

---

# Strategies for Successful Marine Conservation: Integrating Socioeconomic, Political, and Scientific Factors

CAROLYN J. LUNDQUIST\* AND ELISE F. GRANЕК†

\*National Institute of Water and Atmospheric Research, P.O. Box 11-115, Hamilton 2001, New Zealand, email c.lundquist@niwa.co.nz

†Department of Zoology, Oregon State University, 3029 Cordley Hall, Corvallis, OR 97331, U.S.A.

---

**Abstract:** *As the process of marine-protected-area design and implementation evolves, the incorporation of new tools will advance our ability to create and maintain effective protected areas. We reviewed characteristics and approaches that contribute to successful global marine conservation efforts. One successful characteristic emphasized in most case studies is the importance of incorporating stakeholders at all phases of the process. Clearly defined goals and objectives at all stages of the design process are important for improved communication and standardized expectations of stakeholder groups. The inclusion of available science to guide the size and design of marine protected areas and to guide clear monitoring strategies that assess success at scientific, social, and economic levels is also an important tool in the process. Common shortcomings in marine conservation planning strategies include government instability and resultant limitations to monitoring and enforcement, particularly in developing nations. Transferring knowledge to local community members has also presented challenges in areas where in situ training, local capacity, and existing infrastructure are sparse. Inaccessible, unavailable, or outdated science is often a limitation to conservation projects in developed and developing nations. To develop and maintain successful marine protected areas, it is necessary to acknowledge that each case is unique, to apply tools and lessons learned from other marine protected areas, and to maintain flexibility to adjust to the individual circumstances of the case at hand.*

**Key Words:** conservation planning, marine protected areas, marine reserves

Estrategias para la Conservación Marina Exitosa: Integración de Factores Socioeconómicos, Políticos y Científicos

**Resumen:** *A medida que evoluciona el proceso de diseño e implementación de áreas marinas protegidas, la incorporación de nuevas herramientas mejorará nuestra habilidad para crear y mantener áreas protegidas efectivas. Revisamos las características y enfoques que contribuyen a los esfuerzos exitosos de conservación marina global. La importancia de incorporar a los actores en todas las fases del proceso es una característica exitosa enfatizada en la mayoría de los estudios de caso. Es importante que haya metas y objetivos claramente definidos para todas las etapas del proceso de diseño para mejorar la comunicación y estandarizar las expectativas de los grupos interesados. La inclusión de la ciencia disponible para guiar el tamaño y diseño de áreas marinas protegidas y para guiar las estrategias de monitoreo que evalúa el éxito a nivel científico, social y económico también son herramientas importantes en el proceso. Defectos comunes en las estrategias de planificación de conservación marina incluyen la inestabilidad gubernamental y las resultantes limitaciones para el monitoreo y vigilancia, particularmente en países en desarrollo. La transferencia de conocimiento a miembros de la comunidad local también ha enfrentado retos en áreas donde el entrenamiento in situ, la aptitud local y la infraestructura existente son escasos. La ciencia inaccesible, no disponible u obsoleta a menudo es una limitación para los proyectos de conservación en países desarrollados y en desarrollo. Para desarrollar y mantener áreas marinas protegidas exitosas, es necesario reconocer que cada caso es único,*

---

Paper submitted December 10, 2004; revised manuscript accepted June 29, 2005.

*aplicar herramientas y lecciones aprendidas en otras áreas marinas protegidas y mantener la flexibilidad para ajustarse a las circunstancias individuales de cada caso.*

**Palabras Clave:** áreas marinas protegidas, planificación de conservación, reservas marinas

---

## Introduction

Design and implementation of marine protected areas have evolved from opportunistic approaches to theoretical, science-based approaches based on quantitative predictions of potential benefits to fisheries and biodiversity (Leslie 2005 [this issue]). Many theoretical predictions of marine-protected-area benefits to fisheries (e.g., increased abundance, survivorship, and proportion of legal-sized fish within marine protected areas) have been validated by empirical measurements throughout the world (e.g., Rowley 1994; Gell & Roberts 2003; Halpern 2003). No-take marine reserves are also associated with higher diversity and increased abundance and density of non-target species (Halpern 2003). Spillover benefits to fisheries, however, from dispersal and emigration of larvae and adults have been more difficult to demonstrate empirically (Rowley 1994; Gerber et al. 2003). Guidelines have been developed to assist in designing representative, effective networks of marine protected areas based on ecological criteria (Roberts et al. 2003*a*, 2003*b*). No consensus has emerged, however, to guide the planning process (i.e., how to convert scientific, ecological objectives for marine conservation into successful implementation of marine protected areas while simultaneously incorporating diverse stakeholder objectives).

