

A Blueprint for the Oceans: Implications of Two National Commission Reports for Conservation Practitioners

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Abstract: *In the first comprehensive reviews since 1969, two high-level reports on the status of U.S. marine ecosystems and resources have been released: that of the nongovernmental Pew Oceans Commission in 2003 and that of the congressionally mandated U.S. Commission on Ocean Policy in 2004. Although the two commissions differed in the breadth and depth of their mandates, their findings on the state of our oceans and need for new management approaches are similar, and their major recommendations for science, governance, management and conservation, and education echo and reinforce each other. The history behind the two commissions and the structure and objectives of each remind us of the crucial roles conservation practitioners and scientists must play in the implementation of report recommendations. The reports suggest priorities for conservation practitioners to improve science, management, conservation, governance, and education to better manage and protect ocean resources and ecosystems. To redirect activities affecting the state of global marine resources, integrated research; education and outreach by terrestrial, aquatic, and marine conservation practitioners; and a clear definition of their roles in the implementation of recommendations is essential. Marine ecosystems provide a test case of society's ability to manage complexity in human and natural systems in an integrated manner, with extensive opportunities for participation by conservation practitioners from all disciplines.*

Key Words: conservation and management, marine ecosystem, ocean governance, Pew Oceans Commission, U.S. Commission on Ocean Policy

Un Anteproyecto para los Océanos: Implicaciones de Dos Reportes de Comisiones Nacionales para Practicantes de la Conservación

Resumen: *En las primeras revisiones integrales desde 1969, se han publicado dos reportes de alto nivel sobre el estatus de los ecosistemas y recursos marinos de E.U.A.: el de la no gubernamental Comisión Pew para los Océanos en 2003, y el de la Comisión de E.U.A. sobre Políticas para los Océanos, ordenada por el Congreso en 2004. Aunque las dos comisiones difirieron en la amplitud y profundidad de sus trabajos, sus hallazgos sobre el estado de nuestros océanos y la necesidad de nuevos enfoques de manejo son similares, y sus principales recomendaciones para la ciencia, el control, el manejo y conservación y la educación hacen eco y se refuerzan mutuamente. La historia detrás de las comisiones y la estructura y objetivos de cada una nos recuerdan el papel crucial que deben jugar los practicantes y científicos de la conservación en la implementación de las*

Paper submitted December 20, 2004; revised manuscript accepted March 15, 2005.

recomendaciones de los reportes. Los reportes sugieren prioridades para que los practicantes de la conservación mejoren la ciencia, el manejo, la conservación, el control y educación para un mejor manejo y protección de los recursos y ecosistemas oceánicos. La investigación integral, la educación y mayor alcance de los practicantes de la conservación terrestre, acuática y marina así como una definición clara de su papel en la implementación de recomendaciones son esenciales para la redirección de actividades que afectan el estado de los recursos marinos globales. Los ecosistemas marinos son un caso para probar la habilidad de la sociedad para manejar la complejidad en sistemas humanos y naturales de manera integrada, con amplias oportunidades para la participación de practicantes de la conservación de todas las disciplinas.

Palabras Clave: Comisión de E.U.A. sobre Políticas para los Océanos, Comisión Pew para los Océanos, conservación y manejo, control de océanos, ecosistema marino

Introduction

Until recently, society generally considered the global oceans a bountiful, endless resource, too vast for humans to deplete or degrade. It was assumed that fisheries would always replenish themselves, pollution would be diluted by great volumes of water, and dynamic coastlines would absorb the impacts of development along the shores. In recent decades there has been a shift in societal and scientific perception of the world's oceans as fish stocks worldwide continue to decline dramatically (Hutchings 2000; Myers & Worm 2003); new diseases of marine organisms are appearing at an accelerated rate (Harvell et al. 1999; Porter 2001; Lafferty et al. 2004); dispersal and impacts of marine invasive species continue to increase (Carlton 2001); multiple new impacts of global climate change emerge (Danovaro et al. 2004; Edwards & Richardson 2004); and ever-growing human populations along the world's coastlines increasingly affect marine ecosystems through pollution and other stresses (Castro et al. 2000; Schueler & Holland 2000; Crossett et al. 2004). Even important biogenic habitats such as coral reefs, historically considered resistant and resilient to many natural disturbances, now face progressive and synergistic degradation (Gardner et al. 2003; Pandolfi et al. 2003; Wilkinson 2004).

Although this litany of threats and impacts is global, the United States, with the world's largest exclusive economic zone (EEZ), illustrates the diverse problems facing maritime nations. For example, in 2003 the U.S. Pacific Fishery Management Council closed the continental shelf off the western United States to trawling because of the severe depletion of several rockfish (*Sebastes*) species. With respect to pressures from coastal development, more than half the U.S. population currently lives within 80 km of the coast, and this percentage is predicted to rise to more than 75% by 2010 (Beach 2002). Distant inland development increasingly affects U.S. marine systems as well. Nutrient pollution from midwestern farms and industries draining into the Mississippi River watershed fuels an anoxic "dead zone" in the Gulf of Mexico, one of more than 30 dead zones nationwide. Spanning an area as large as 20,000 km² in some years, this dead zone affects Gulf fisheries and thus the regional economy (Boesch et al. 2001). San Francisco Bay has become one of the best-studied exam-

ples of a highly invaded marine ecosystem (Cohen & Carlton 1998; Carlton 2001), and the Florida Keys provide an example of coral reef ecosystems suffering from disease (Porter et al. 2001). Although the United States has a relatively well-established system for managing much of its 9.4 million km² of land through zoning and management planning, of the 11.5 million km² of the U.S. ocean area (including all territorial waters and the EEZ), currently < 0.1% is covered under any substantive management strategy (POC 2003).

