement EBM approaches within their boundaries and contribute to broader EBM efforts in the regions in which they occur?
5. Can insights derived from an evaluation of National Marine Sanctuaries and EBM be extrapolated to the broader global discussion of MPAs?

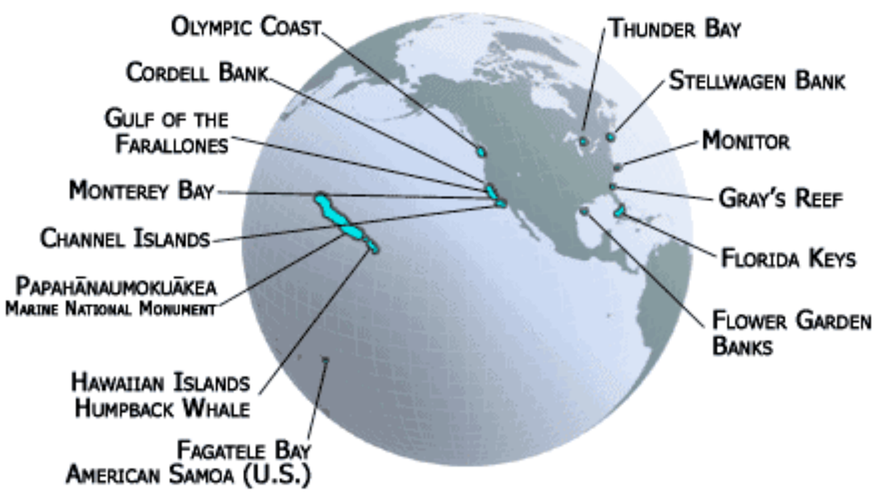

Figure 1: **The locations managed by the Office of National Marine Sanctuaries (http://sanctuaries.noaa.gov/visit/welcome.html).**

The DGS participants compiled eight case studies to examine the role of the Sanctuaries in implementing EBM within their boundaries. The case studies present a variety of approaches employed by DGS participants to identify existing and potential EBM actions. To promote synthesis of these case studies, we focused on aspects that help move EBM from *theory* to *practice*.

In April 2009, NCEAS hosted a "Synthesis Working Group" that brought together representative graduate students and faculty from seven of the eight universities and

ONMS staff to examine their case studies, share findings and establish commonalities amongst all Sanctuaries, and to produce a synthesis of their findings. That synthesis resulted in two elements: (I) Current examples of EBM in Sanctuaries and (II) emerging tools for EBM. This report describes case study examples where strong EBM language was applied to guiding documents, co-management strategies, stakeholder involvement, and marine zoning. Second, we describe tools and results that have been used for planning, implementing and assessing EBM. Our overarching goal is to describe examples that can provide guidance for resource managers to realize EBM in practice.

Table 1: **The date established, location, and area for each National Marine Sanctuary (NMS) and Marine National Monument (MNM) that collaborated with a University participant in the Distributed Graduate Seminar.**

Name	Established	Location	Area	University
Channel Islands NMS	1980	California	1,658 mi^2 (4,294 km^2)	University of California Santa Barbara
Florida Keys NMS	1990	Florida	3,707 mi^2 (9,600 km^2)	University of South Florida
Hawaiian Islands Humpback Whale NMS	1992	Hawai'i	1,400 mi^2 (3,600 km^2)	University of Hawai'i, Manoa
Monterey Bay NMS	1992	California	5,322 mi^2 (13,784 km^2)1	California State University Monterey Bay
Olympic Coast NMS	1994	Washington	3,309 mi^2 (8,570 km^2)	University of Washington
Papahanaumokuakea MNM	2006	Hawai'i	138,997 mi^2 (360,000 km^2)	University of Hawai'i, Manoa
Stellwagen Bank NMS	1992	Massachusetts	842 mi^2 (2,181 km^2)	University of New Hampshire
Thunder Bay NMS	2000	Michigan	448 mi^2 (1,160 km^2)	University of Michigan

[1] In March 2009 Monterey Bay National Marine Sanctuary expanded to include the Davidson Seamount Management Zone, adding 775 square statute miles.

I. Examples of EBM within ONMS

A. EBM in Policy Language: Case Study: Stellwagen Bank National Marine Sanctuary

The University of New Hampshire examined the policy language within a central guiding document of the Stellwagen Bank National Marine Sanctuary (SBNMS; Figure 2), the SBNMS Draft Management Plan (DMP), to understand if and how EBM is meant to be initiated within the sanctuary. Each sanctuary in the National Marine Sanctuary System has a management plan. In general, management plans are used to inform decision making and project planning, while articulating goals, objectives, and priorities. Management plans are organized into action plans that link to management issues.

The group compared language within the SBNMS DMP to nine elements for ecosystem-based management defined by Communication Partnership for Science and the Sea (COMPASS) (Table 2; McLeod et al. 2005). The SBNMS DMP includes management objectives and action plans that provide strategies for achieving these objectives. The approach identified assets, shortcomings, and stakeholders that could provide leverage for or act as barriers to effective EBM implementation. The SBNMS DMP outlines actions for EBM, yet actual strategies for implementation were missing.

Figure 2: Map of Stellwagen Bank National Marine Sanctuary and surrounding environs.

Table 2: **Key elements of ecosystem-based management as articulated by the U.S. Commission on Ocean Policy and the Pew Oceans Commission, and described by Communication Partnership for Science and the Sea (COMPASS).**

COMPASS Elements of EBM

- Make protecting and restoring marine ecosystems and all their services the primary focus, even above short-term economic or social goals for single services. Only intact, healthy ecosystems can provide the complete range of benefits that humans want and need over long periods of time.

- Consider cumulative effects of different activities on the diversity and interactions of species.

- Facilitate connectivity among and within marine ecosystems by accounting for the import and export of larvae, nutrients, and food.

- Incorporate measures that acknowledge the inherent uncertainties in ecosystem-based management and account for dynamic changes in ecosystems, for example as a result of natural oscillations in ocean state or shifts in the frequency or intensity of storms. In general, levels of precaution should be proportional to the amount of information available such that the less that is known about a system, the more precautionary management decisions should be.

- Create complementary and coordinated policies at global, international, national, regional, and local scales, including between coasts and watersheds. Ecosystem processes operate over a range of spatial scales, and thus appropriate scales for management will be goal-specific.

- Maintain historical levels of native biodiversity in ecosystems to provide resilience to both natural and human-induced changes.

- Require evidence that an action will not cause undue harm to ecosystem functioning before allowing that action to proceed.

- Develop multiple indicators to measure the status of ecosystem functioning, service provision and effectiveness of management efforts.

- Involve all stakeholders through participatory governance that accounts for both local interests and those of the wider public.

The SBNMS DMP incorporates several elements of EBM, indicating the potential for future implementation of EBM. These include operationalizing ecological integrity, defining the sanctuary's ecology and uses, and identifying and zoning habitats. Additionally, the SBNMS DMP outlines the development of an oceanographic circulation model to integrate local, regional, and larger-scale patterns. For multiple uses and cumulative impacts, action plans within the DMP call for collaborative research regarding recreational and commercial fishing, habitat zoning, laying of cables and pipelines, alteration of benthic habitat, bycatch and discard, ballast water, pollutants and wastes, marine mammal disturbances, vessel strikes, noise levels and gear modifications. The sanctuary also aims to protect and manage maritime heritage and develop outreach, tourism, and education. Integrated with these action plans, the SBNMS DMP stipulates observing, monitoring, and other long-term research, and it recommends monitoring include socioeconomic impacts to adequately address social capital. All of these components are consistent with the COMPASS elements of EBM.

In addition to the components above, the SBNMS DMP recognizes the importance of involving multiple stakeholders and clarifying the roles and responsibilities of various agencies and groups for sanctuary management, both of which are fundamental for realizing EBM. The SBNMS DMP also specifies that the sanctuary needs to provide advice, information, and coordination of efforts across these agencies and groups. To facilitate cooperation and collaboration, an Interagency Cooperation action plan is included for information sharing among agencies and with the public. Additional action plans include the establishment of an information management system, a portal for public access to databases and a website for all pertinent fishing regulations, research and agency contact information within the sanctuary.

However, the SBNMS DMP lacks a holistic approach to implementing EBM. Further, actions plans and the tactics to achieve them lack clear definitions. Specifically, the plan offers many strategies and objectives that move toward EBM, but linking and coordinating strategies are absent. Also, existing overlaps among stakeholders' goals are not acknowledged. These overlaps are essential to facilitate stakeholder partnerships that could share and leverage resources while working toward common goals. The SBNMS DMP does identify possible collaborations, yet fails to outline how relationships will be pursued and maintained. Finally, action plans frequently focus on single issues and do not account for cumulative effects from multiple, overlapping issues.

Evaluating existing policies and documents is an important starting point for implementing EBM and allows managers and stakeholders to understand the present situation and move forward realistically within existing frameworks. It also identifies areas within the framework that need alteration. In this case, the SBNMS Draft Management Plan is not a final version of the Plan and can still be modified. Thus, ONMS staff can use this analysis to alter the draft for better implementation of EBM in the future. To apply a similar approach to another region, managers can employ a simple and systematic framework, such as the one provided here to ask what strategies are being employed, what is missing, and what stakeholder groups are involved. These questions should be based on clear EBM elements, such as those outlined by COMPASS (Table 2).

Additionally, management plan goals or actions can be evaluated based on EBM goals, such as the seven EBM action items provided in COMPASS (McLeod et al. 2005). This process clarifies objectives and strategies and provides a starting point for implementing EBM.