Marine-protected-area theory was first developed as a fisheries management tool (Dugan & Davis 1993; Rowley 1994) and proponents rarely discussed the incorporation of socioeconomic issues or the planning process leading toward implementation. As the process for developing marine protected areas has evolved, scientists and managers have become more aware of the socioeconomic considerations relevant to marine conservation planning (Agardy 2000; Mascia 2003) and, particularly, the need to include stakeholders at an early stage. The evolution of the design of marine protected areas has resulted in the incorporation of more diverse stakeholder groups and inclusion of a suite of diverse aims from biodiversity and fishery conservation to recreational, educational, cultural, and historical objectives.

Here we discuss guidelines to successful marine conservation planning, design, and implementation and outline challenges for future conservation efforts. We highlight five important characteristics of successful marine conservation projects: (1) stakeholder involvement, (2) explicit definition of objectives, (3) inclusion of available science, (4) monitoring programs designed to evaluate

objectives, and (5) effective design of marine protected areas. Key remaining challenges to the success of marine conservation efforts are (1) instability of host governments and management institutions, (2) limited scientific information, (3) individuality of cases, and (4) transfer of knowledge of successful planning processes to new situations.

## Characteristics of Successful Marine Conservation Strategies

### Stakeholder Involvement

Stakeholder involvement in marine conservation strategies, from development and implementation to management and monitoring, is identified as one characteristic of successful marine conservation projects (Leslie 2005). Although the breadth and extent of stakeholder involvement vary among cases, incorporating diverse interest groups should be recognized as a necessary component of successful conservation planning. Community involvement is essential in the planning, design, establishment, and management of marine protected areas (Mascia 2003; ISRS 2004), especially when stakeholders are expected to support and assist with the process. Stakeholder involvement from the initial planning stages helps instill a sense of ownership and commitment in the parties involved (Cinner et al. 2005 [this issue]; Granek & Brown 2005 [this issue]). This involvement can foster long-term interest in protected areas, and local support expands the pool of individuals formally and informally overseeing activities in the conservation area. Involvement of local stakeholders in Papua New Guinea and the Comoros Islands, Africa, resulted in both acceptance of and assistance with enforcement of protected area regulations, which is important if existing resources are insufficient to enforce a protected area (Cinner et al. 2005; Granek & Brown 2005).

Stakeholder involvement in developed countries becomes more complex as the diversity of stakeholder groups increases and discrepancies in objectives become more likely. Fernandes et al. (2005 [this issue]) note that stakeholder involvement was a key to success in the Great Barrier Reef Marine Protected Area network and facilitated the incorporation of biological, socioeconomic, political, and cultural objectives in selection of the optimal

network design. In the Channel Islands, involving stakeholders from an early stage allowed for development of a consensus statement that defined the problems the marine protected area network would address (Davis 2005 [this issue]). The consensus statement facilitated communication among groups relative to the goals of the network and expected outcomes. Davis (2005) also highlights a shortcoming in the stakeholder involvement process in the Channel Islands, namely that the constituency of involved groups was more diverse than the number of representatives in the working group. Therefore, stakeholder subset groups expressed concern that their interests were not represented in decision-making, which resulted in reduced support by some groups for final decisions.

Stakeholder education is a prerequisite to their involvement in marine planning processes, but it is often overlooked. An education program should acknowledge stakeholder concerns and educate stakeholders about the benefits and limitations of marine protection (Fernandes et al. 2005). For example, Granek and Brown (2005) showed the benefits of teaching natural history to local resource users, which resulted in greater understanding and appreciation of local living marine resources. Education should not be limited to stakeholders, however, because scientists and managers can also be educated on issues that will increase their understanding of socioeconomic processes that will invariably affect implementation. These processes include information on resource industries, political systems, legal frameworks for protection, social systems, and consideration of potential socioeconomic impacts of marine protected areas. Effective planning, monitoring, and enforcement follow years of communication and building trust among all participants in the marine conservation processes and require that the community, political system, and economic system all support conservation values (S. Aíramé, personal communication).