In response to these diverse and widespread problems, and to the corresponding perception that the United States lacks a comprehensive approach to management of its marine ecosystems, two high-level commissions were recently established to review and make recommendations about U.S. ocean policy. These commissions, one convened by a private foundation and the other chartered by U.S. law, conducted extensive studies of the major threats, management challenges, and opportunities for better management of U.S. coasts and oceans. The two reports focus on U.S. jurisdictions, but the issues they highlight mirror global trends and carry relevant lessons for coasts and oceans worldwide. Here, we provide a brief overview and comparison of these reports and discuss several important roles for conservation practitioners in implementing the necessary reforms. Our definition of conservation practitioners includes scientists, managers, educators, and policy makers. Results from these commissions and associated stakeholder input provide conservation practitioners with an unprecedented opportunity to catalyze fundamental changes in marine science, management and conservation, governance, and education to achieve better conservation in the largest and most neglected part of the biosphere. Moreover, U.S.-targeted reforms will have global consequences for marine conservation and management because of the large area within U.S. waters, the diversity of marine ecosystems represented within these boundaries, and the overall size of the U.S. maritime economy. In an increasingly globalized context, this economy includes major transactions with the economies of many other coastal nations. Potential reforms to U.S. marine policy should have deep and widespread relevance for international conservation practitioners.

Background

In 1969 the U.S. Commission on Marine Science, Engineering and Resources (known as the Stratton Commission) reported on the status of the nation's marine resources. That commission's work led directly to the creation of the National Oceanic and Atmospheric Administration (NOAA), the largest U.S. civilian agency with jurisdiction over marine science and policy. The commission, and subsequently NOAA (which is within the Department of Commerce), emphasized the economic development of largely untapped natural resources such as oil, minerals, and seafood. In 2000, more than 30 years after the Stratton Commission and in a markedly different socioeconomic and environmental context, two new commissions were appointed to revisit and renew attention to the status and policy of U.S. coastal and oceanic areas (hereafter referred to collectively as marine areas).

In May 2000 the Pew Charitable Trusts created the Pew Oceans Commission (Pew Commission) to assess the current status and science of living marine resources in U.S. territorial waters and to recommend approaches for protecting and restoring our marine ecosystems. The Pew Commission was comprised of 18 commissioners from a variety of professions, including academic scientists, former and current government leaders, commercial fishers, and leaders from environmental organizations and private industry. In 2003, after 3 years, 15 regional hearings (with invited expert testimony and public comment from diverse individuals and stakeholder groups), 12 focus group meetings, and a series of seven commissioned reports on various topics, the Pew Commission released its final report, *America's Living Oceans: Charting a Course for Sea Change* (POC 2003).

Overlapping in time and operating largely in parallel, the U.S. Commission on Ocean Policy (U.S. Commission), created by the Oceans Act of 2000 (signed by President Clinton in August 2000), was mandated to assess both living and nonliving marine resources, their economic benefits, and overall management of these resources. The U.S. Commission, a 16-member panel appointed by President G.W. Bush in 2001, included representatives from many of the same sectors as the Pew Commission, plus retired Navy personnel and representatives of the oil, gas, and shipping industries, but lacked fishers or representatives from environmental organizations. The U.S. Commission held a series of public meetings (9 regional and 16 overall) and conducted 18 site visits to gather testimony and public comment. As symbols of the mostly noncompetitive and complementary nature of the activities of the two commissions (Senkowsky 2004), Pew Commission members were invited to testify at a U.S. Commission hearing in Washington, D.C., and commissioners from both groups participated in a joint panel at the 2004 meeting of the American Association for the Advancement of Science. The U.S. Commission issued its final report, *An*

Ocean Blueprint for the 21st Century, in 2004 (USCOP 2004).

Major Commission Conclusions and Recommendations

Despite the different authority, scope, and makeup of the two commissions, both reports highlight similar patterns and trends in education and research, resource management, governance, and the science-policy-media triumvirate that are both troubling and hopeful. In addition to summarizing the current state of U.S. marine ecosystems and policy landscape, each commission details a series of recommendations for marine conservation and restoration, with emphases on sustainability and stewardship (Table 1).

The U.S. Commission report generally reflects its closer ties to government with less sweeping and more pragmatic recommendations. For example, both the Pew Commission and U.S. Commission recognize that fragmentation of the nation's marine jurisdictions is a barrier to better resource management, and both call for innovations in legislation and government institutions. Both reports recommend creating a structure for coordinating ocean policy within the executive branch—a National Ocean Council—chaired by a cabinet-level assistant to the president (Table 1). The Pew Commission, however, advocates building a unified ocean management agency from scratch, whereas the U.S. Commission advocates restructuring within NOAA and strengthening and consolidating other existing agencies, leading ultimately to a “unified federal agency structure” for ecosystem-based management.

The U.S. Commission report also appeals more frequently to national pride and economic opportunity. For example, it proposes that the United States become a world leader in ocean research, and, like the Stratton Commission, argues that an important motivation for U.S. reform should be economic advantage through the sustainable use of ocean resources. In contrast, the Pew Commission, echoing Aldo Leopold's (1949) land ethic, emphasizes maintaining ocean resources for biodiversity and ecosystem function.

In addition to establishing a new or restructured marine agency, both commissions' recommendations include new U.S. ocean policy frameworks, improved governance, ecosystem-based management as an overarching theme for marine resource management, better incorporation of science in decision making, and increased funding for ocean science (Table 1). Although the reports' recommendations vary in terms of specific approaches, several are shared within each area. We group recommendations into five general themes: science and research, governance, conservation and management, education, and funding.

Table 1. Major recommendations of the Pew Commission and U.S. Commission by category.