B. Co-management Strategies

Ecosystem-based management inherently engages numerous governing entities and many different stakeholder groups. As such, successful co-management is a significant element of EBM in practice. The Thunder Bay National Marine Sanctuary (TBNMS) and Olympic Coast National Marine Sanctuary (OCNMS) case studies explored the status of co-management strategies and cross-jurisdictional management goals within these two Sanctuaries.

Case Study: Thunder Bay National Marine Sanctuary

The Great Lakes region offers a unique example of historical and current governance that encourages co-management within and outside sanctuary boundaries. This governance structure involves two nations, eight states, one province, several tribal territories, and a number of international, intergovernmental and interagency institutions.

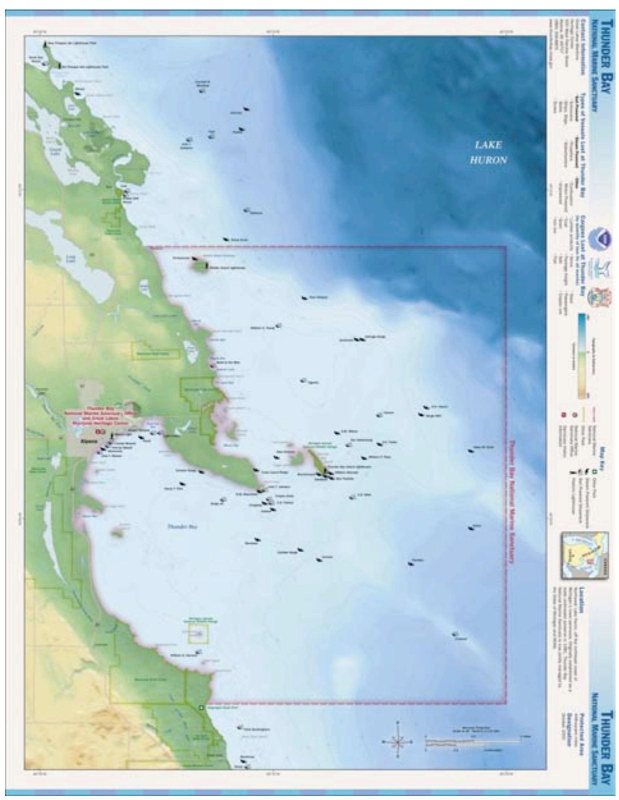

Figure 3: Map of Thunder Bay National Marine Sanctuary and surrounding environs.

A series of formal agreements in the Great Lakes region laid the foundation for more than one hundred years of inclusive, cooperative management that continues today. The Boundary Waters Treaty ('Treaty'), signed in 1909, between the US and Canada conceptualized and institutionalized an early form of EBM by connecting industrial, agricultural, and municipal activities in tributaries to water quality and quantity in the Great Lakes. The Treaty also established the International Joint Commission (IJC) to resolve disputes between the two countries.

The Thunder Bay National Marine Sanctuary (TBNMS; Figure 3) in Lake Michigan is managed in the context of this larger cooperative governance structure. The sanctuary explicitly adopted a "joint-management" strategy of equal partnership, named the Joint Management Committee, where all key decisions are made collaboratively. This committee is determined by the State of Michigan and National Oceanic and Atmospheric Administration (NOAA) and consists of a representative appointed by the director of the Michigan Department of History, Arts and Libraries and the director of the ONMS. This committee is in addition to the Sanctuary Advisory Council, that provides advice to the TBNMS superintendent and which includes municipal, state, national, international, and tribal representatives.

In addition to the history of co-management, the sanctuary facilitates, and education focusing on maritime heritage, including the 116 historic shipwrecks within its boundaries. Kayakers, snorkelers, divers, and researchers visit these shipwrecks. Natural and anthropogenic impacts, such as ice, waves, invasive mussels, anchoring, diving practices and looting, threaten these maritime heritage resources (TBNMS Draft Management Plan). "Interpretive enforcement" is a strategy for the sanctuary that seeks to enhance compliance to regulations through education. As part of this strategy, law enforcement officers interact with users on shore before sanctuary resources are adversely affected. The sanctuary thus relies on local law enforcement agencies' assistance. This focus on preserving marine heritage resources combined with the need for co-management strategies exemplifies the broad definition of EBM.

The history of collaborative management in TBNMS and the larger Great Lakes region serves as an excellent model for federal-state cooperation. Additionally, the managing framework in this region highlights the importance of communicating among government entities, management agencies, and other stakeholders about the diverse goals for ecosystems and marine resource preservation. The success of this system has stimulated the consideration of additional sanctuary sites within the Great Lakes ecosystem. Further the governance structure enforces the idea that groups and agencies must engage stakeholders and management institutions *outside* of their boundaries to effectively implement EBM *within* their boundaries.

Case Study: Olympic Coast National Marine Sanctuary

The coastal border of the Olympic Coast National Marine Sanctuary (OCNMS; Figure 4) includes the lands of four tribes: the Makah, Quileute, Hoh and Quinault (hereinafter referred to as the "Tribes"). The Tribes have specific agreements with the US government that date back to 1855 (Makah Tribal Council 2008). These treaties reserve the Tribes' rights to marine resources and are based on the Usual and Accustomed Areas (U&As) as delineated in the Boldt decision process (1974). The rights were reaffirmed by the Boldt (*United States v. Washington*, 384 F.Supp. 312; W.D. Wash. 1974) and Rafeedie decisions (Ruling by Federal Western Washington District Court Judge Edward Rafeedie 1994). These treaties existed prior to the sanctuary's designation. Tribal authorities manage tribal fishing within their U&As in cooperation with the National Marine Fisheries Service (NMFS) and Washington State Department of Fish and Wildlife (WSDFW); however, they are still subject to federal policies (e.g., Marine Mammal Protection Act, Endangered Species Act). Within the OCNMS, the Tribes are exempt from most prohibitions regarding resource uses.

Figure 4: Map of Olympic Coast National Marine Sanctuary and surrounding environs.

The sanctuary is currently completing an update to its management plan. The first plan, created in 1994, provides an example of the challenges and opportunities involved in sanctuary management in consultation with Native American tribes with treaty rights to resources within the sanctuary. The case study explores evidence of cooperation and conflict concerning marine resource co-management within OCNMS boundaries, including various groups' influence and authority.

Given the Tribes' rights and understanding of the local environment, their involvement as managers with the NMFS and WSDFW is essential to successful EBM implementation. Furthermore, the OCNMS faces the challenge of respecting tribal rights while simultaneously addressing other stakeholder interests. To this end, the Tribes, the State of Washington, and the ONMS established the Olympic Coast Intergovernmental Policy Council (IPC) to promote communication and exchange information and policy recommendations for the management of the sanctuary (IPC 2007). While the IPC recognize that the cooperative management approach has proven to be effective, they suggest that ever-changing resource and management needs required continued evolution of management schemes. Commentary arising from the sanctuary's management plan review echoes this need for management refinement and calls for approaches that incorporate the Tribes' ecological knowledge and honoring the sanctuary's treaty trust responsibility.

Although the OCNMS case study provides an example of an emerging co-management strategy, it also identifies some shortcomings in the process. Discrepancies exist between tribal interpretation of the site designation documents and those realized in implementation. Not all stakeholder needs are being addressed, thus co-management is not adequately implemented, which limits the OCNMS's ability to fully employ EBM principles.

There is enormous potential for facilitating the initiation of EBM within and beyond sanctuary borders, not only through the use of ecosystem-based objectives within management plans but also by building frameworks for communication and cooperative action among agencies and stakeholder groups. The TBNMS and OCNMS case studies identified co-management examples that illustrate the importance of looking outside specific management boundaries to implement EBM. Although the language in the Sanctuaries' policies strongly supports EBM, partners with additional authority are needed for successful implementation. In summary, the sanctuaries are not prerequisites for implementing EBM, but they facilitate comprehensive and coordinated conservation and management, especially in areas characterized by multiple use and complex governance structures.

C. Stakeholder Involvement

Sanctuaries are mandated to utilize participatory governance through a stakeholder body called the Sanctuary Advisory Council (SAC). Considering and integrating multiple interests of stakeholders within the community is critical for EBM. Additionally, public outreach and education are critical components for regional awareness and support. Involving the wider community in steps of the management process fosters bottom-up support and regulatory compliance.

Case Study: Hawaiian Islands Humpback Whales National Marine Sanctuary

Although co-management addresses the jurisdictional entities that should be involved in EBM, additional stakeholder groups exist. It is important to engage groups that are not directly involved in management to understand and include their concerns. The Hawaiian Islands Humpback Whale National Marine Sanctuary (HIHWNMS; Figure 5) case study provides an example of education and outreach to effectively engage the public and scientific communities using a charismatic species: the humpback whale (*Megaptera novaeangliae*). Despite the fact that EBM emphasizes moving from a single-species to an ecosystem focus, a large marine mammal species can engage additional stakeholder groups and raise public awareness to protect the valuable ecosystem upon which this species relies. Since humpback whales have such a large geographic range and far-reaching ecological significance, this single-species focus maintains important aspects of EBM, as the protection of this single species' habitat and resources will also protect a broad ecosystem.

This case study describes two approaches underway at the sanctuary. The first approach focuses solely on educational activities within the Hawaiian Islands. The second approach includes an examination of whale populations within the sanctuary, as well as a larger region within the Pacific.