### Defining Goals and Objectives

A weakness of marine conservation projects has been the failure to accurately define the problem, resulting in an inability to effectively address objectives and leading to perceived failures or loss of support from certain stakeholder groups (Clark et al. 2002). Jones (2002) lists 10 potential objectives with which to select marine protected areas and judge their effectiveness: (1) protect rare and vulnerable habitats and species, (2) conserve a representative set of habitat types, (3) maintain and restore ecological function, (4) promote research and education, (5) establish harvest refugia, (6) control tourism and recreation, (7) promote integrated coastal management, (8) maintain aesthetic values, (9) maintain traditional values, and (10) preserve cultural symbolic value of protected areas. Each objective could be accompanied by a set of mensu-

erable criteria to judge effectiveness of the protected area in meeting the objective. Thus clearly defined and shared objectives are valuable for defining expected outcomes, for ensuring that expectations are not overly ambitious, and for guiding the relative importance of socioeconomic, political, and biological criteria in the decision-making process.

The timeframe and expected recovery dynamics of marine protected areas need to be carefully explained to stakeholders to avoid overexpectations and dissatisfaction with short-term effects. McClanahan (2000) showed how the biological benefits of marine protected areas can take many years to emerge and that organisms from different trophic levels may vary in their recovery rate. For example, trigger fish abundance in East African marine parks recovered in 5–10 years, but the associated decline of their urchin prey to more natural levels took many more years to equilibrate. This observation suggests that more than 30 years of protection was required for full recovery of keystone predators and stabilization of associated trophic-level impacts (McClanahan 2000). Research in New Zealand has similarly demonstrated long-term changes in community dynamics in the decades following protection (Shears & Babcock 2003). In contrast, other no-take marine reserves have shown very rapid responses to protection (Halpern 2003).

Cinner et al. (2005) note that the goal of managed areas in Papua New Guinea is conservation of marine resources, including fisheries. Because the goal is explicit and agreed upon, stakeholders are aware of the expected outcomes and methods for measuring success and consequently lend their support. Granek and Brown (2005) recognize that problem definition was a priority for the Mohéli Marine Park, Comoros Islands. Identifying the park goals from the outset ensured that community members and government agencies approached the process of park creation from the same outlook. This allowed for park zoning and regulations that addressed the shared objectives of the park and garnered local support for enforcing park regulations. Problem definition and identification of solutions served as points of entry for involving and educating local stakeholders in the Great Barrier Reef, Australia (Fernandes et al. 2005), and in the California Channel Islands (Davis 2005). For the Great Barrier Reef, the review of existing marine protected areas to assess the current situation identified shortfalls in protection in the existing marine park zoning (Fernandes et al. 2005). Different objectives for protection of biodiversity and resources in Chile have resulted in different types of protection and associated objectives to achieve those specific goals (Fernández & Castilla 2005 [this issue]). In contrast, the lack of clear biological, social, economic, or cultural objectives in many of New Zealand's early marine protected areas has made it difficult to determine their overall success (Langlois & Ballantine 2005 [this issue]).

### Inclusion of Available Science

Optimal design of marine-protected-area networks requires a substantial amount of biological information, which may or may not be provided by the available science. The theory of marine protected areas suggests that networks should include representative and replicated habitats and rare and unique species and community types (Murray et al. 1999; Secretariat for the Convention on Biological Diversity 2004). The size and shape of areas necessary to protect marine habitats depend on connectivity among diverse habitats used by different species and life stages. Thus, movement and dispersal rates of larval, juvenile, and adult stages should all be considered. Larger marine protected areas are predicted to be more effective than smaller areas at conserving biodiversity because they include more habitat types, have smaller edge effects, and are more likely to be self-seeding because the transport of larvae and adults outside protected area boundaries because of oceanographic and behavioral processes is reduced (Warner et al. 2000; Halpern 2003). Replication of different habitat types is also important to provide "insurance" in the case of more localized environmental catastrophes (Allison et al. 2003). What is clear is that the biological information required to make fully educated choices based on these ecological criteria for design of marine protected areas is generally far in excess of the available information.

Lack of available information on local biodiversity, habitat structure, and other important ecosystem variables that influence the placement of protected areas is often a major obstacle in planning and justification of marine protected areas. A common theme of successful protected areas established to date is to include, wherever possible, appropriate and available science in the decision-making process. When local science is not available or comprehensive, however, cautious planning can still result in success. This does not imply that science is unimportant; rather, the benefits of current protection of unassessed habitats can outweigh delaying conservation implementation until sufficient information is collected. Anecdotal information provided by local stakeholders can be valuable in many cases where scientifically designed surveys are lacking and may help overcome potential uncertainties in locating marine protected areas.