<i>Area and topic</i>	<i>Pew Oceans Commission</i>	<i>U.S. Commission on Ocean Policy</i>
Science and research research funding research programs	<p>double funding for basic ocean science and research and implement comprehensive national ocean research and monitoring strategy</p> <p>broaden programs to monitor and understand ecosystems</p>	<p>double funding for basic and applied ocean research and implement a comprehensive national ocean research and monitoring strategy</p> <p>enhance ocean and coastal-related social and economic research</p> <p>implement the national Integrated Ocean Observing System and a nationwide monitoring network</p> <p>improve methods to transfer, archive, and integrate research data to create products for use by multiple user communities</p>
integrate science	<p>improve use of existing scientific information by creating a mechanism or institution that regularly provides independent scientific oversight of ocean and coastal management</p>	<p>enshrine NOAA's roles and responsibilities through passage of an Organic Act</p> <p>accede to the United Nations Law of the Sea</p> <p>create a national ocean council (executive office of the president) strengthen NOAA</p> <p>combine ocean and coastal programs from NOAA and other agencies where possible</p> <p>encourage voluntary regional ocean councils</p>
Governance general legislation	<p>enact National Ocean Policy Act (NOPA)</p> <p>establish national System of Marine Reserves</p>	
government institutions	<p>establish permanent interagency oceans council (executive office of the president)</p> <p>establish national oceans agency (outside Dept. of Commerce)</p>	
regional governance	<p>establish regional ocean ecosystem councils</p>	
Conservation and management coordinate management	<p>institute effective mechanisms at all levels of government to manage development and minimize impact on coastal ecosystems and their watersheds</p>	<p>create a coordinated management structure for federal waters</p>
ecosystem-based management	<p>implement ecosystem-based planning and marine zoning</p>	<p>move toward an ecosystem-based management approach in all ocean and coastal management efforts</p>
watershed management	<p>develop plan to protect water quality on watershed basis</p>	<p>strengthen link between watershed and coastal management</p> <p>provide better financial, technical, and institutional support for watershed initiatives</p>
coastal zone management	<p>identify and protect from development habitat critical for functioning of coastal ecosystems</p> <p>redirect government programs and subsidies from harmful coastal development and toward beneficial activities including restoration</p>	<p>devote additional resources to habitat protection and restoration</p> <p>provide additional support for state coastal zone management programs</p> <p>review federal programs and revise those that may encourage inappropriate coastal development</p> <p>increase the use of state revolving funds to achieve pollution reduction</p>
pollution	<p>develop action plan to address nonpoint-source pollution</p> <p>revise, strengthen, and redirect pollution laws to focus on nonpoint-source pollution on watershed basis</p> <p>address unabated point sources of pollution</p> <p>create flexible framework to address emerging and nonconventional sources of pollution</p> <p>strengthen control of toxic pollutants</p>	<p>make significant reduction of nonpoint-source pollution a national priority</p> <p>develop measurable nonpoint-source water pollution reduction goals</p> <p>reduce atmospheric deposition of pollutants to coastal and ocean waters</p>

Table 1. (continued)

Area and topic	Pew Oceans Commission	U.S. Commission on Ocean Policy
fisheries management	<p>redefine principal objective of U.S. marine fishery policy</p> <p>separate conservation and allocation decisions</p> <p>require bycatch monitoring and management plans as a condition for fishing</p> <p>regulate use of fishing gear destructive to marine habitats</p> <p>require comprehensive access and allocation planning as a condition for fishing</p>	<p>maintain RFMC system but fine-tune the process</p> <p>separate fisheries allocation and biological assessment decisions</p> <p>reduce overcapitalization of U.S. fisheries</p> <p>encourage the use of dedicated access privileges in fishery management</p> <p>require independent scientific review</p> <p>address excess bycatch and habitat impacts by adopting an ecosystem-based approach</p>
marine aquaculture	<p>implement National Marine Aquaculture Policy based on sound conservation principles and standards</p> <p>provide international leadership for sustainable marine aquaculture</p>	<p>increase data collection for recreational saltwater fishing, through licensing if necessary</p> <p>designate NOAA as lead agency for marine aquaculture and create office of sustainable marine aquaculture within NOAA</p> <p>designate the Secretaries of Commerce and Agriculture as co-chairs of the Joint Subcommittee on Aquaculture designate NOAA to develop an environmentally sound permitting, leasing, and regulatory program for marine aquaculture</p> <p>designate NOAA to expand marine aquaculture research, development, training, extension, and technology transfer, in coordination with Sea Grant, states, tribes, industry and others work with the United Nations Food & Agriculture Organization to encourage and facilitate worldwide adherence to the aquaculture provisions of the Code of Conduct for Responsible Fisheries</p>
Education	<p>promote ocean literacy and broad public support</p> <p>broaden ocean education and awareness through a commitment to teach and learn about our oceans at all levels of society</p> <p>inspire next generation of leaders with understanding and appreciation for oceans</p>	<p>cultivate broad public stewardship increase attention to ocean education through coordinated and effective formal and informal programs from kindergarten through adulthood</p> <p>prepare new generation of ocean scientists, policy makers, and leaders</p>
Funding trust fund	<p>establish a fishery conservation and management trust fund</p>	<p>establish an ocean policy trust fund</p>

With respect to priorities for further research, the commissions highlight—as essential components of marine ecosystem conservation and management—the need for an improved understanding of marine ecosystem function and how marine ecosystems respond to natural and anthropogenic perturbations (e.g., Folke et al. 2004). Both reports recommend enhancing fisheries research to include more studies that contribute to ecosystem-based management and to supplement conventional species-specific stock assessments. This recommendation reflects concerns voiced by marine fish ecologists and conservation biologists about the overwhelming concentration of agency interest and research dollars on such assessments rather than broader ecological issues, including maintenance of genetic structure, essential habitats, and community interactions (Myers et al. 2004; Mangel & Levin 2005). Both reports strongly recommend increased understanding of invasive species and genetic, life-history, species, and ecosystem diversity in the sea. Although the role of biodiversity in marine ecosystems is still poorly understood, both commissions cite the importance of biodiversity in ensuring ecosystem resilience and maintaining potential sources of pharmaceuticals and other ecosystem goods and services. The U.S. Commission also advocates investment in the development of an ocean monitoring system and other marine technological advancements to improve living and nonliving marine resource management.