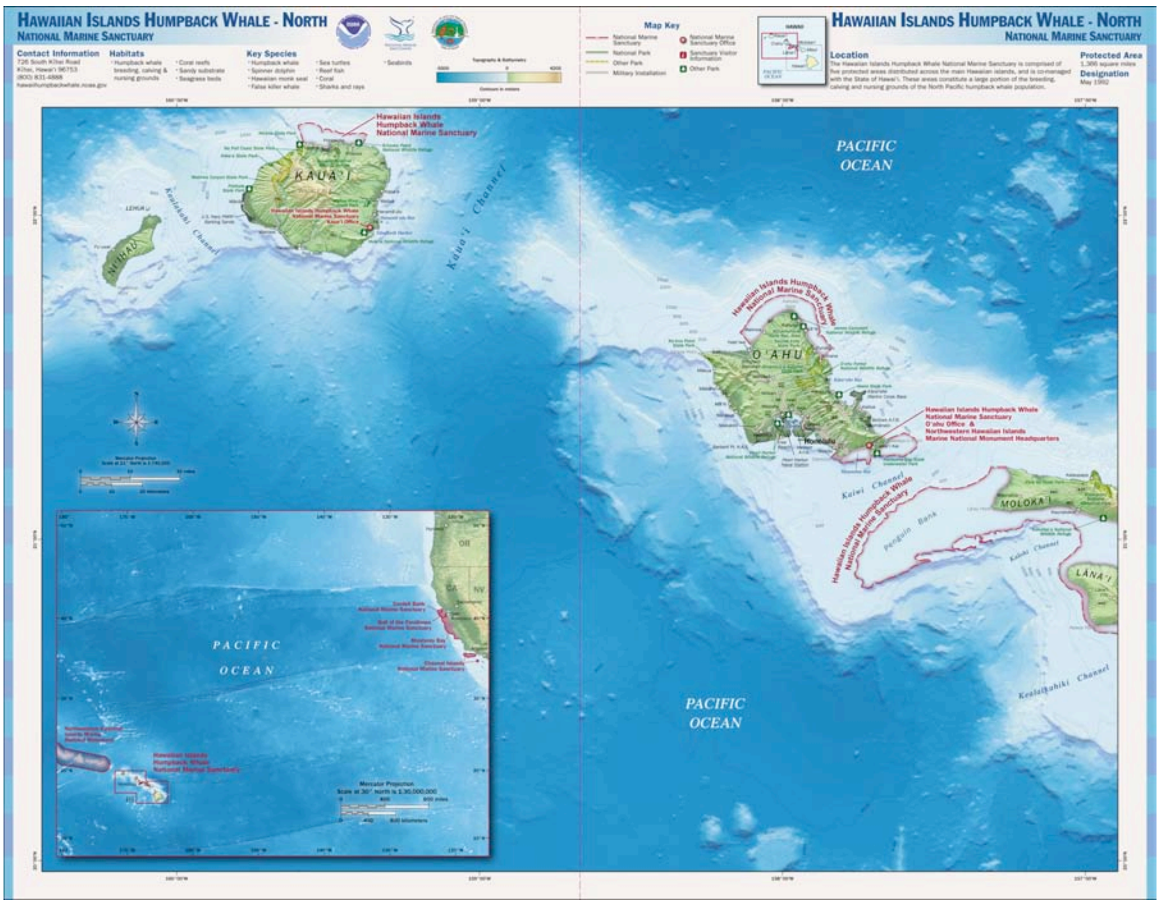

Figure 5: **Map of Hawaiian Islands Humpback Whale National Marine Sanctuary and surrounding environs.**

In public and stakeholder education, the sanctuary offers a variety of educational opportunities, from in-school visits, reaching 15,000 students, and field experiences introducing students to marine-related careers, to educator workshops on incorporating ocean literacy into the classroom. The sanctuary also provides monthly lectures on various aspects of the sanctuary, informational signs at popular whale-viewing sites and educational materials on protecting Hawai'i's marine resources through informational newspaper inserts. In addition the HIHWNMS has trained over 2,000 volunteers in humpback whale research and monitoring. These are a few of the many examples of how the sanctuary endeavors to educate all of Hawai'i's residents and visitors on both the biology and ecology of humpback whales, as well as the importance of the overall ecosystem present within the sanctuary.

In addition to local outreach, HIHWNMS is involved in a project called The Structure of Populations, Levels of Abundance, and Status of Humpback whales (SPLASH). The SPLASH collaboration involves over 400 researchers from 50 different research groups in 10 different countries. It was established to determine the population structure of humpback whales throughout the North Pacific Ocean. The study uses both photo IDs and tissue samples (used to conduct genetic analysis of individual whales) to investigate population sizes, movement patterns, and connectivity between feeding and calving grounds. Initial analyses have already provided insights into population size and migration between specific feeding and calving grounds (Calambokidis et al. 2007). This information is important for managing humpback whale populations and for evaluating changes within the various ecosystems where the whales are found.

Although both projects focus on whales, they have implications for EBM. As charismatic megafauna, whales engage the public and additional stakeholders and are the focus of large-scale management and research. As such, they are a useful avenue to begin raising awareness and research focus on ecosystem-level issues and resources. Further, they engage additional stakeholder groups in the process of implementing EBM by demonstrating the effects of ecosystem change on a particular species and the need to mitigate detrimental effects. In summary, single-species concentration does not necessarily need to be abandoned when it provides a valuable avenue for connecting with stakeholders and the greater scientific community, and for initiating long-term research and monitoring of ecosystems on a large-scale. Instead of forsaking single-species management prospects altogether, EBM can be implemented in this realm, especially if there is a broad ecosystem focus and a diverse stakeholder involvement.

D. Marine Zoning

In an EBM context, marine zoning divides the marine environment and designates "areas for particular allowable uses in both space and time, including networks of fully protected marine reserves and other types of marine protected areas" (McLeod et al. 2005). The COMPASS Scientific Consensus Statement on Marine EBM highlights marine zoning as one of the important actions consistent with EBM. Zoning has particular promise for successful EBM implementation as it directly addresses multiple uses, stakeholders, and strives to minimize conflict. The two case studies that follow, the Channel Islands National Marine Sanctuary (CINMS) and the Florida Keys National Marine Sanctuary (FKNMS) address aspects of zoning in the sanctuaries. In the CINMS, an extensive review process resulted in clear zoning to help implement EBM. The FKNMS is currently reviewing re-zoning to further incorporate EBM into their management plan.

Case Study: The Channel Islands National Marine Sanctuary

The marine reserve network within the CINMS (Figure 6) protects biodiversity and habitats by encompassing diverse oceanographic and habitat regimes across three main bioregions: The Oregonian Province, the Californian Province, and the Transition Zone (Airamé et al. 2003). The western Oregonian Province, including San Miguel Island and northern Santa Rosa Island, contains colder, nutrient rich, upwelling waters. Consequently, this area has high productivity and hosts assemblages typical of central California, Oregon, and Washington. The eastern Californian Province, including Anacapa Island and the eastern tip of Santa Cruz Island, contains temperate waters and hosts a species assemblage characteristic of southern California. In the Transition Zone, including Santa Barbara Island and southern Santa Rosa and Santa Cruz Islands, the water mixes from surrounding regions and supports an assortment of southern and northern species (Airamé et al. 2003).

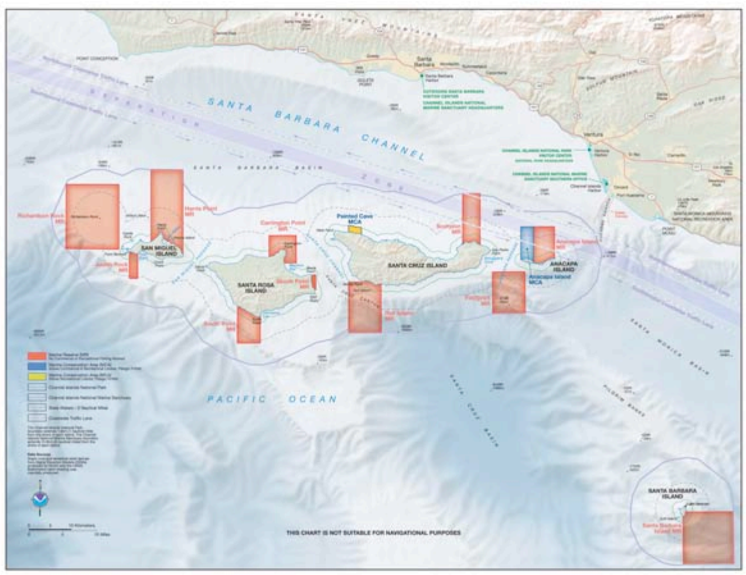

Figure 6: Map of the Channel Islands National Marine Sanctuary and surrounding environs, including the network of State Marine Reserves and Conservation Areas.

In 1998, a diverse group of stakeholders began discussing the development of marine reserves within the sanctuary. Goals included protecting ecosystem biodiversity, achieving sustainable fisheries, maintaining short and long-term economic viability, preserving natural and cultural heritage, and promoting education and stewardship of the marine environment (CINMS 2002, Airamé et al. 2003). In addition to implementing marine zoning, these goals represent an ambitious process to reconcile conflicting and cross-jurisdictional management goals.

CINMS created scientific and socio-economic panels and conducted a series of community meetings to provide input during the design process (Leeworthy and Wiley 2002). This joint federal and state process was organized to be comprehensive in involving the community during the three phases of planning: (1) information gathering, data synthesis and criteria development, (2) applying criteria and developing reserve proposal, and (3) decision making (see Figure 7). The scientific panel, after careful consideration of habitats, species life histories and model inputs, determined the recommended size and spacing guidelines that would be needed to optimize larval export and adult spillover. Scientists recommended implementing one to four reserves in each bioregion with an overall goal of 30-50% of all habitats being represented (Airamé et al. 2003). The optimal reserve design was contentious, with some stakeholders' perception being that conservation values took precedence over minimizing socioeconomic impacts (Davis 2002).