There are differing opinions on the role and level of dominance science should play in the planning process. Some proponents suggest a process-oriented approach, where science informs site selection and educates stakeholders such that they support ecologically relevant sites (Jones 2002; Roberts et al. 2003b). Others believe in a consensus-based approach, where science should be weighed equally with socioeconomic, cultural, and other values (Jones 2002). A combination of these two approaches appears most successful, whereby science determines multiple options for marine protected area siting

and stakeholders are involved throughout the process to contribute their knowledge (qualitative and quantitative) to determine potential sites. The relative importance of social, economic, political, and biological information in the decision-making process may also vary with respect to objectives of the marine protected area in that biodiversity goals may focus primarily on biological criteria whereas fishery objectives may weigh socioeconomic criteria more heavily. This consensus-based approach assists in selecting the best option for the various stakeholders with differing objectives through a transparent, scientifically informed process. The long-term involvement of stakeholders in two case studies with objectives based on biodiversity criteria resulted in final network designs that satisfied most biological objectives and successfully incorporated socioeconomic, cultural, and political objectives (Davis 2005; Fernandes et al. 2005).

### Managing and Monitoring for the Future

Monitoring is important for measuring success toward objectives and for applying active adaptive management principles to marine conservation. Monitoring can contribute to maintaining interest and support of stakeholder groups by demonstrating short- and long-term successes. Because recovery time varies between species (McClanahan 2000) and is often a long-term result, identifying successful short-term results helps predict expected recovery times and allows stakeholders to gauge their expectations in a more realistic timeframe. It is important to establish the foundation for monitoring during the implementation stage. Often little post-implementation institutional support for monitoring is present, which undermines the ability to determine whether protected-area goals are being achieved. Ongoing monitoring includes continual assessment to measure attainment of scientific and social objectives. Carr and Reed (1993) reinforce the need to monitor performance of marine protected areas to inform marine conservation science on ecological impacts of various management options (size, shape, spacing) and to determine whether a marine protected area is successful in meeting its specified objective. One of the criteria for assessing conservation planning approaches is identification of specific conservation action targets (Leslie 2005), and suitable monitoring to address these targets ensures that effectiveness of marine protection can be evaluated.

Marine protected area networks are important not only for biodiversity conservation but also as management and learning tools (Dayton et al. 2000; Guidetti 2002). Marine protected areas of different sizes, shapes, and configurations within a network are useful to evaluate theories of optimal size and shape for various management goals in the design of marine protected areas, which then feed into adaptive management strategies. Comparison of multiple-use and no-take reserves within a controlled

scientific framework can clarify impacts of different activities on natural communities. Schroeter et al. (2001) relate fishing effort for sea cucumbers with declines in abundance in certain management areas to illustrate a potential approach to comparing no-take reserves and exploited areas based on stock assessments. Marine protected areas provide baseline information about natural systems, which assists researchers in determining ecological impacts of climate change and natural environmental variability (Dayton et al. 2000). Monitoring of no-take marine reserves in New Zealand has shown unpredicted impacts on the local fauna because the ecology of the area was inadequately understood before protection (Shears & Babcock 2003; Langlois & Ballantine 2005).

### Design of Marine Protected Areas

Marine scientists are beginning to identify general patterns of minimum size and shape for protected areas within a network to incorporate dispersal processes into protected-area design (Botsford et al. 2003; Shanks et al. 2003). Size is an important consideration when designing a marine protected area (Halpern 2003). An effective marine protected area must be large enough to retain a large proportion of the mobile marine organisms within its boundaries (Rowley 1994; Stobutzi 2001). Migratory marine mammals, fishes, and invertebrates require larger marine protected areas. Their high rates of offshore, seasonal, and ocean-wide migrations mean that substantial portions of their lives are spent outside small, protected coastal areas (Rowley 1994). Patterns of larval accumulation and retention should be compared between potential areas because both behavior and oceanographic processes limit dispersal distance (Warner et al. 2000). Source-sink dynamics are also important to consider because areas that rarely receive larval recruits may take much longer to recover than more suitable larval settlement and recruitment areas (Crowder et al. 2000). Dispersal distances vary across orders of magnitude. In one taxonomic comparison, ranges of dispersal distances for different groups are marine algae, 1 m to 5 km; invertebrates, 10 m to 1000 km; and fishes, 1 km to 1000 km (Kinlan & Gaines 2003).

