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# Co-Management Approach to Marine Conservation in Mohéli, Comoros Islands

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**Abstract:** *Many developing countries experience habitat degradation and unsustainable natural resource exploitation, with biodiversity and habitat conservation efforts often impeded by political instability and limited funding. Challenges in previous conservation efforts coupled with the current rate of marine habitat degradation and species declines warrant consideration of an innovative conservation approach. Co-management of protected areas addresses biological, cultural, economic, and political concerns and empowers communities through collaboration and integration in conservation efforts. It provides flexibility for adaptive practices to address underlying socioeconomic factors affecting conservation efforts and may compensate for limited or missing scientific data. The ecosystems of the Comoros Islands in the West Indian Ocean, a biodiversity hotspot with high endemism and diverse tropical marine habitats, are adversely affected by existing ecological, socioeconomic, and political conditions. Mohéli Marine Park was designed to address threats to the marine environment and is a model for co-management practices. We conducted a year-long evaluation of the park implementation process, including community and fisher participation. After 3 years of operation with 80% local community control, the park maintains a small staff to monitor sea turtle nesting beaches, reef health, fisheries, and uninhabited islets and to guide ecotourists and educate visitors. Our analysis revealed successes and shortcomings of the co-management approach. Successes included local communities empowered to participate in natural resource management, increased local involvement in conservation initiatives, and use of traditional knowledge when scientific information was unavailable. The Comoros example also illustrates that co-management is not immune to social issues, inadequate government law enforcement, or political instability and is an incomplete substitute for sound science. Lessons learned are applicable elsewhere and offer a template for effective scientific research and monitoring, policy making, and management of protected areas in developing nations.*

**Key Words:** community conservation, marine park, marine reserve

Estrategia de Cogestión para la Conservación Marina en Mohéli, Islas Comoros

**Resumen:** *Muchos países en desarrollo adolecen de degradación ambiental y explotación no sustentable de recursos naturales, sus esfuerzos de conservación de la biodiversidad y el hábitat a menudo son obstruidos por inestabilidad política y financiamiento limitado. Los retos de esfuerzos de conservación previos combinados con la tasa actual de degradación del hábitat marino y las declinaciones de especies justifican la consideración de una estrategia innovadora de conservación. La cogestión de áreas protegidas atiende aspectos biológicos, culturales, económicos y políticos y concede autoridad a las comunidades mediante la colaboración e integración de esfuerzos de conservación. Proporciona flexibilidad para prácticas adaptativas para abordar factores socioeconómicos subyacentes que afectan a los esfuerzos de conservación y pueden compensar la escasez o falta de datos científicos. Los ecosistemas de Islas Comoros en el Océano Índico Occidental, un sitio*

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prioritario para la conservación con alto endemismo y diversos hábitats marinos tropicales, son afectados por las condiciones ecológicas, socioeconómicas y políticas actuales. El Parque Marino Mohéli fue diseñado para atender las amenazas al ambiente marino y es un modelo de prácticas de cogestión. Durante un año hicimos una evaluación del proceso de implementación del parque que incluye la participación de la comunidad y de los pescadores. Después de 3 años de operación con 80% de control de la comunidad local, el parque mantiene un pequeño grupo para monitorear las playas de anidación de tortugas, la salud de los arrecifes, las pesquerías y los islotes deshabitados y para guiar a ecoturistas y educar a visitantes. Nuestro análisis reveló éxitos y fallas de la estrategia de cogestión. Los éxitos incluyeron el otorgamiento de poder a las comunidades locales para participar en la gestión de los recursos naturales, el incremento de la participación local en las iniciativas de conservación y el uso del conocimiento tradicional cuando no hay información científica disponible. El ejemplo de Comoros también ilustra que la cogestión no es inmune a temas sociales, al cumplimiento inadecuado de leyes o a la inestabilidad política y es un sustituto incompleto de la ciencia. Las lecciones aprendidas son aplicables en otras partes y ofrecen una plantilla para la investigación y monitoreo científico efectivo, la definición de políticas y la gestión de áreas protegidas en países en desarrollo.