Fisheries reforms (including marine aquaculture and agriculture policy) are explicitly outlined in the recommendations of each report. Currently, marine fisheries are managed through a system of regional fishery management councils (regional councils) established by the original Magnuson-Stevens Fishery Conservation and Management Act of 1976. The regional councils, composed of governor-appointed members, representatives from state and tribal fish and wildlife agencies, and NOAA personnel, are regulated by NOAA's National Marine Fisheries Service (NMFS or NOAA Fisheries), although the level of agency oversight varies by region. Recommendations on allowable harvest are made through peer-reviewed stock assessments evaluated by each council's Scientific and Statistical Advisory Committee (SSC). Although some regional councils adhere strongly to the recommendations of their SSCs, others have been less strict (Eagle & Thompson 2003; Okey 2003). Both reports recommend changes to the council system, including tightened conflict-of-interest restrictions for council appointees and requirements for more even representation from commercial fishing, recreational fishing, and nonindustry sectors (see also Sanchirico & Hanna 2004*b*). The U.S. Commission advocates mandatory training in fishery science, basic stock assessment, social science, fishery economics, and legislative regulations for all council members within 6 months of appointment.

The two commissions advocate broader approaches to resource management, including coordination at the lev-

els of whole watersheds, coastal zones, and ecosystems. The U.S. Commission supports habitat protection and a clarification of “essential fish habitat” designations (as currently mandated under the Sustainable Fisheries Act of 1996) to incorporate multispecies approaches, including the development of guidelines for design, implementation, and evaluation of marine protected areas. The U.S. Commission also proposes a goal to recover marine biodiversity to natural levels. The Pew Commission provides more explicit recommendations for the establishment of networks of marine reserves and other policies that promote a reduction in human impacts on marine systems.

Both reports also highlight the need for enhanced education to improve the public's “ocean literacy.” Despite the growing popularity of marine aquaria, recreational fishing, and seafood products from around the world, the oceans are generally “out of sight, out of mind” for most of the U.S. public. Because public support for improved marine management requires more widespread appreciation of the benefits from and threats to marine systems, wide-ranging education at all levels is essential to any national policy intended to improve marine ecosystem health. The U.S. Commission suggests a federal coordinating committee provide oversight of this educational agenda to ensure efficient integration across programs. It also recommends funding for experiential learning programs and centers to foster the interests of the substantial number of high school and college students enamored with marine biology.

Finally, both commissions emphasize the need for better funding of marine science and management via establishment of a trust fund, commitments of general revenues, and new fee structures. For example, the U.S. Commission recommends using royalties from oil and gas extraction to fund an Ocean Policy Trust Fund, whereas the Pew Commission recommends that general revenues be allocated to marine research and management to remove any budgetary incentives from increased, potentially polluting activities. The Pew Commission also recommends that royalties and fees from regional fishing activities be used to establish permanent conservation and management funds within regions (Sanchirico & Hanna 2004*a*).

The Role of Conservation Practitioners in Marine Conservation

Given the major recommendations from these two commissions, what roles should conservation practitioners play in supporting and implementing change regionally and globally? This question is especially timely because decades of post-Stratton experience suggest that these reports may be a once-in-a-generation opportunity for major reform in national marine resource policy. The strategy adopted by the Stratton Commission has had a major influence on the state of U.S. oceans and indirectly on

global oceans. Unfortunately, this strategy failed to promote management activities to prevent broad-scale degradation of marine habitats and resources. There is great potential for legislation resulting from the two current ocean commissions to shape national and global ocean management and conservation for decades to come (information on pending legislation from the 108th Congress is available at <http://www.conbio.org/images/sections/marine/graneketal2005.pdf>). Below we discuss four main areas (science and research, conservation management, governance, and education) in which conservation practitioners can play an active role.

Science and Research: Interdisciplinary and Integrative Projects

The two reports clearly state that there is sufficient science to recognize that our oceans are in need of better management (Safina & Chasis 2004). The reports, however, also identify the need for both more integrated research at multiple ecological levels and better resources for ocean monitoring. Both reports argue that conventional resource-use priorities and models have negatively affected marine populations, thereby creating a need for cooperative research among biologists, social scientists, and managers to develop better management practices. The historical lack of holistic, ecosystem-based thinking and an emphasis on maximum use rather than maximum sustainability are problems terrestrial conservation biologists have habitually faced.

Conservation practitioners working on marine issues must learn from those who study similarly complex systems on land and in freshwater. Watershed studies that integrate hydrology, ecology, fisheries, ecotoxicology, engineering, natural resource economics, and social ecology provide a model for greater interdisciplinary study and incorporate the geographical components needed for better integration of coastal and marine components. Collaboration among terrestrial and marine scientists, especially in human-dominated environments, is essential to successfully manage coastal marine environments because of the intrinsic interconnectedness of the water cycle.

Because the physical, biological, and social attributes of marine systems are different from terrestrial systems, it is important to avoid misapplication of popular terrestrial conservation approaches. For example, classic principles and techniques, including minimum viable population modeling, systematic reserve design, analyses of habitat connectivity, and identification of biodiversity hotspots, require modification and reinterpretation for many marine systems (e.g., Carr et al. 2003). Likewise, societal attitudes about ownership of the oceans and the resources that lie within them are often fundamentally different from the views applied to land-use planning (but see Beck et al. 2004). In large, developed countries like the United States, people who directly rely on the ocean as a source of employment are a small minority relative to the vast

populations of coastal and inland residents who may be ignorant of the ecosystem goods and services derived from the sea. Consequently, some socioeconomic and political lessons learned from terrestrial conservation efforts may be less applicable to marine settings. Ultimately, as its name suggests, marine conservation science must integrate the theory, knowledge, and concerns that uniquely lie at the intersection of marine science, conservation, and conventional marine resource management.