Theoretical models suggest a minimum size of at least twice the mean dispersal distance for an isolated marine protected area to sustain viable populations (Lockwood et al. 2002). As more marine protected areas are included in a network design, the minimum size decreases because other protected locations are within dispersal distances to provide propagules to sustain the local population (Lockwood et al. 2002). The science working group for the Channel Islands, California, suggested 35 km<sup>2</sup> as a minimum viable area for their system of offshore islands, kelp forests, seagrass beds, and deep submarine canyons, although only 8 of 10 marine protected areas of this size were realized after stakeholder compromise (Davis 2005).

Fernandes et al. (2005) include operational principles in the design of the Great Barrier Reef marine-protected-area network to ensure a minimum size (20 km across) and to minimize fragmentation effects.

Unfortunately, dispersal processes are one of the most difficult variables to measure in marine systems (Rowley 1994). Sophisticated new tools, including chemical and genetic signals, are increasing our ability to determine the origin of larvae and adults and to estimate dispersal distances and places of origin of various species. Hydrodynamic models interpret potential dispersal patterns of larvae based on physical oceanographic features (Palumbi et al. 2003). One potential benefit of newly implemented networks of protected areas (e.g., Channel Islands, Great Barrier Reef) is to determine how protected-area size and spacing affect adult and larval dispersal processes. Monitoring existing networks to glean information on dispersal processes is a key to informing future protected-area design.

Adequate replication of habitat types within a marine-protected-area network is another important design consideration to protect against uncertainty because environmental factors beyond human control can negatively impact protected areas. Replication provides an "insurance" area in case of a stochastic event in another area and a source of colonists for the disturbed area following such an event (Allison et al. 2003). Marine protected areas that are distant from each other, but that have similar physical habitats, can provide information on the impacts of local variation in ocean circulation and other variables in regions subject to different external forces.

Many software packages calculate potential designs of marine protected areas based on distribution and abundance of diverse habitat types, replication of habitats, preferential inclusion of hotspots, rare and endangered biological and physical communities, and socioeconomic factors (Sala et al. 2002). These software packages, however, require large data sets to make decisions regarding biodiversity and more detailed information on the biological and physical habitat distributions than is often available (e.g., Sala et al. 2002).

### Remaining Challenges to Successful Marine Conservation Strategies

Although the conservation toolbox has been greatly expanded in recent years, many weaknesses in the implementation of marine protected areas remain. Government instability, poverty, overpopulation, and resultant limitations to monitoring and enforcement plague conservation projects in developing nations. Transferring knowledge to local community members has also presented challenges in areas where in situ training, local capacity, and existing infrastructure are sparse. Lack of available or current

science often limits conservation projects, in both developed and developing regions. When little scientific information is available but the need for conservation action is pressing, alternative strategies must be considered. Finally, each specific locale has unique cultural, socioeconomic, and scientific factors that need to be evaluated to design, implement, and successfully manage a conservation strategy.

### **Inadequate Enforcement**

Lack of government stability and resources has plagued conservation projects and compromised enforcement of marine protected areas (McClanahan 1999; White et al. 2002). Government instability can lead to a breakdown of monitoring and enforcement infrastructure. One partial solution is extensive involvement of local community members and other stakeholders in conservation projects. Sharing responsibility with the community engages and empowers individuals and increases their willingness to participate in ongoing monitoring and enforcement of local resource conservation. Effects of government instability are not limited to developing nations. Political and funding cycles in developed nations can challenge managers and scientists via inconsistent funding for planning, implementation, enforcement, and management (S. Airamé, personal communication).

Inadequate enforcement is a key issue affecting many marine protected areas in both the developing and developed world (McClanahan 1999; Evans & Russ 2004). Enforcement challenges stem from lack of surveillance because of inaccessibility (far offshore or inaccessible coastline); lack of funding to police an area; failure to assign enforcement responsibility to a designated agency; or lack of public support for a protected area, resulting in socially acceptable poaching (Jones 2002). In the Great Barrier Reef system, significant increases in targeted species have been observed only on inshore reefs with adequate surveillance and law enforcement (Evans & Russ 2004). Other studies have shown that brief instances of poaching can quickly eliminate earlier gains in target species recovery (Russ & Alcala 2003). In one instance, technical policy inconsistencies led to fishing of the Bodega Marine Life Refuge in northern California after 30 years of protection because existing legislation restricted only invertebrate fisheries and not finfish. Further legislation was enacted quickly to confirm full no-take status (P. Connors, personal communication). Thus continuing education, adequate funding for monitoring and enforcement, and appropriate penalties for noncompliance are important for success.