**Palabras Clave:** conservación comunitaria, parque marina, reserva marina

## Introduction

With marine resources in decline worldwide and habitat degradation affecting an increasing expanse of our oceans, conservation initiatives are being implemented in a wide variety of sites, each with unique challenges (Halpern 2003; Lubchenco et al. 2003). Political instability and limited funding coupled with poor socioeconomic conditions affect conservation projects and may hinder their effectiveness. To address coastal and marine threats in developing countries, conservation practitioners are exploring alternative tools (Mascia 2003). We focused on one alternative, the co-management approach, that empowers local communities with opportunities to participate in natural resource management. Co-management provides an opportunity to address biodiversity issues and partially mitigate cultural, economic, and political concerns. This flexible and adaptive approach can address a multitude of factors affecting conservation efforts, including limited scientific information. Mohéli Marine Park in the Comoros Islands was designed and implemented employing a co-management approach. The park serves as a case study through which to examine the strengths and shortcomings of the co-management approach as a template for area-based marine conservation.

The three islands of the Union of the Comoros (formerly the Federal Islamic Republic of Comoros)—Grande Comore, Anjouan, and Mohéli together with Mayotte (a French *territoire*)—form the archipelago of Comoros (Fig. 1), a biologically diverse tropical island chain located in the western Indian Ocean (Caldecott et al. 1996). The 1659-km<sup>2</sup> islands (Batistinni & Vérin 1984) are volcanic, lie south of the equator between Madagascar and the east coast of Africa in the Mozambique Channel, and are surrounded by patch and fringing coral reefs and a handful of smaller uninhabited islets.

The Comoros archipelago has a high level of endemism and relatively high diversity. The World Wide Fund for

Nature's Global 200 conservation priority list identifies Comoros as within one of the 43 marine priority ecoregions (Olson & Dinerstein 1998) because of its biological distinctiveness. The five beaches of Itsamia, a village on the eastern side of Mohéli, have been identified as among the top 10 nesting beaches worldwide for green sea turtles (*Chelonia mydas*), with an estimated nesting population of 5000 females annually (IUCN 2002). There is evidence that waters around the islands also serve as juvenile habitat for green sea turtles and Hawksbill sea turtles (*Eretmochelys imbricata*) that once nested on Comoros beaches (Frazier 1985; Woodworth 1992; Mortimer 1993; E.F.G., personal observation). The famed coelacanth (*Latimeria chalumnae*), a living marine fossil, occurs in the coastal waters of Comoros and has been caught off the islands of Anjouan and Grande Comores (Fricke et al. 1991; Fricke & Hissmann 2000). Additionally, Mohéli and Anjouan once hosted notable populations of dugongs (*Dugong dugon*). Today documented sightings of dugongs are rare and restricted to certain regions (A. Anziz, personal communication). The Comoros marine environment is diverse, consisting of coastal mangroves, sea grass beds, inshore reefs, uninhabited islets and offshore reefs.

The marine and terrestrial environments of the Comoros face significant threats of biodiversity loss from unplanned development, overexploitation of marine and terrestrial natural resources, and habitat degradation due to destructive fishing and harvesting methods (UNDP 1997; E.F.G., personal observation). Overpopulation (population growth rate of 2.6%/year, down from 3.2%/year until 2001; Fukuda-Parr 2003), political instability (more than 20 coup attempts since independence in 1975; UNDP 1997), and poverty (48th out of 94 countries; Fukuda-Parr 2003), which are frequently beyond the scope of conservation projects, also contribute to decreasing biodiversity (Cincotta et al. 2000). Although fishing records have not been well maintained, anecdotal information from

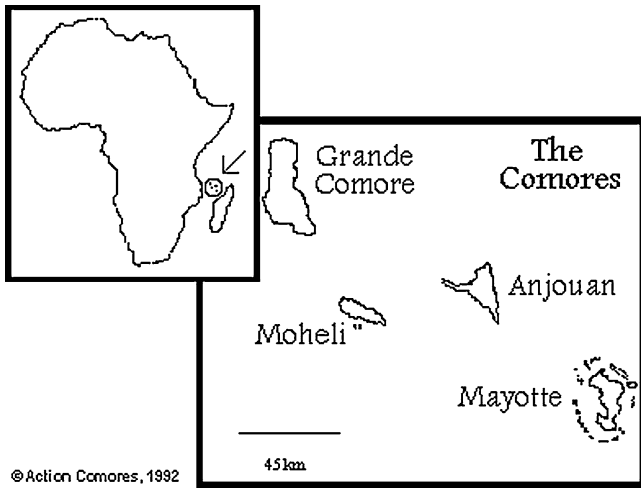


Figure 1. Comoros archipelago and its location between the African continent and Madagascar in the Mozambique Channel.

local fishers provides evidence indicating an overall decline in inshore fisheries over the past 50 years. The loss of beaches and reefs because of the extraction of sand and coral for local construction has also significantly affected the marine environment surrounding the Comoros (UNDP 1997).