Given the diversity of human uses within the CINMS, it is not surprising that reaching a consensus for the network of marine reserves was a challenge. Although the stakeholders did not reach consensus, 94% of the 9,161 comments received from the public were in support of the marine reserves. A stakeholder-based community group called the Marine Reserves Working Group (MRWG) addressed all legitimate concerns that arose from the public comments. In 2001, the MRWG concluded their meetings and presented the Sanctuary Advisory Council with a composite map of two proposals for the network of marine reserves, including areas of consensus and non-agreement.

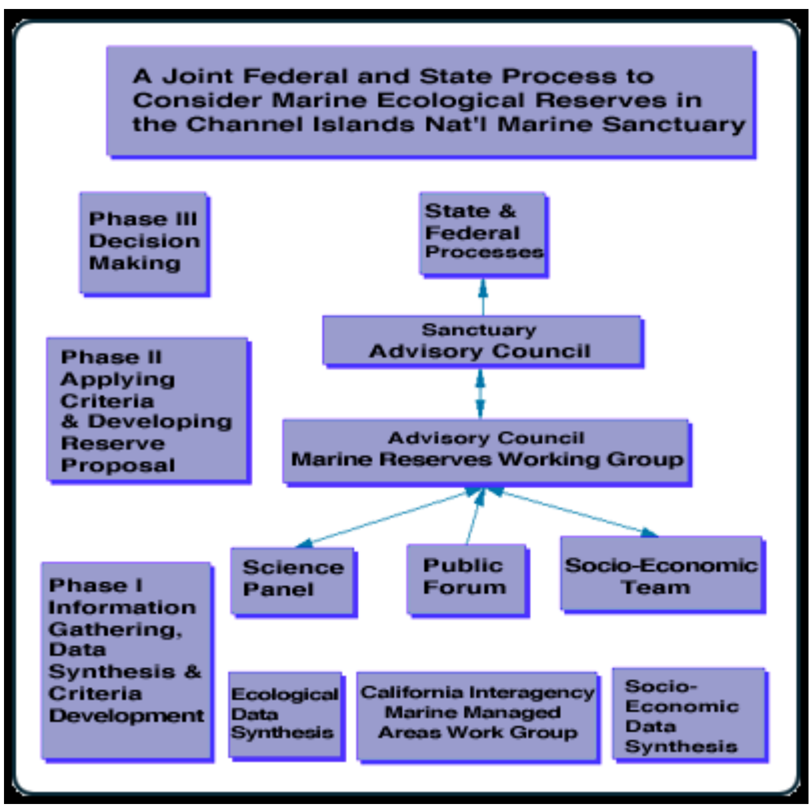

Figure 7: **Diagram of the collaborative federal/state process for MPA design in the CINMS (http://channelislands.noaa.gov/marineres/cp.html).**

In 2001, the Department of Fish and Game (DFG) worked together with the CINMS to make a formal recommendation based on results from the community process, current legislation, regulations and jurisdictions to the California Fish and Game Commission (CFGC). The DFG and CINMS provided the CFGC with all records of the community process, including scientific recommendations, socioeconomic analyses, MRWG maps, and all public comments. In 2002 the CFGC established a network of Marine Protected Areas (MPAs) within the nearshore waters of the CINMS with eleven marine regions that completely prohibit harvest (one reserve has been in place on Anacapa Island since 1978) and two marine conservation areas that allow some commercial and recreational fishing of lobsters and pelagic fish. In 2006 and 2007, NOAA expanded the MPAs into federal waters.

As reviewed in Airamé et al. (2003), the Channel Islands network of marine reserves design maximizes ecological benefits while minimizing economic impacts to local fisheries. Complementary to EBM goals, the CINMS reserves produce large-bodied individuals of several important species which contribute disproportionately to reproductive output. In a recent evaluation (First Five Years of Monitoring the Channel Islands Marine Protected Area Network, February 2008), studies revealed that targeted species of fish (e.g., lingcod, sheephead, kelp bass, rockfishes) were significantly more abundant and had significantly higher biomass inside reserves, while non-targeted species did not show significant differences (CDFG 2008). Ongoing surveys investigating habitat and species assemblages inside and outside of reserves will provide additional information about the efficacy of marine reserves, as well as provide insurance against management uncertainties. Zoning was achieved via a cross-jurisdictional process that involved the input of many stakeholders in the planning process. This case study highlights the successful implementation of marine zoning as a part of EBM. However, a more comprehensive approach to ocean zoning, in the form of altering the governance structure, would likely be a more challenging process as it would involve at least 20 federal agencies and 140 marine statutes (Crowder et al. 2006).

Case Study: The Florida Keys National Marine Sanctuary

The Florida Keys National Marine Sanctuary (FKNMS; Figure 8) utilizes marine zoning to protect local coral species which serve as important ecosystem engineers that have been sensitive to climate change and disease in recent years. Declining populations of two primary reef-building corals, *Acropora palmata* and *Acropora cervicornis*, created the need for an ecosystem-based approach to resource protection and the development of tools to visualize the complex socioeconomic, ecological, and jurisdictional parameters. This case study describes how marine zoning within FKNMS achieved these goals.

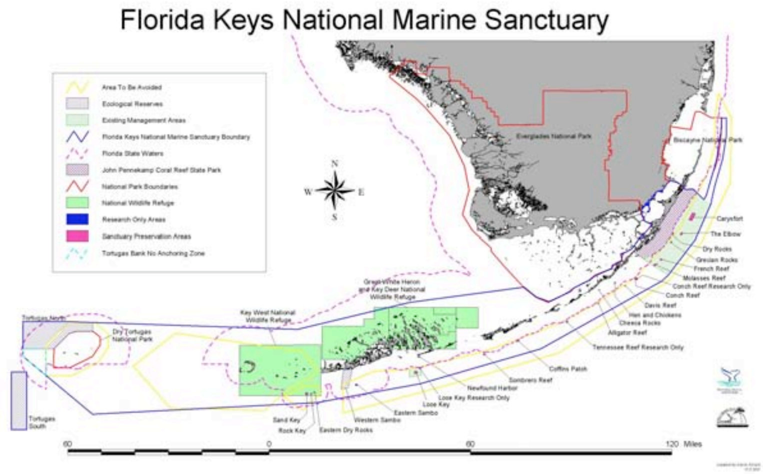

Figure 8: **Map of the Florida Keys National Marine Sanctuary and surrounding environs, including elements of marine zoning.**

Widespread declines in Acroporids have been documented over the last three decades in the Florida Keys (Porter and Meier 1992, Jaap et al. 1998, Miller et al. 2002) and the greater Caribbean (Aronson and Precht 2001). The decline of Acroporids severely altered the FKNMS reefs' condition and resulted in a loss of reef structure and ecological functions (Jackson 1994, Miller et al. 2002). In May 2006, the National Marine Fisheries Service (NMFS) listed *A. palmata* and *A. cervicornis* as threatened under the Endangered Species Act (ESA). This listing brought about a renewed sense of urgency to identify and protect remnant populations. It also provided an impetus for coordinating efforts among the numerous jurisdictions in the FKNMS, using marine zoning, and expansion of existing protected areas (e.g., Sanctuary Protection Areas and Ecological Reserves).

Previously, the FKNMS implemented marine zoning under a supplemental statutory authority. The case study here addressed the need to expand these areas. An important step in coordinating Acroporid habitat protection and restoration efforts is visualization of existing populations, ecological parameters, and jurisdictional boundaries. This case study engaged managers and research coordinators to develop a product that could meet their current habitat visualization needs and be useful in future re-zoning efforts within the FKNMS. This spatial visualization product, known as a GeoPDF is a combination of GIS and mapping data compatible with Adobe Systems PDF. A GeoPDF is intuitive to use, easily interpreted, and adaptive.

The lessons learned from the process of creating and implementing marine zoning can be used to effectively implement EBM throughout the system of sanctuaries. The CINMS case study provides an example of successful implementation of zoning that involves multiple groups and input. To support such goals, the FKNMS case study developed a useful tool for development of appropriate marine zones to effectively move toward EBM.

II. Emerging Tools for EBM implementation

The previous case studies focused on current examples of EBM. The following studies provide specific tools and methods for the planning, evaluation and implementation of EBM. These tools support EBM by allowing for inclusion of numerous stakeholders, addressing multiple uses, and providing guidance on how to protect habitat and biodiversity while minimizing conflict. The PMNM tool lends itself to determining possible zonation or other EBM strategies through stakeholder resource prioritization and the assessment of possible threats. The CINMS example provides a cumulative impacts tool for aiding in the zoning process. The Monterey Bay National Marine Sanctuary (MBNMS) tool provides managers with an evaluation methods for EBM implementation and effective resource allocation.

Case Study: Papahanumokuakea Marine National Monument

The Papahanaumokuakea Marine National Monument (PMNM; Figure 9) case study proposed a new planning and management approach to better integrate stakeholder input for the identification and conservation of focal resources. The approach addresses cross-sector purposes and stakeholders by explicitly involving many users in identifying critical ecosystem benefits (both resources and services) and cumulative impacts. This process used stakeholder involvement to prioritize resources, determine resource vulnerability, and integrate these aspects into a spatial conservation planning tool. The three primary steps involved are:

1) Resource identification and prioritization via a participatory stakeholder process;

2) Resource vulnerability determinations through an expert interview method;

3) Integration of vulnerability determination and prioritization of resources through a site-based algorithm for marine spatial planning.

The first step was a value-driven process whereby stakeholders used a modified Delphi technique (Crance 1987). This process helped identify important resources and attributes of the PMNM (Table 3) and prioritized the resources for management actions using stakeholder perspectives. The second step determined environmental vulnerability and used expert opinion surveys to minimize bias. Vulnerability arose as a key concept for prioritizing management strategies, particularly in conservation planning (Wilson et al. 2005, Wilson et al. 2006). Once established, vulnerabilities were overlaid with threats previously identified in the Monument. Doing so allowed vulnerable areas to be viewed in tandem with potential threats.