### **Overcoming Limited or Missing Scientific Information**

A common problem in conservation planning is that little is known about many areas, such that determining the most appropriate locations for marine protected areas or

a network of marine protected areas is often based on anecdotal information. For governments with resources to collect baseline data and maps of habitats and ecosystems, this process, although time-consuming and expensive, can result in informed planning approaches. Lack of baseline information and resources to collect this information, however, is not a reason to postpone action. Instead, dataless management can result in effective marine conservation by incorporating information from similar systems, local fisher knowledge, and common sense approaches to protect a system for which little quantitative information is available (Johannes 1998). Working groups are another approach to gather both scientific and anecdotal evidence to determine areas most suitable for protection (e.g., Arnold 2005). This approach does not require expert scientists but can include local stakeholders with knowledge of the area.

Ad hoc approaches may result in protection of poor-quality habitats because of lack of knowledge and social pressure to conserve areas least used by stakeholders (Crowder et al. 2000; Stewart et al. 2003). Most of New Zealand's current marine no-take areas were approved in an ad hoc fashion of "opportunism, informed by science" (Roberts 2000), in that the first no-take reserves were proposed in areas most likely to gain support (e.g., near university marine laboratories) rather than being based on hotspots of biodiversity or other scientific criteria. Evidence shows benefits from opportunistic protection of marine areas (Roberts 1998, 2000; Stewart et al. 2003), even in very small marine protected areas (Shears & Babcock 2003). Large-scale marine conservation planning approaches show that globally, however, managers are moving toward a more scientifically informed decision-making process based on global biodiversity and vulnerability of different habitat types (see examples in Leslie 2005).

### **Individuality of Cases**

The processes employed and the lessons learned from previous conservation projects are important resources for new and existing conservation strategies. Emulating problem definition, stakeholder involvement, objectives identification, and the processes used in case studies such as the Channel Islands or the Great Barrier Reef is useful to conservation planning. However, recognition that each case is unique and that approaches from the conservation toolbox may need to be adapted to fit the situation at hand is an important aspect of the design, planning, implementation, and management processes. It is important that our toolbox not be reinvented for each individual marine planning approach. Best-practice guidelines for marine conservation planning processes should be accessible to conservationists globally so that knowledge is transferred between individual cases and local capacity is supported through global experience.

In comparing marine protected areas in wealthy and poor nations, some key generalities appear: Size of marine protected areas, impact on the livelihood of local resource users, and buy-in of local stakeholders will differ. In developing nations, implementation of marine protected areas may be more contentious because stakeholders are more likely to depend on local resource exploitation for sustenance (ISRS 2004). The level of government enforcement capacity and infrastructure that supports management and monitoring will also vary by country and level of industrialization of a region. Balancing existing knowledge and processes with the unique attributes of each case will allow for an adaptive yet structured conservation implementation and management process.

## Conclusion

Rethinking design, implementation, management, and monitoring of marine conservation projects will contribute to advances in our ability to create and maintain effective protected areas. Defining goals and objectives clearly and early in the design process is important for improving communication and standardizing expectations of stakeholder groups. Incorporating socioeconomic and political information that complements the science at all phases of the process is a key guideline associated with successful projects. The inclusion of available science (both scientific and local knowledge), marine-protected-area design considerations, and long-term monitoring strategies that assess success at all levels—scientific, social, and economic—are important tools in the process. Compiling baseline information (both scientific and local knowledge) allows for evaluation of effectiveness of the project and adaptive management to increase potential benefits of conservation strategies. Zoning to accommodate multiple uses (including extractive uses) and incorporation of traditional fishing into protected-area design can benefit conservation objectives by providing a lesser degree of protection while encouraging stakeholder support. Shortcomings remain in marine conservation planning strategies. By acknowledging that each case is unique, applying tools and lessons learned from other marine protected areas, and maintaining flexibility to adjust to the individual circumstances of the case at hand, however, we are assembling tools that will allow us to develop and maintain marine protected areas that attain new levels of success.

## Acknowledgments

We thank the Society for Conservation Biology and the Pew Fellows Program in Marine Conservation for sponsorship of the symposium at the 2003 SCB Annual Meet-

ing that resulted in this manuscript. We thank D. Lohrer, N. Gust, S. Airamé, and A. Arnold for helpful comments.