Such integrative, interdisciplinary research can lead to fresh perspectives and improved problem solving. For example, interactions among oceanographers, atmospheric scientists, and biogeochemists will provide new information on environmental patterns and trends and new methods for monitoring to inform long-term conservation planning. Biogeochemical tools and genetics can provide useful information to oceanographers and ecologists who study the transport of organisms across large spatial scales (Palumbi 2004). Because of the effects of centuries of human exploitation, combinations of paleontology, historical ecology, population genetics, mathematical modeling, and other approaches will be necessary to estimate "natural" population levels and suitable recovery targets (Jackson et al. 2001; Roman & Palumbi 2003), as called for in the U.S. Commission report.

Integration among fields of study will provide important tools for more holistic assessments of best practices in marine management and restoration. For example, to the extent that the design of marine reserves is a scientific process embedded within a larger sociopolitical process, it depends on integrating biophysical data about potential reserve sites with socioeconomic information from fishers, other stakeholders, and resource managers (Sala et al. 2002; Friedlander et al. 2003; Stewart & Possingham 2003). A growing literature on bioeconomic analyses of invasive species impacts, mitigation, and adaptation also demonstrates the utility of combining biological and social research (e.g., Shogren & Tschirhart 2005).

Conservation practitioners can better contribute to ocean research by initiating and participating in interdisciplinary and integrative projects that assess whole systems instead of individual commodities. Such research will require expertise from academia, government, and non-governmental entities. Despite much progress, conservation scientists need to be bolder in crossing the boundaries among disciplines and sectors. By working in relative isolation in their own sector, marine scientists have collectively failed to answer the most critical questions underlying ocean sustainability (e.g., Caddy & Seijo 2005). Systems of reward for interdisciplinary research need immediate and sustained change, starting at the highest levels so that applied, collaborative work receives appropriate value in professional evaluation. Research scientists and scholars bear part of the responsibility for redirecting the way they work collaboratively to change the culture and structure of their institutions to better address large societal problems. These are challenging undertakings for

the individual, but perhaps also hopeful and fulfilling undertakings.

Conservation Management: Integration across Landscapes and Sectors

A significant shortcoming of management in the U.S. marine environment is the fragmented nature of the process. Species are managed in isolation of the habitats in which they exist, fisheries are managed separately from the prey species they consume or the predator species they feed, and the various activities and uses of ocean resources are often managed by disparate government agencies. Without a cohesive approach to management, certain activities or species slip through the cracks. Comprehensive marine conservation management requires integration across species, ecosystems, and sectors (Browman & Stergiou 2004).

Conservation practitioners with experience in terrestrial and aquatic zoning and other forms of ecosystem-based management can assist marine managers in developing analogous approaches that incorporate available science, stakeholder feedback, and management effectiveness (including feasibility of enforcement). Watershed-based management is a necessary step in the advancement of marine conservation. Without addressing the diverse and interacting activities in the coastal upland environment, it will be impossible to tackle the suite of problems facing many coastal marine habitats. Currently, interlinked marine and terrestrial habitats are not managed together, limiting the effectiveness of conservation efforts for both habitats. Watershed-based conservation projects that encompass natural and human processes will best mitigate diverse impacts on nearshore marine environments, ranging from nutrient pollution and sedimentation to habitat and species declines (e.g., Wolanski et al. 2003; Ledoux et al. 2005). In addition, coastal-zone land use and pollution are frequently considered separately during planning processes. As the population living within 80 km of the coastline continues to grow—and as pollution pressures increase in parallel—these two issues must be better integrated in resource management and monitoring projects. In turn, marine conservation and management projects that incorporate relevant upland issues from the outset will have greater potential for success. Finally, because management is a sociopolitical process best facilitated by broad public support, public outreach to promote understanding and support of adaptive approaches will increase the likelihood of success (Gladwell 2000).

Governance: Participation in the Public Process

A major component of the reports' recommendations focuses on restructuring marine governance and establishing new regional and federal councils to facilitate integrated oversight of ocean resources (Table 1). Con-

servation practitioners can play an active role in this reform and restructuring, regardless of where their expertise lies. Conservation practitioners can also work to ensure that important principles of conservation biology are integrated into the enhanced mandatory training for regional council members as called for by the U.S. Commission, for regional council members. Academic conservation scientists can act through professional mechanisms by providing expert review, comment, or testimony about the importance of biodiversity conservation, ecosystem-based management, and the costs and benefits of various policy scenarios under consideration. At this crossroads in ocean policy, professional organizations and coalitions of conservation scientists can write position papers explicitly designed to gain the attention of policy makers or contribute information and knowledge to nongovernmental organizations (e.g., COMPASS 2005). To be effective, conservation practitioners must cultivate written and oral communication skills to clearly and concisely communicate to scientists, policy makers, politicians, the private sector, and the public about the pressing need for drastic management and conservation reform (Done & Reichelt 1998; Kochin & Levin 2003). Finally, as with any public issue, conservation practitioners can contribute to the process as individual citizens—writing to representatives, calling elected officials, and sharing knowledge with those who have been elected to legislate and implement national and regional policy. Multiple pieces of legislation have been introduced to committees in the U.S. House of Representatives and Senate related to one or several of the recommendations proposed by the commission reports (see <http://www.conbio.org/images/sections/marine/graneketal2005.pdf>). The success of certain bills will, to some extent, depend on their importance to the general public. Both reports provide support for more participatory governance, often through more representative and regional government bodies, and it is the right and responsibility of conservation practitioners, as educated and informed citizens, to participate in these processes.

Education: Advancing Public Awareness and Training Professionals

Conservation practitioners will have a role in two categories of marine education: public education (general public, K-12, and undergraduates) and training of new conservation practitioners. The reports emphasize the need to improve ocean literacy and raise awareness of how marine issues directly affect citizens, regardless of geographic or socioeconomic position. In addition to reaching coastal residents, marine educators must also target people living in inland areas to expand the constituency for marine science and conservation. Conservation practitioners can raise awareness of marine issues by communicating policy-relevant science in concise, accessible, and

compelling ways to the public, the media, and decision makers. Marine conservation practitioners can learn from the struggles climate scientists have had in communicating climate change to policy makers and the public. Recent media projects that attempt to harness the powers of popular culture and mass media (including the Internet) to transmit science-based and conservation messages (e.g., *Shifting Baselines* [www.shiftingbaselines.org] and *Ocean Revolution* [www.oceanrevolution.org]) also suggest tools for conservation practitioners to reach wider public audiences. Such communication can lead to public popularization of important environmental issues (e.g., Bonanno & Constance 1996).