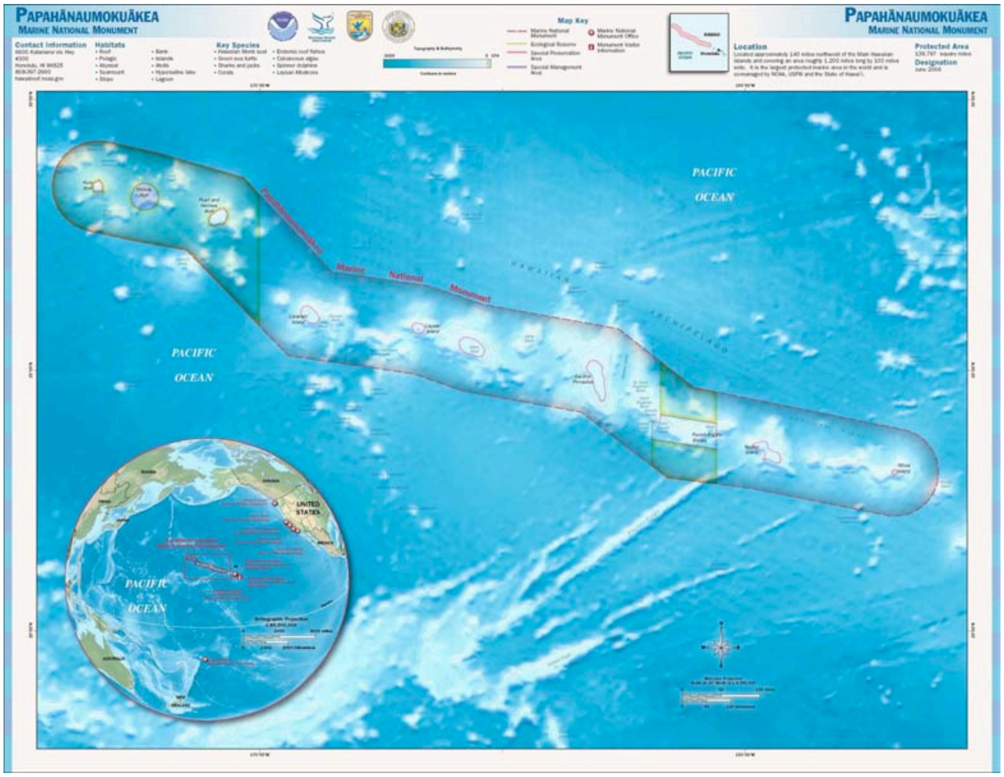

Figure 9: **Map of the Papahanaumokuakea Marine National Monument and surrounding environs.**

This approach informs managers on the resources most threatened and those most valuable to stakeholders. Data on specific resources could then be integrated via geospatial information tools for ecosystem-based analysis and decision-making by managing agencies.

This approach is important for moving from evaluating regulations and documents to implementing ecosystem-level planning for EBM including stakeholder involvement, cumulative impacts and long-term research. Initially, this tool's application requires the identification and involvement of a diverse array of stakeholders to carry out the preliminary interview process. From there, managers can better visualize cumulative impacts, potentially vulnerable areas, and possible threats across sectors and use stakeholder advice. Such an approach could be seen as a second step following the review of a management plan, to allow this process to take place in the context of current management.

Table 3: Example of an ecosystem-based resource list for the Papahanaumokuakea Marine National Monument.

Resource	Code	Description
Ecozones & Habitats	E1	Pelagic
	E2	Deep Reef
	E3	Outer Reef
	E4	Inner Reef
	E5	Pavement
	E6	Sand / Mud
	E7	Algal Beds
	E8	Sandy Beach
	E9	Rocky Intertidal
	E10	Interior Terrestrial
	E11	Unclassified Habitat (Other)
	H1	Seamounts
	H2	Lagoons
	H3	Tidal Passages
	H4	Spawning Sites
	H5	Areas of High Biodiversity (Spp. Richness, Diversity)
Biological Resources	B1	Threatened, Endangered and Protected Species
	B2	Endemic Species
	B3	Biogenic Reefs
	B4	Seabirds, Shorebirds
	B5	Marine Mammals
	B6	Migratory Species
	B7	Benthic Shallow Water Invertebrates
	B8	Crustaceans
	B9	Reef Fish
	B10	Bottom Fish
	B11	Pelagic Marine Life
	B12	Reptiles
	B13	Long-lived, Low Reproductive Species
Socio-Cultural Resources	SCR1	Native Hawaiian Ancestral Sites
	SCR2	Native Hawaiian Ceremonial Foundations
	SCR3	Maritime Heritage
Processes	P1	Seasonal Spawning/Reproduction Events
	P2	Pacific Decadal Oscillation, Geostrophic Fronts
	P3	Ecological-Evolutionary Connectivity

Case Study: The Channel Islands National Marine Sanctuary (CINMS)

While the PMNM case study provided a method for implementing EBM via stakeholder involvement, additional guiding tools are necessary to design or alter new and existing management strategies. To this end, the CINMS case study presented a tool for understanding cumulative and multiple impacts across a system from various stressors. Such a tool can assist stakeholders and managers in decision-making, consensus building, and prioritization. Doing so will aid in the development of spatial management or the alteration of existing regulations to address cumulative impacts.

Using the Halpern et al. (2008) "ecosystem-specific multi-scale spatial model" or Cumulative Impacts Tool (CIT), the CINMS case study examined ways in which sanctuary managers might understand the cumulative impacts of multiple stressors on various habitats within their boundaries and prioritize mitigation actions accordingly. The tool incorporates spatial information on marine habitats and the intensity of stressors associated with human activities (in this case a total of 25 stressors), and calculates the impact of those stressors on marine ecosystems based on the unique vulnerability of each ecosystem to each stressor. Ecosystem vulnerability is estimated via expert judgment, based on a structured survey that asks experts to quantify ecosystem vulnerability along five different criteria (scale and intensity of stressors, and the number of species affected, the degree to which they are affected, and their recovery time after removal of the stressor). Using the tool, the case study identified the top three threats to CINMS (ocean acidification, Ultra Violet radiation, and atmospheric deposition) as issues that must be addressed on an international level. Commercial shipping was identified as the fourth largest ecosystem stressor in this area, and related impacts such as air quality, water quality, noise pollution, and invasive species all ranked in the top ten. An additional effect associated with shipping was the threat of large cetacean mortality by a ship strike. As shipping increases to meet global trade demands, shipping-related pollution is predicted to rise, especially in congested areas around the nation's major ports. Approximately 70% of all international shipping occurs within 240 nautical miles (nm) of land (IMO 2000), and there is growing awareness of negative impacts on both near-shore marine ecosystems and human health.

The UCSB group analyzed two possible management schemes to examine how they might alter the effect of commercial shipping on shipping-related pollution and associated impacts.

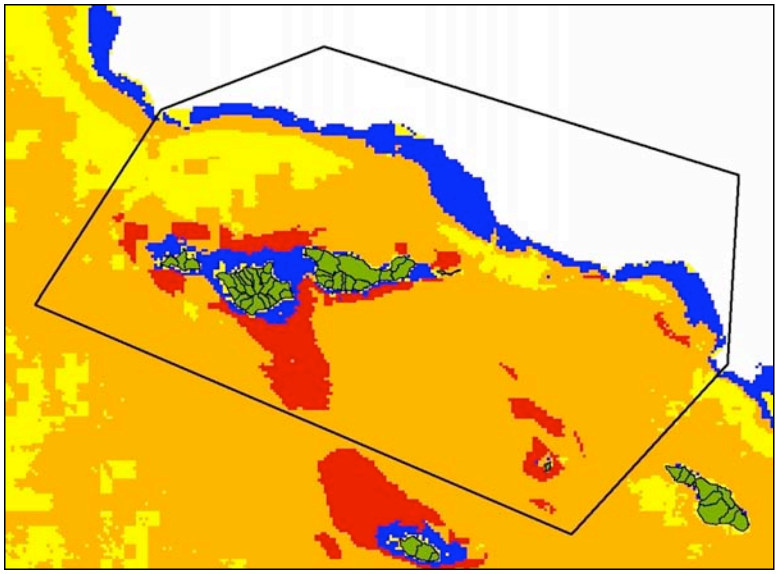

Figure 10: Map of percent change in impact per pixel for Management Option 2. Change in impact is measured as a percentage change from the original impact to impacts recalculated with a reduction in vessel speed and low sulfur fuel use. Blue = 0-2%, yellow = 2-4%, orange = 4-6%, red = 6-8%.

Management Option 1 removes all shipping outside of the channel through a relocation of the traffic separation scheme (TSS). Management Option 2 examines a vessel speed reduction (VSR) to 10 knots in conjunction with a switch to low sulfur fuel inside the Santa Barbara Channel. At lower speeds, ocean-going vessels burn fuel more efficiently which reduces emissions. Low sulfur fuel contains only a fraction of the sulfur content of residual oil and has been shown to reduce SO_x emissions (CARB 2008).

After examination of results, Option 1 was considered a stressor “displacement” rather than a cumulative impacts reduction. Vessels operating at high speeds outside the channel still emit air pollutants at high levels, and studies indicate that pollutants produced offshore continue to impact air quality on land due to prevailing onshore winds (CARB 2008). Also, vessels operating at high speeds outside the channel still provide a threat to marine mammals through increased chance of ship strikes (Vanderlaan and Taggart 2007). Option 2 results in an average 5% overall decrease in shipping and shipping-related stressors across the sanctuary. Interestingly, the findings indicate that the greatest impacts from commercial shipping occur in the sensitive habitat surrounding the islands and not in the TSS. A VSR would also reduce risk of ship strikes. These results allow CINMS managers to view shipping impacts on the sanctuary’s entire spatial area. Managers can then make better-informed choices that address more than one effect, species, or location.