## Literature Cited

- Agardy, T. 2000. Information needs for marine protected areas: scientific and societal. *Bulletin of Marine Science* 66:875–888.
- Allison, G. W., S. D. Gaines, J. Lubchenco, and H. P. Possingham. 2003. Ensuring persistence of marine reserves: catastrophes require adopting an insurance factor. *Ecological Applications* 13:S8–S24.
- Arnold, A., editor. 2005. Shining a spotlight on the biodiversity of New Zealand's marine ecoregion: experts workshop on marine biodiversity, 2003. World Wildlife Fund for Nature, Wellington, New Zealand.
- Botsford, L. W., F. Micheli, and A. Hastings. 2003. Principles for the design of marine reserves. *Ecological Applications* 13:S25–S31.
- Carr, M. H., and D. C. Reed. 1993. Conceptual issues relevant to marine harvest refuges: examples from temperate reef fishes. *Canadian Journal of Fisheries and Aquatic Science* 50:2019–2028.
- Cinner, J. E., M. J. Marnane, and T. R. McClanahan. 2005. Conservation and community benefits from traditional coral reef management at Ahus Island, Papua New Guinea. *Conservation Biology* 19:in press. DOI: 10.1111/j.1523-1739.2005.00269.x.
- Clark, T., et al. 2002. Conserving biodiversity in the real world: professional practice using a policy orientation. *Endangered Species Update* 19:156–160.
- Crowder, L. B., S. J. Lyman, W. F. Figueira, and J. Priddy. 2000. Source-sink population dynamics and the problem of siting marine reserves. *Bulletin of Marine Science* 66:799–820.
- Davis, G. E. 2005. Science and society: marine reserve design at the California Channel Islands. *Conservation Biology* 19:in press. DOI: 10.1111/j.1523-1739.2005.00317.x.
- Dayton, P. K., E. Sala, M. J. Tegner, and S. Thrush. 2000. Marine reserves: parks, baselines, and fishery enhancement. *Bulletin of Marine Science* 66:617–634.
- Dugan, J. E., and G. E. Davis. 1993. Applications of marine refugia to coastal fisheries management. *Canadian Journal of Fisheries and Aquatic Science* 50:2029–2042.
- Evans, R. D., and G. R. Russ. 2004. Larger biomass of targeted reef fish in no-take marine reserves on the Great Barrier Reef, Australia. *Aquatic Conservation: Marine and Freshwater Ecosystems* 14:505–519.
- Fernandes, L., et al. 2005. Establishing representative no-take areas in the Great Barrier Reef: large-scale implementation of theory on marine protected areas. *Conservation Biology* 19:in press. DOI: 10.1111/j.1523-1739.2005.00302.x.
- Fernández, M., and J. C. Castilla. 2005. Marine conservation in Chile: historical perspective, lessons, and challenges. *Conservation Biology* 19:in press. DOI: 10.1111/j.1523-1739.2005.00277.x.
- Gell, F. R., and C. M. Roberts. 2003. The fishery effects of marine reserves and fishery closures. World Wildlife Fund for Nature—US, Washington, D.C.
- Gerber, L. R., L. W. Botsford, A. Hastings, H. P. Possingham, S. D. Gaines, S. R. Palumbi, and S. Andelman. 2003. Population models for marine reserve design: a retrospective and prospective synthesis. *Ecological Applications* 13:S47–S64.
- Granek, E. F., and M. A. Brown. 2005. Co-management approach to marine conservation in Mohéli, Comoros Islands. *Conservation Biology* 19:in press. DOI: 10.1111/j.1523-1739.2005.00301.x.
- Guidetti, P. 2002. The importance of experimental design in detecting the effects of protection measures on fish in Mediterranean MPAs. *Aquatic Conservation: Marine and Freshwater Ecosystems* 12:619–634.
- Halpern, B. S. 2003. The impact of marine reserves: do reserves work and does reserve size matter? *Ecological Applications* 13:S117–S137.
- ISRS (International Society for Reef Studies). 2004. Marine protected areas (MPAs) in management of coral reefs. Briefing paper 1. International Society for Reef Studies, Florida Institute of Technology,