Awareness building needs to target all ages. It is not just a cliché that effective education and outreach starts with children. Consequently, enhanced ocean education needs to be incorporated into school curricula beginning in the primary grades. Conservation practitioners can assist by collaborating with curriculum developers, giving presentations to school children, and facilitating field trips. To ensure that practitioners are using resources wisely, assessments of the efficacy of our education and outreach efforts should benefit from the same careful measurement and experimental skills that scientists apply to science (Mentkowski et al. 2002).

To train future conservation practitioners, efforts should reinforce and strengthen the nascent but growing trend of promoting interdisciplinary higher education in the natural and social sciences (e.g., Clark 2001; Zarin et al. 2003). Despite numerous national reports and new funding programs that provide guidelines and support for interdisciplinary research and education, many universities are still poorly equipped to produce graduates with the mix of depth and breadth needed for conservation science and policy (Secord & Greengrove 2002; Committee on Science, Engineering, and Public Policy 2005). This situation reflects ongoing administrative barriers in universities, where traditional departments dominate institutions and hire and reward faculty who work within their disciplinary norms rather than across or among multiple disciplines. Solutions will require grassroots initiatives from faculty and students, together with clear support from their administrations. Funding incentives such as the National Science Foundation's Bio-Complexity in the Environment Priority Area and Integrated Graduate Education and Research Traineeships are important incentives for collaborative advances. Academic training should include these principles and skills because current students will be on the front lines of implementing every aspect of marine conservation policy. A cadre of highly trained experts in science or policy conversant in both fields and capable of collaboratively tackling complex issues in marine science and conservation is essential (Kinzig & Starrett 2003). Cross-disciplinary openness and communication skills will bring the relevant expertise of scientists and policy makers together for effective problem solving.

Conclusions

Conservation of marine ecosystems provides a critical test of society's ability to manage human and natural complexity in an inclusive and cross-cutting way and provides enormous opportunities for conservation practitioners from all disciplines. By highlighting a suite of recommendations for improving ocean governance and management, the recent commission reports outline new roles for conservation practitioners. Admittedly, many of the roles conservation practitioners can play are familiar. The once-in-a-generation timing of the commissions' reports, however, means that various approaches can now be employed to greater effect. The reports also coincide with other emerging opportunities for researchers, educators, policy analysts, and advocates to reform the way practitioners study, talk about, govern, and manage marine systems for greater sustainability and stewardship. These roles extend to people who may not identify themselves as "marine" conservation practitioners. Given the breadth and depth of both the problems and the opportunities facing oceans and coastal zones (e.g., clear though often ignored linkages between watersheds and nearshore habitats), conservation practitioners need to continue recruiting committed people to address the research, education, and resource management gaps in how we interact with the marine environment.

How conservation practitioners implement their roles must surpass standard platitudes to cross boundaries. The urgency for immediate action is based on the current status and poor record of ocean management since the Stratton Report. Overwhelming declines in global fisheries and populations of organisms that are incidentally killed in those fisheries are themselves evidence of the failure to manage marine resources in a dynamic environment. This is, in large part, due to a failure to truly integrate natural and human research, policy analysis, public outreach, and institutional implementation. For decades, social science research has been treated as a poor second cousin to biological and physical sciences, and the broad scientific community has recognized too late the critical sociocultural roles of fishers, coastal communities, and markets in managing fisheries. This is gradually changing, as illustrated by successful pioneering efforts to integrate fishers' traditional knowledge of coral reef ecosystems into scientific knowledge (e.g., Johannes 1982), community-based restoration in Chesapeake Bay (Pfeiffer 1997), and co-management of fisheries such as Maine lobster (Acheson & Taylor 2001).

Incorporating human behavior and markets into conservation through education and increased public awareness can also be advantageous. Only recently have market forces been recognized as a major conservation tool in both marine and terrestrial systems, with green labeling and consumer education programs forging paths toward sustainability that are inclusive and far-reaching (Stickney

et al. 2004). As in many successful conservation plans, acknowledgment and incorporation of human impacts, desires, and needs can lead to durable conservation solutions.

No sector or stakeholder group, whether researchers, educators, maritime industries, or environmentalists, can address the problems facing ocean ecosystems alone, but conservation science must be an essential part of informed policy making. For example, in fisheries, the goal of achieving healthier marine ecosystems requires a transition from predominantly single-species management to more holistic, ecosystem-targeted approaches. Such ecosystem-based management, in turn, will require more thorough information and understanding about the functioning of both natural and human systems and human interactions with marine ecosystems. Given that decisions will always need to be made in the context of limited information, management should incorporate learning and allow for adaptation as our understanding of dynamic ecosystems and the consequences of past management decisions changes. This message—that science must play a more integrated role in the definition, design, and implementation of adaptive management processes—is also not new, but the urgency of the situation in U.S. and global oceans and the vast public interests at stake are vehicles for making the point firmly and with specific, detailed recommendations for action. Scientists must participate at all levels to ensure that science is available to those who make decisions about oceans and to show policy makers that good science is necessary but not sufficient for establishing ocean policy; stakeholders of all kinds must work to concisely and cogently communicate to solve common and clearly defined problems.