This case study exemplifies how the CIT can be used to realize EBM in practice. The ecosystem-based nature of the tool promotes EBM through a greater understanding of the larger impacts due to multiple stressors in a given area. In more complicated scenarios, the CIT allows managers to prioritize actions across multiple stressors and multiple scales. In addition to the case studies presented in this section, the CINMS case study provides a tool that can help implement EBM initiatives and examine how changes in management may affect the system.

Case Study: Monterey Bay National Marine Sanctuary

In the Monterey Bay National Marine Sanctuary (MBNMS; Figure 11) Draft Management Plan, Action Plans are sets of strategies and goals to address the most pressing issues facing the sanctuary, as determined through a public comment process. The Action Plans list hundreds of partners including federal, state, regional, and local agencies, academic and educational institutes, and non-specific groups. This case study used four pieces of information to assess the relevance, or magnitude, of EBM within sanctuary boundaries: (1) number of regulations, (2) number of action plans, (3) number of governing agencies, and (4) amount of management effort per governing agency. The case study defined nine zones within the sanctuary based on jurisdictional and geographic boundaries (Figure 12, inset). Jurisdictional boundaries were coastal, state, and federal, and the geographical boundaries were north, central, and south. Relevance is defined as the individual and interactive influence of specific EBM characteristics within the sanctuary. The spatial extent of EBM characteristics and geographical zones were used to create cartograms to visually represent the relevance of EBM within the sanctuary boundaries; the estimate of the extent of EBM is substituted for the spatial area per designated zone.

In the coastal and state zones, many local agencies manage small areas while the larger federal zones are managed by a few wide reaching federal agencies. Further, the proximity of human populations to coastal and state zones increases the need for interagency cooperation within those zones. Essentially, coastal, state, and federal zones require co-management and cross-jurisdictional cooperation, but interagency cooperation is greater in coastal and state zones.

Figure 11: Map of the Monterey Bay National Marine Sanctuary and surrounding environs.

Based on the analysis of all four measures, the sanctuary had a higher relevance in the central coast and state zones. These results make intuitive sense as human-induced impacts occur more frequently close to populated areas (e.g., the central coast and state zones). It is clear that Action Plans and agencies play an important role in determining the relevance of EBM within sanctuary boundaries. Additionally, ecological impacts radiate from population centers and seem to result in a higher EBM relevance in these locations. Clearly, the sanctuary must facilitate and promote interactions between the federal, state, regional, and local agencies, academic and educational institutions and stakeholder groups to successfully implement EBM within its boundaries.

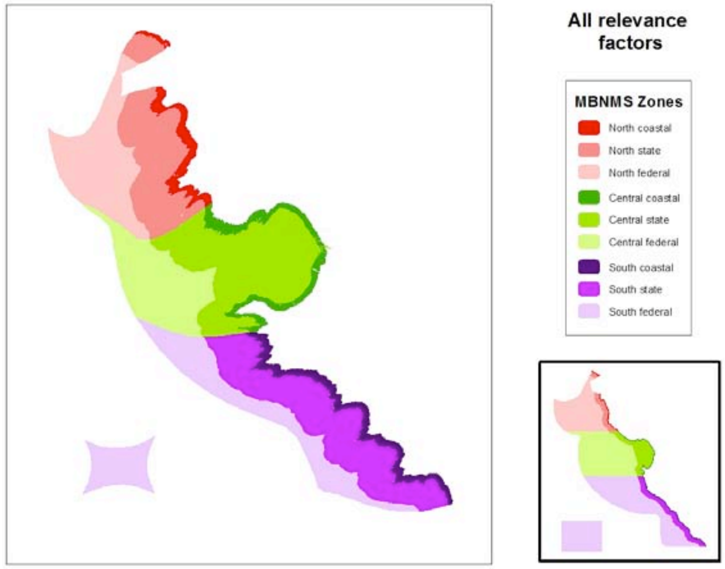

Figure 12: Cartogram depicting the relative influence of "relevance factors" in the implementation of EBM in the MBNMS. Inset depicts zones prior to inclusion in the cartogram.

This case study compares sanctuary's actions with stated priorities set forth by their guiding documents and produces a visual tool describing where the sanctuary is in fact focusing its resources. Further, the method can be modified to include additional management aspects or to look at specific activities and issues.

CONCLUSIONS

Reports from two Commissions, the U.S. Commission on Ocean Policy and the Pew Oceans Commission, provide us with a blueprint for ocean stewardship that has ecosystem-based management as its foundation (Watkins and Panetta 2006). The Commissions' reports recommend specific actions necessary to drive advances in the ocean including employing marine protected areas (MPAs) as an ecosystem-based management tool. Ecosystem-based approaches to management are incremental and adaptive by nature. The critical question becomes whether we can overcome institutional and technical barriers to integrate MPAs into broader ecosystem-based management goals as an effective conservation tool (Cicin-Sain and Belfiore 2005).

Questions of scale and complexity further complicate our ability to understand the role of MPAs in the larger ecosystem context (Perry and Ommer 2003, Schneider 2001, Levin 2002). As such, the utility of MPAs as effective ecosystem-based management tools is still highly debated. Crowder (2006) points out that MPAs alone do not resolve the problem of fragmented management responsibilities among multiple government jurisdictions or the mismatch between scales of government and functional ecosystem scales. Field (2006) identifies the challenges of reconciling traditional methods used to assess fisheries stocks for species-specific management practices with the effects of MPAs on those species. A similar tension between place- and species-based management approaches is evident in MPAs designated by the International Whaling Commission (Gerber 2005). Craig (2006) questions whether National Marine Sanctuaries, the central framework for managing MPAs in U.S. waters, are adequate for the job. The plan for the DGS was the simultaneous exploration of these issues at sanctuaries ranging from Hawai'i to the Gulf of Maine.

The university participants in the DGS were chosen to bring a range of geographic, technical, and cultural perspectives to the seminar. The coupling of university partners with adjacent Sanctuaries proved to be illuminating for all parties involved. While the case studies yielded, and indeed continue to yield as they develop further, interesting insights into the specific EBM issues at the respective sanctuaries, the Sanctuary Program's important role as a facilitator of management action was an emergent property of the case studies. While direct regulatory involvement of sanctuaries in EBM was limited, it is clear that by facilitating engagement among regulatory partners—federal, state, and local—the footprint of the ONMS in the implementation of EBM is considerable and is deserving of future attention. We hope that this DGS serves as a point of departure for the continuing exploration of the role that Sanctuaries can play in the implementation of EBM throughout US waters.

REFERENCES

Airamé, S., J.E. Dugan, K.D. Lafferty, H. Leslie, D.A. McArdle, R.R. Warner. 2003. Applying ecological criteria to marine reserve design: a case study from the California Channel Islands. Ecological Applications 13(1):S170-S184.

Aronson, R.B. and Precht, W.F. 2001. Evolutionary paleoecology of Caribbean coral reefs. In: Allmon, W.D, Bottjer, D.J. (eds). Evolutionary paleoecology: the ecological context of macroevolutionary change. Columbia University Press, New York: pp 171–233

Benson, Catherine S. 2007. Appropriation, Conceptions, Conservation: The Interaction of NGOs, Protected Areas, People, and Place in Papua New Guinea Yale University Master's Thesis.

Calambokidis J., Falcone, E.A., Quinn, T.J., Burdin, A.M., Clapham, P.J., Ford, J.K.B., Gabriele, C.M., LeDuc, R., Mattila, D., Rojas-Bracho, L., Straley, J.M,, Taylor, B.L., Urban, J., Weller, D., Witteveen, B.H., Yamaguchi, M., Bendlin, A., Camacho, D., Flynn, K., Havron, A., Huggins, J., Maloney, N. (2008). SPLASH: Structure of populations, levels of abundance and status of humpback whales in the North Pacific. Final report for Contract AB133F-03-RP-00078 to U.S. Dept of Commerce, WASC, Seattle, WA. 57 pp.

California Air Resources Board. "California's ocean-going vessel clean air plan". Accessed online November 17, 2008. http://www.arb.ca.gov/ports/marinevess/presentations/091206/091206plan.pdf.

Carden, Kristin (Unpublished) Legal and Jurisdictional Barriers and Opportunities to the Integration of the Channel Islands National Marine Sanctuary into Ecosystem-Based Management Efforts at Local and Regional scales. University of California, Santa Barbara.

CDFG. 2008. Channel Islands Marine Protected Areas: First 5 years of monitoring: 2003-2008. S. Airamé and J. Ugoretz, editors. California Department of Fish and Game, Partnership for Interdisciplinary Studies of Coastal Oceans, Channel Islands National Marine Sanctuary, and Channels Islands National Park. www.dfg.ca.gov/marine.

Channel Islands National Marine Sanctuary. (2002). History of community-based process on marine reserves at the Channel Islands National Marine Sanctuary 1999-2001. Channel Islands National Marine Sanctuary, Santa Barbara, California. http://channelislands.noaa.gov/marineres/PDF/mpa_history%20of%20process.pdf

Channel Islands National Marine Sanctuary. (2009.) Mission Statement. http://channelislands.noaa.gov/focus/about.html (accessed April 2, 2009).

Christensen, Norman L., Bartuska, Ann M., Brown, James H., Carpenter, Stephen, Carla, and Crance, J. H. 1987. Guidelines for using the Delphi technique to develop habitat suitability index curves. Biological Report No. 82 (10.134). National Ecology Center, Division of Wildlife and Contaminant Research, Fish and Wildlife Service, US Dept. of the Interior, Washington, DC.