- Melbourne, Florida. Available from <http://www.fit.edu/isrs/> (accessed April 2005).
- Johannes, R. E. 1998. The case for data-less marine resource management: examples from tropical nearshore finfisheries. *Trends in Ecology & Evolution* **13**:243–246.
- Jones, P.J. S. 2002. Marine protected area strategies: issues, divergences and the search for middle ground. *Reviews in Fish Biology and Fisheries* **11**:197–216.
- Kinlan, B. P., and S. D. Gaines. 2003. Propagule dispersal in marine and terrestrial environments: a community perspective. *Ecology* **84**:2007–2020.
- Langlois, T. J., and W. J. Ballantine. 2005. Marine ecological research in New Zealand: Developing predictive models through the study of no-take marine reserves. *Conservation Biology* **19**:in press. DOI: 10.1111/j.1523-1739.2005.00278.x.
- Leslie, H. 2005. A synthesis of marine conservation planning approaches. *Conservation Biology* **19**:in press. DOI: 10.1111/j.1523-1739.2005.00268.x.
- Lockwood, D. R., A. Hastings, and L. W. Botsford. 2002. The effects of dispersal patterns on marine reserves: does the tail wag the dog? *Theoretical Population Biology* **61**:297–309.
- Mascia, M. B. 2003. The human dimension of coral reef marine protected areas: recent social science research and its policy implications. *Conservation Biology* **17**:630–632.
- McClanahan, T. R. 1999. Is there a future for coral reef parks in poor tropical countries? *Coral Reefs* **18**:321–325.
- McClanahan, T. R. 2000. Recovery of a coral reef keystone predator, *Balistapus undulatus*, in East African marine parks. *Biological Conservation* **94**:191–198.
- Murray, S. N., et al. 1999. No-take reserve networks: sustaining fishery populations and marine ecosystems. *Fisheries* **24**:11–25.
- Palumbi, S. R., S. D. Gaines, H. Leslie, and R. R. Warner. 2003. New wave: high-tech tools to help marine reserve research. *Frontiers in Ecology and the Environment* **1**:73–79.
- Roberts, C. M. 1998. Sources, sinks and the design of marine reserve networks. *Fisheries* **23**:16–19.
- Roberts, C. M. 2000. Selecting marine reserve locations: optimality versus opportunism. *Bulletin of Marine Science* **66**:581–592.
- Roberts, C. M., et al. 2003a. Application of ecological criteria in selecting marine reserves and developing reserve networks. *Ecological Applications* **13**:S215–S228.
- Roberts, C. M., et al. 2003b. Ecological criteria for evaluating candidate sites for marine reserves. *Ecological Applications* **13**:S199–S214.
- Rowley, R. J. 1994. Marine reserves in fisheries management. *Aquatic Conservation: Marine and Freshwater Ecosystems* **4**:233–254.
- Russ, G. R., and A. C. Alcala. 2003. Marine reserves: rates and patterns of recovery and decline of predatory fish, 1983–2000. *Ecological Applications* **13**:1553–1565.
- 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.
- Schroeter, S. C., D. C. Reed, D. J. Kushner, J. A. Estes, and D. S. Ono. 2001. The use of marine reserves in evaluating the dive fishery for the warty sea cucumber (*Parastichopus parvimensis*) in California, U.S.A. *Canadian Journal of Fisheries and Aquatic Science* **58**:1773–1781.
- Secretariat for the Convention of Biological Diversity. 2004. Technical advice on the establishment and management of a national system of marine and coastal protected areas. Convention of Biological Diversity, Quebec.
- Shanks, A. L., B. A. Grantham, and M. H. Carr. 2003. Propagule dispersal distance and the size and spacing of marine reserves. *Ecological Applications* **13**:S159–S169.
- Shears, N. T., and R. C. Babcock. 2003. Continuing trophic cascade effects after 25 years of no-take marine reserve protection. *Marine Ecology Progress Series* **246**:1–16.
- Stewart, R. R., T. Noyce, and H. P. Possingham. 2003. Opportunity cost of ad hoc marine reserve design decisions: an example from South Australia. *Marine Ecology Progress Series* **253**:25–38.
- Stobutzi, I. C. 2001. Marine reserves and the complexity of larval dispersal. *Reviews in Fish Biology and Fisheries* **10**:515–518.
- Warner, R. R., S. E. Swearer, and J. E. Caselle. 2000. Larval accumulation and retention: implications for the design of marine reserves and essential fish habitat. *Bulletin of Marine Science* **66**:821–830.
- White, A. T., C. A. Courtney, and A. Salamanca. 2002. Experience with marine protected area planning and management in the Philippines. *Coastal Management* **30**:1–26.