Because the world has become a global economy and the United States is a role model for certain conservation strategies, the extent to which the two commissions' reports are implemented will have repercussions worldwide. The Bush Administration recently responded to the recommendations of the U.S. Commission, commending the commission and commenting on the steps the administration is currently taking. The problems addressed by both commissions, however, risk taking a back seat to other priorities that have already been articulated by the administration. This would be a serious mistake because the current administration has been handed a rare opportunity to make a lasting, critical, and historic imprint on the welfare of the country via improved marine management. Moreover, many of the changes, especially those concerning governance reform (e.g., creating bodies for more centralized oversight and coordination of ocean research, education, and policy), are relatively painless. Other recommended changes, such as those that would have agencies (e.g., the regional councils) with relatively narrow constituencies (e.g., the fishing industry) become more open and inclusive toward other stakeholders, are admittedly more controversial. Nevertheless, the commis-

sions are clear about the importance of their recommendations, whether painless or not, to the long-term sustainability of our ecosystems, the services they provide, and the economies that rely on these services. Faced with daunting charges, the Pew Commission and U.S. Commission members have done their jobs well, providing a broad suite of important recommendations for all parties to discuss, refine, and implement in various ways. Now it is our turn as conservation practitioners to work collaboratively across disciplines and sectors for improved ocean management and conservation.

Literature Cited

- Acheson, J. M., and L. Taylor. 2001. The anatomy of the Maine lobster co-management law. *Society and Natural Resources* **14**:425–441.
- Beach, D. 2002. Coastal sprawl: the effects of urban design on aquatic ecosystems in the United States. Pew Oceans Commission, Arlington, Virginia.
- Beck, M. W., T. D. Marsh, S. E. Reisewitz, and M. L. Bortman. 2004. New tools for marine conservation: the leasing and ownership of submerged lands. *Conservation Biology* **18**:1214–1223.
- Boesch, D. F., R. H. Burroughs, J. E. Baker, R. P. Mason, C. L. Rowe, and R. L. Siefert. 2001. Marine pollution in the United States. Pew Oceans Commission, Arlington, Virginia.
- Bonanno, A. and D. Constance. 1996. Caught in the net: the global tuna industry, environmentalism, and the state. University Press of Kansas, Lawrence.
- Browman, H. I., and K. Stergiou. 2004. Perspectives on ecosystem-based approaches to the management of marine resources. *Marine Ecology Progress Series* **274**:269–303.
- Caddy, J. F. and J. C. Seijo. 2005. This is more difficult than we thought! The responsibility of scientists, managers and stakeholders to mitigate the unsustainability of marine fisheries. *Philosophical Transactions: Biological Sciences* **360**:59–75.
- Carlton, J. T. 2001. Introduced species in U.S. coastal waters: environmental impacts and management priorities. Pew Oceans Commission, Arlington, Virginia.
- Carr, M. H., J. E. Neigel, J. A. Estes, S. Andelman, R. R. Warner, and J. L. Largier. 2003. Comparing marine and terrestrial ecosystems: implications for the design of coastal marine reserves. *Ecological Applications (Suppl.)* **13**:S90–S107.
- Castro, M. S., C. T. Driscoll, T. E. Jordan, W. G. Reay, W. R. Boynton, S. P. Seitzinger, R. V. Styles, and J. E. Cable. 2000. Contribution of atmospheric deposition to the total nitrogen loads to thirty-four estuaries on the Atlantic and Gulf Coasts of the United States. Pages 77–106 in R. M. Valigura, M. S. Castro, H. Greening, T. Meyers, H. Paerl, and R. E. Turner, editors. An assessment of nitrogen loads to U.S. estuaries with an atmospheric perspective. American Geophysical Union, Washington, D.C.
- Clark, T. W. 2001. Developing policy-oriented curricula for conservation biology: professional and leadership education in the public interest. *Conservation Biology* **15**:31–39.
- Cohen, A. N. and J. T. Carlton. 1998. Accelerating invasion rate in a highly invaded estuary. *Science* **279**:555–558.
- Committee on Science, Engineering, and Public Policy. 2005. Facilitating interdisciplinary research. National Academy of Sciences, Committee on Science, Engineering, and Public Policy, Washington, D.C.
- Communication Partnership for Science and the Sea (COMPASS). 2005. Scientific consensus statement on ecosystem-based management for the oceans. COMPASS, Oregon State University, Corvallis. Available at <http://compassonline.org/?q = EBM> (accessed March 2005).