Cicin-Sain, B. and S. Belfiore (2005). "Linking marine protected areas to integrated coastal and ocean management: A review of theory and practice." Ocean & Coastal Management 48(11-12): 847-868.

Crance, J. H. 1987. Guidelines for using the Delphi technique to develop habitat suitability index curves. Biological Report No. 82 (10.134). National Ecology Center, Division of Wildlife and Contaminant Research, Fish and Wildlife Service, US Dept. of the Interior, Washington, DC.

Crowder, L. B., Osherenko, G., Young, O. R., Airame, S., Norse, E. A., Baron, N., Day, J. C., Bouvere, F., Ehler, C. N., Halpern, B. S., Langdon, S. J., McLeod, K. L., Ogden, J. C., Peach, R. E., Rosenberg, A. A., Wilson, J. A. 2006. Resolving mismatches in US ocean governance. Science 313:617-618.

D'Antonio, R.F., Franklin, J.F., MacMahon, J.A., Noss, R.F., Parsons, D.J., Peterson, C.H., Turner, M.G., Woodmansee, R.G. (1996) The Report of the Ecological Society of America Committee on the Scientific Basis for Ecosystem Management. Ecological Applications: Vol. 6, No. 3, pp. 665-691.

Davis, J. ed. 2002. Balancing ecology and economics: Lessons learned from the planning of a marine reserve network in the Channel Islands (US). MPANews 4(6): 1-4.

FAO. 2007. Draft International Guidelines on the Management of Deep-sea Fisheries in the High Seas. As adopted by the Expert Consultation on International Guidelines on the Management of Deep-sea Fisheries in the High Seas (Bangkok, Thailand, 11-14 September 2007). Food and Agricultural Organization (FAO) of the United Nations, Bangkok, Thailand.

Field, J. C., Punt, A. E., Method, R.D., Thomson, C.J. (2006). "Does MPA mean 'Major Problem for Assessments'? Considering the consequences of place-based management systems." Fish and Fisheries 7(4): 284-302.

Garthe, S., Huppop, O. 2004. Scaling possible adverse effects of marine wind farms on seabirds: developing and applying a vulnerability index. Journal of Applied Ecology 41:724-734.

Gerber, L. R., Hyrenbach, K. D., Zacharias, M.A. (2005). "Ecology: Do the Largest Protected Areas Conserve Whales or Whalers?" Science 307(5709): 525-526.

Grumbine, R. 1994. What is ecosystem management? Conservation Biology 8:27-38.

Halpern B.S., Walbridge, S., Selkoe, K.A., Kappel, C.V., Micheli, F., D'Agrosa, C., Bruno, J.F., Casey, K.S., Ebert, C., Fox, H.E., Fujita, R., Heinemann, D., Lenihan, H.S., Madin, E.M.P., Perry, M.T., Selig, E.R., Spalding, M., Steneck, R., Watson, R. 2008. A global map of human impact on marine ecosystems. Science, 319: 948-952.

Halpern, B. S., Selkoe, K.A., Micheli, F., Kappel, C.V. 2007. Evaluating and ranking the vulnerability of global marine ecosystems to anthropogenic threats. Conservation Biology 21:1301–1315.

Hiddink, J. G., S. Jennings, and M. J. Kaiser. 2007. Assessing and predicting the relative ecological impacts of disturbance on habitats with different sensitivities. Journal of Applied Ecology 44:405-413.

[HIHWNMS] Hawaiian Islands humpback Whales National Marine Sanctuary (2007) Assessment of Additional Marine Resources for Possible Inclusion in the Hawaiian Islands humpback Whale National Marine Sanctuary. Prepared for Governor Linda Lingle, State of Hawai‘i by the Hawaiian Islands humpback Whale National Marine Sanctuary Program, National Ocean Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce and the Division of Aquatic Resources, Department of Land and Natural Resources, State of Hawai‘i. 58 pp.

International Maritime Organization. Study of Greenhouse Gas Emissions from Ships. MEPC 45(8) (2000)

Jaap, W.C. 1998. Boom-bust cycles in Acropora. Reef Encounter 23, 12–13

Jackson, J.B.C. 1994. Community unity. Science 264:1412–1413

Jostes, J. C., Eng, M. 2001. Facilitators’ Report Regarding the Channel Islands National Marine Sanctuary Marine Reserves Working Group. Prepared for Channel Islands National Marine Sanctuary Sanctuary Advisory Council. http://channelislands.noaa.gov/pdf2/MRWGfacilRpt2.pdf

Leeworthy, V.R., Wiley, P.C. 2002. Socioeconomic impact analysis of Marine Reserve Alternatives for the Channel Islands National Marine Sanctuary. NOAA, NOS, Special Projects, Silver Spring, MD.

Levin, S. A. (2002). "Complex adaptive systems: Exploring the known, the unknown, and the unknowable." American Mathematical Society 40(1): 2-19.

Linstone, H. A., Turoff, M. (Editors). 2002. The Delphi Method: Techniques and Applications. New Jersey Institute of Technology, Newark, NJ.

LSNMCA, 2007. Memorandum of Understanding between Queen of England, Minister of the Environment, and Minister of Natural Resources. Lake Superior National Marine Conservation Area. October 25, 2007.

Lubchenko, J., Palumbi, S.R., Gaines, S.D., Andelman, S. (2003). Plugging a hole in the ocean: the emerging science of marine reserves. Ecological Applications, 13(1): S3-S7.

McLeod, K. L., Lubchenco, J., Palumbi, S. R., Rosenberg, A. A. 2005. Scientific Consensus Statement on Marine Ecosystem-Based Management. Signed by 221 academic scientists and policy experts with relevant expertise and published by the Communication Partnership for Science and the Sea at http://compassonline.org/?q=EBM.

Miller M.W., Bourque, A.S., Bohnsack, J. 2002. An analysis of the loss of acroporid corals at Looe Key, Fl, USA: 1983-2000. Coral Reefs 21: 179-182

Mitchell, R. K., Agle, B. R., Wood, D.J. 1997. Toward a theory of stakeholder identification and salience: defining the principle of who and what really counts. The Academy of Management Review 22:853-886.

Monterey Bay National Marine Sanctuary Regulations. 18 September 1992. Federal Register 57(182):43310-43330.

NMSA 2000. "National Marine Sanctuaries Act. Title 16, Chapter 32, Sections 1431 et seq. United States Code as amended by Public Law 106-513, November 2000. Available from: http://sanctuaries.noaa.gov/library/National/NMSA.pdf

[NMSP] National Marine Sanctuary Program Regulations, Title 15 part 922 (2008). United States Code of Federal Regulations. [cited 2008 December 2008]. Available from: http://montereybay.noaa.gov/intro/mp/archive/regulations.html#code

[NOAA] National Oceanic and Atmospheric Administration, National Ocean Service, National Marine Sanctuary Program. 2006. Monterey Bay National Marine Sanctuary Draft Management Plan, Volume III: October 2006.

NRC (National Research Council) (2000). Marine protected areas: tools for sustaining ocean ecosystems. National Academy Press, Washington, D.C., USA.

Parks Canada. 2009. Lake Superior National Marine Conservation Area of Canada. Available from: http://www.pc.gc.ca/amnc-nmca/on/super/index_E.asp (Accessed on 4-9-09).

Perry, I. R., Ommer, R.E. (2003). "Scale issues in marine ecosystems and human interactions." Fisheries Oceanography 12(4-5): 513-522.

Pew Oceans Commission. 2003. *America's Living Oceans: Charting a Course for Sea Change*. Pew Oceans Commission, Arlington, VA.

Porter, J.W., Meier, O.W. 1992. Quantification of loss and change in Floridian reef coral populations. American Zoologist 32:625–640

Saaty, T. L. 1987. Risk—its priority and probability: the analytic hierarchy process. Risk Analysis 7:159-172.

Schneider, D. C. (2001). "The Rise of the Concept of Scale in Ecology." BioScience 51(7): 545-553.

Scott, S. G., Lane, V.R. 2000. A stakeholder approach to organizational identity. Academy of Management Review 25:43-62.

Selkoe, K. A., Halpern, B.S., Toonen, R. J. 2008b. Evaluating anthropogenic threats to the Northwestern Hawaiian Islands. Aquatic Conservation: Marine and Freshwater Ecosystems [online] http://dx.doi.org/10.1002/aqc.961.

U.S. Commission on Ocean Policy. 2004. *An Ocean Blueprint for the 21st Century*. Final Report of the U.S. Commission on Ocean Policy to the President and Congress, Washington DC.

Vanderlaanm, A., Taggartm C. 2007. Vessel collisions with whales: the probability of lethal injury based on vessel speed. Marine Mammal Science, 23(1):144-156

Wilson, K., R. L. Pressey, A. Newton, M. Burgman, H. Possingham, and C. Weston. 2005. Measuring and incorporating vulnerability into conservation planning. Environmental Management 35:527-543.

Watkins, J. D., Panetta, L.E. From Sea to Shining Sea. Priorities for Ocean Policy Reform, Washington, D.C.: Meridian Institute, 2006.

Wilson, K. A., McBride, M. F., Bode, M., Possingham, H.P. 2006. Prioritizing global conservation efforts. Nature 440:337-340.

Wilson, K., Pressey, R. L., Newton, A., Burgman, M. Possingham, H., Weston, C. 2005. Measuring and incorporating vulnerability into conservation planning. Environmental Management 35:527-543.

Zacharias, M. A., Gregr, E.J. 2005. Sensitivity and vulnerability in marine environments: An approach to identifying vulnerable marine areas. Conservation Biology 19:86-97.

APPENDIX A

Institutions and participants in the Distributed Graduate Seminar

California State University, Monterey Bay
Faculty: James Lindholm
NOAA liaison: Andrew DeVogelaere and Erica Burton
Students: Shane Anderson, Nick Donlou, Meghan Frolli, Amanda Grant, Jeremy Kerr, Ashley Knight, Chelsea Parrish-Kuhn, Matthew Subia, Scott Toews, Jessica Watson

Hawai'i Institute of Marine Biology
Faculty: Judy Lemus and Janna Shackeroff
NOAA liaison: Malia Chow
Students: Kimo Carvalho, Katherine Cullison, Matthew Dunlap, Erik Franklin, Melanie Hutchinson, Matthew Iacchei, Ashley Kerr, John N. Kittinger, Brandi Kokubun, Benjamin Laws, Joseph O'Malley, Lora L. N. Reeve, Derek J. Skillings, Toby Wood

University of California, Santa Barbara
Faculty: Robert Warner, Ben Halpern, Satie Airame
NOAA liaison: Steve Katz
Students: Leslie Abramson, Ashley Apel, Kristin Carden, Katherine Emery, Kristine Faloon, Skip Forest, Alicia Glassco, Shirley Han, Lauren Hess, Phil Johnson, Theresa Karasek, Peggy Lynch, Paul Matson, Becca Selden, Clare Shelton, Courtney Scarborough, Sarah Teck, Sarah Valencia

University of Connecticut
Faculty: Peter Auster
NOAA liaison: Brad Barr
Student: Ryan Patrylak

University of Michigan
Faculty: Donald Scavia
NOAA liaison: Ellen Brody and Edward S. Rutherford
Students: Catherine Benson, Katharine Birkett, Evan Childress, Laura Colangelo, Michael Eggleston, Michael Fainter, Jennifer Johnson, Matthew Knittel, Shaw Lacy, Julie Mida, James Roberts, Bryan Sederberg, Oneida Ana Watson

University of New Hampshire
Faculty: Andrew Rosenberg
NOAA liaison: Brad Barr
Students: Daniel Bergeron, Jay Clausen, Angelic DeButts, Lindsey Fong, Jason Goldstein, Patricia Jarema, Emily Klein, Thomas Langley, Alesia Read, Lynn Rutter, Matthew Smith

University of South Florida
Faculty: Mark Luther
NOAA liaison: Brian Keller
Students: Tanya Beck, Jennifer Dupont, Mark Hartman, Heather Havens, Mark Horwitz, Luke McEachron, Tiffany Roberts, Nekesha Williams

University of Washington
Faculty: Dave Fluharty
NOAA liaison: Robert Pavia
Students: Albert Arthur, Barbara Bennett, Diane Capps, Chelsea Combest-Friedman, Kirstin Csik, Brandon Fisher, Cirse Gonzales, Jamie Mooney, Amanda Murphy, Jongseong Ryu, Becky Skeele, Xintian Wang

ONMS CONSERVATION SERIES PUBLICATIONS

To date, the following reports have been published in the Marine Sanctuaries Conservation Series. All publications are available on the Office of National Marine Sanctuaries website (http://www.sanctuaries.noaa.gov/).

The Application Of Observing System Data In California Current Ecosystem Assessments (ONMS-10-01)

Reconciling Ecosystem-Based Management and Focal Resource Conservation in the Papahānaumokuākea Marine National Monument (ONMS-09-04)

Preliminary Comparison of Natural Versus Model-predicted Recovery of Vessel-generated Seagrass Injuries in Florida Keys National Marine Sanctuary (ONMS-09-03)

A Comparison of Seafloor Habitats and Associated Benthic Fauna in Areas Open and Closed to Bottom Trawling Along the Central California Continental Shelf (ONMS-09-02)

Chemical Contaminants, Pathogen Exposure and General Health Status of Live and Beach-Cast Washington Sea Otters (*Enhydra lutris kenyoni*) (ONMS-09-01)

Caribbean Connectivity: Implications for Marine Protected Area Management (ONMS-08-07)

Knowledge, Attitudes and Perceptions of Management Strategies and Regulations of FKNMS by Commercial Fishers, Dive Operators, and Environmental Group Members: A Baseline Characterization and 10-year Comparison (ONMS-08-06)

First Biennial Ocean Climate Summit: Finding Solutions for San Francisco Bay Area's Coast and Ocean (ONMS-08-05)

A Scientific Forum on the Gulf of Mexico: The Islands in the Stream Concept (NMSP-08-04)

M/V *ELPIS* Coral Reef Restoration Monitoring Report Monitoring Events 2004-2007 Florida Keys National Marine Sanctuary Monroe County, Florida (NMSP-08-03)

CONNECTIVITY Science, People and Policy in the Florida Keys National Marine Sanctuary (NMSP-08-02)

M/V *ALEC OWEN MAITLAND* Coral Reef Restoration Monitoring Report Monitoring Events 2004-2007 Florida Keys National Marine Sanctuary Monroe County, Florida (NMSP-08-01)

Automated, objective texture segmentation of multibeam echosounder data - Seafloor survey and substrate maps from James Island to Ozette Lake, Washington Outer Coast. (NMSP-07-05)

Observations of Deep Coral and Sponge Assemblages in Olympic Coast National Marine Sanctuary, Washington (NMSP-07-04)

A Bioregional Classification of the Continental Shelf of Northeastern North America for Conservation Analysis and Planning Based on Representation (NMSP-07-03)

M/V *WELLWOOD* Coral Reef Restoration Monitoring Report Monitoring Events 2004-2006 Florida Keys National Marine Sanctuary Monroe County, Florida (NMSP-07-02)

Survey report of NOAA Ship McArthur II cruises AR-04-04, AR-05-05 and AR-06-03: Habitat classification of side scan sonar imagery in support of deep-sea coral/sponge explorations at the Olympic Coast National Marine Sanctuary (NMSP-07-01)

2002 - 03 Florida Keys National Marine Sanctuary Science Report: An Ecosystem Report Card After Five Years of Marine Zoning (NMSP-06-12)

Habitat Mapping Effort at the Olympic Coast National Marine Sanctuary - Current Status and Future Needs (NMSP-06-11)

M/V *CONNECTED* Coral Reef Restoration Monitoring Report Monitoring Events 2004-2005 Florida Keys National Marine Sanctuary Monroe County, Florida (NMSP-06-010)

M/V *JACQUELYN L* Coral Reef Restoration Monitoring Report Monitoring Events 2004-2005 Florida Keys National Marine Sanctuary Monroe County, Florida (NMSP-06-09)

M/V *WAVE WALKER* Coral Reef Restoration Baseline Monitoring Report - 2004 Florida Keys National Marine Sanctuary Monroe County, Florida (NMSP-06-08)

Olympic Coast National Marine Sanctuary Habitat Mapping: Survey report and classification of side scan sonar data from surveys HMPR-114-2004-02 and HMPR-116-2005-01 (NMSP-06-07)

A Pilot Study of Hogfish (*Lachnolaimus maximus* Walbaum 1792) Movement in the Conch Reef Research Only Area (Northern Florida Keys) (NMSP-06-06)

Comments on Hydrographic and Topographic LIDAR Acquisition and Merging with Multibeam Sounding Data Acquired in the Olympic Coast National Marine Sanctuary (ONMS-06-05)

Conservation Science in NOAA's National Marine Sanctuaries: Description and Recent Accomplishments (ONMS-06-04)

Normalization and characterization of multibeam backscatter: Koitlah Point to Point of the Arches, Olympic Coast National Marine Sanctuary - Survey HMPR-115-2004-03 (ONMS-06-03)

Developing Alternatives for Optimal Representation of Seafloor Habitats and Associated Communities in Stellwagen Bank National Marine Sanctuary (ONMS-06-02)

Benthic Habitat Mapping in the Olympic Coast National Marine Sanctuary (ONMS-06-01)

Channel Islands Deep Water Monitoring Plan Development Workshop Report (ONMS-05-05)

Movement of yellowtail snapper (*Ocyurus chrysurus* Block 1790) and black grouper (*Mycteroperca bonaci* Poey 1860) in the northern Florida Keys National Marine Sanctuary as determined by acoustic telemetry (MSD-05-4)

The Impacts of Coastal Protection Structures in California's Monterey Bay National Marine Sanctuary (MSD-05-3)

An annotated bibliography of diet studies of fish of the southeast United States and Gray's Reef National Marine Sanctuary (MSD-05-2)

Noise Levels and Sources in the Stellwagen Bank National Marine Sanctuary and the St. Lawrence River Estuary (MSD-05-1)

Biogeographic Analysis of the Tortugas Ecological Reserve (MSD-04-1)

A Review of the Ecological Effectiveness of Subtidal Marine Reserves in Central California (MSD-04-2, MSD-04-3)

Pre-Construction Coral Survey of the M/V Wellwood Grounding Site (MSD-03-1)

Olympic Coast National Marine Sanctuary: Proceedings of the 1998 Research Workshop, Seattle, Washington (MSD-01-04)

Workshop on Marine Mammal Research & Monitoring in the National Marine Sanctuaries (MSD-01-03)

A Review of Marine Zones in the Monterey Bay National Marine Sanctuary (MSD-01-2)

Distribution and Sighting Frequency of Reef Fishes in the Florida Keys National Marine Sanctuary (MSD-01-1)

Flower Garden Banks National Marine Sanctuary: A Rapid Assessment of Coral, Fish, and Algae Using the AGRRA Protocol (MSD-00-3)

The Economic Contribution of Whalewatching to Regional Economies: Perspectives From Two National Marine Sanctuaries (MSD-00-2)

Olympic Coast National Marine Sanctuary Area to be Avoided Education and Monitoring Program (MSD-00-1)

Multi-species and Multi-interest Management: an Ecosystem Approach to Market Squid (*Loligo opalescens*) Harvest in California (MSD-99-1)