- Crossett, K. M., T. J. Culliton, P. C. Wiley, and T. R. Goodspeed. 2004. Population trends along the coastal United States: 1980–2008. National Oceanic and Atmospheric Administration, Washington, D.C.
- Danovaro, R., A. Dell'Anno, and A. Pusceddu. 2004. Biodiversity response to climate change in a warm deep sea. *Ecology Letters* 7:821–828.
- Done, T. J., and R. E. Reichelt. 1998. Integrated coastal zone and fisheries ecosystem management: generic goals and performance indices. *Ecological Applications* 8 S110–S118; Supplement.
- Eagle, J. and B. H. Thompson Jr. 2003. Answering Lord Perry's question: dissecting regulatory overfishing. *Ocean & Coastal Management* 46:649–679.
- Edwards, M. and A. J. Richardson. 2004. Impact of climate change on marine pelagic phenology and trophic mismatch. *Nature* 430:881–884.
- Folke, C., S. Carpenter, B. Walker, M. Scheffer, T. Elmqvist, L. Gunderson, and C. S. Holling. 2004. Regime shifts, resilience, and biodiversity in ecosystem management. *Annual Review of Ecology, Evolution, and Systematics* 35:557–581.
- Friedlander, A., J. S. Nowlis, J. A. Sanchez, R. Appeldoorn, P. Usseglio, C. McCormick, S. Bejarano, and A. Mitchell-Chui. 2003. Designing effective marine protected areas in Seaflower Biosphere Reserve, Colombia, based on biological and sociological information. *Conservation Biology* 17:1769–1784.
- Gardner, T. A., I. M. Côté, J. A. Gill, A. Grant, and A. R. Watkinson. 2003. Long-term region-wide declines in Caribbean corals. *Science* 301:958–960.
- Gladwell, M. 2000. *The tipping point*. Little, Brown, and Company, Boston.
- Harvell, C. D., et al. 1999. Emerging marine diseases—Climate links and anthropogenic factors. *Science* 285:1505–1510.
- Hutchings, J. A. 2000. Collapse and recovery of marine fishes. *Nature* 406:882–885.
- Jackson, J. B. C., et al. 2001. Historical overfishing and the recent collapse of coastal ecosystems. *Science* 293:629–638.
- Johannes, R. E. 1982. Traditional conservation methods and protected marine areas in Oceania. *Ambio* 11:258–261.
- Kinzig, A. and D. Starrett. 2003. Coping with uncertainty: a call for a new science-policy forum. *Ambio* 32:330–5.
- Kochin, B. F. and P. S. Levin. 2003. Lack of concern deepens the oceans' problems. *Nature* 424:723.
- Lafferty, K. D., J. W. Porter, and S. E. Ford. 2004. Are diseases increasing in the ocean? *Annual Review of Ecology, Evolution, and Systematics* 35:31–54.
- Ledoux, L. S. Cornell, T. O'Riordan, R. Harvey, and L. Banyard. 2005. Towards sustainable flood and coastal management: identifying drivers of, and obstacles to, managed realignment. *Land Use Policy* 22:129–144.
- Leopold, A. 1949. *A Sand County almanac*. Oxford University Press, Oxford, United Kingdom.
- Mangel, M., and P. S. Levin. 2005. Regime, phase and paradigm shifts: making community ecology the basic science for fisheries. *Philosophical Transactions: Biological Sciences* 360:95–105.
- Mentkowsky, M., et al. 2002. Learning that lasts: integrating learning, development, and performance in college and beyond. Jossey-Bass, San Francisco.
- Myers, R. A. and B. Worm. 2003. Rapid worldwide depletion of predatory fish communities. *Nature* 423:280–283.
- Myers, R. A., S. A. Levin, R. Lande, F. C. James, W. W. Murdoch, and R. T. Paine. 2004. Hatcheries and endangered salmon. *Science* 303:1980.
- Okey, T. A. 2003. Membership of the eight regional fishery management councils in the United States: are special interests over-represented? *Marine Policy* 27:193–206.
- Palumbi, S. R. 2004. Marine reserves and ocean neighborhoods: the spatial scale of marine populations and their management. *Annual Review of Environment and Resources* 29:31–68.
- Pandolfi, J. M., et al. 2003. Global trajectories of the long-term decline of coral reef ecosystems. *Science* 301:955–958.
- Pew Oceans Commission (POC). 2003. *America's living oceans: charting a course for sea change. A report to the nation*. Pew Oceans Commission, Arlington, Virginia.
- Pfeiffer, R. M. 1997. Maryland's oyster recovery partnership: environmental and economic restoration. *Journal of Shellfish Research* 16:273.
- Porter, J. W., editor. 2001. *The ecology and etiology of newly emerging marine diseases*. Kluwer Academic Publishers, Dordrecht, The Netherlands.
- Porter, J. W., P. Dustan, W. C. Jaap, K. L. Patterson, V. Kosmynin, O. W. Meier, M. E. Patterson, and M. Parsons. 2001. Patterns of spread of coral disease in the Florida Keys. *Hydrobiologia* 460:1–24.
- Roman, J. and S. R. Palumbi. 2003. Whales before whaling in the North Atlantic. *Science* 301:508–510.
- Safina, C., and S. Chasis. 2004. Saving the oceans. *Issues in Science and Technology* 21:37–44.
- Sala, E., O. Aburto-Oropeza, G. Paredes, I. Parra, J. C. Barrera, and P. K. Dayton. 2002. A general model for designing networks of marine reserves. *Science* 298:1991–1993.
- Sanchirico, J. N., and S. S. Hanna. 2004a. Navigating U.S. fishery management into the 21st century. *Marine Resource Economics* 19:395–406.
- Sanchirico, J. N., and S. S. Hanna. 2004b. Sink or swim time for U.S. fishery policy. *Issues in Science and Technology* 21:45–52.
- Schueler, T., and H. K. Holland. 2000. *The practice of watershed protection*. Center for Watershed Protection, Ellicott City, Maryland.
- Secord, D. and C. Greengrove. 2002. Something from nothing: environmental science as a vehicle for building natural sciences and environmental education into a new interdisciplinary urban public university. *Journal of Environmental Education* 37:32–37.
- Senkowsky, S. 2004. A tale of two commissions: Scientists seek to broaden constituency for changing US ocean policy. *BioScience* 54:495–499.
- Shogren, J. F. and J. Tschirhart. 2005. Integrating ecology and economics to address bioinvasions. *Ecological Economics* 52:267–271.
- Stewart, R. R., and H. P. Possingham. 2003. Planning for marine reserve systems that integrate conservation and economic goals. *Science and Management of Protected Areas Association, Acadia University, Wolfville, Nova Scotia*. Available from <http://www.sampaa.org/PDF/ch12/12.2.pdf> (accessed February 2005).
- Stickney, R. R., S. Shumway, and B. Costa-Pierce. 2004. The sustainable seafood movement. *World Aquaculture* 35:4–5.
- U.S. Commission on Ocean Policy (USCOP). 2004. *An ocean blueprint for the 21st century*. U.S. Commission on Ocean Policy, Washington, D.C.
- Wilkinson, C., editor. 2004. *Status of coral reefs of the world: 2004*. Australian Institute for Marine Science, Cape Ferguson, Queensland.
- Wolanski, E., R. Richmond, L. McCook, and H. Sweatman. 2003. Mud, marine snow and coral reefs —The survival of coral reefs requires integrated watershed-based management activities and marine conservation. *American Scientist* 91:44–51.
- Zarin, D. J., K. A. Kainer, F. E. Putz, M. Schmink, and S. K. Jacobson. 2003. Integrated graduate education and research in Neotropical working forests. *Journal of Forestry* 101:31–37.