In 1998, in response to these growing threats, the World Conservation Union (IUCN) and the Comorian government, with funding from the World Bank's Global Environment Facility (GEF) and the U.N. Development Programme (UNDP), initiated a 5-year project entitled Conservation of Biodiversity and Sustainable Development in the Federal Islamic Republic of the Comoros (hereafter Project Biodiversity). The goals of the project were to address the loss of biodiversity in Comoros and develop local capacity for natural resource management (UNDP 1997). The project prescribes two marine and three terrestrial protected areas and development of 5-

year Conservation Action Plans for three endangered species: green sea turtle, coelacanth, and Livingstone's flying fox (*Pteropus livinstonii*). We considered one aspect of the project: the co-management approach used to design, implement, and oversee the creation and operation of Mohéli Marine Park, the first national park in the Union of the Comoros. The unique planning and establishment processes, including strengths and shortcomings of the approach and areas for improvement in the application of this method, are highlighted. The paucity of scientific data on the distributions of habitats and species in this region necessitated a planning strategy that relied on the strength of local community involvement, coordination, and knowledge.

## Methods

### Study Area

Mohéli, with a land surface area of 212 km<sup>2</sup>, is fringed by alternating sandy and rocky beaches with intermittent mangrove forest along the southeastern and southern coast. Creation of the Mohéli Marine Park focused on the coastal environment from the high tide mark out to a depth of 100 m from the east side of the island south to the west side, with the exception of the more developed north coast. The park includes nine uninhabited offshore islets to the east and south. Ten villages with traditional fishing grounds within this zone were included in the design and implementation process for the park. The marine park covers 404 km<sup>2</sup> (from the high tide mark out to 100-m depth; Fig. 2).

Mohéli was selected as the site for the first marine park because it has experienced relatively low levels of habitat degradation (e.g., less dynamite fishing and coral bleaching) and less turtle poaching and has relatively few inhabitants compared with surrounding islands. In addition,

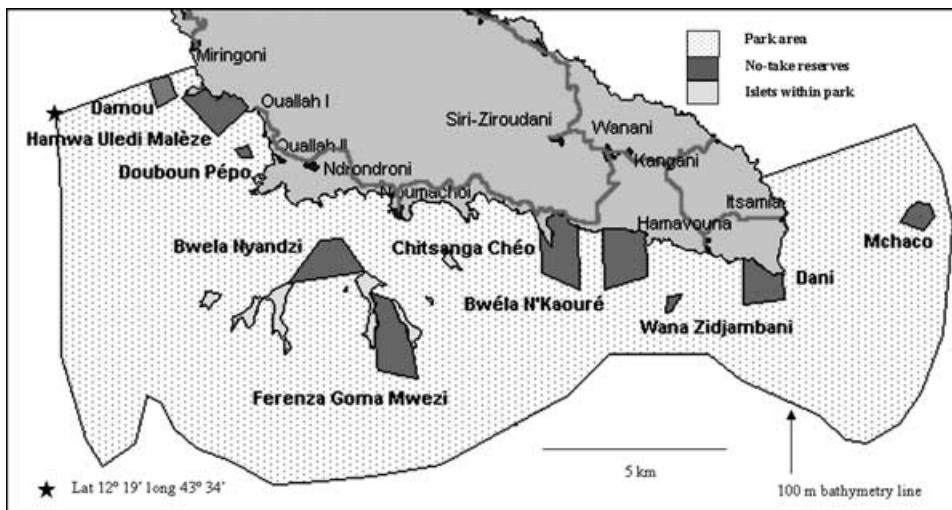


Figure 2. Map of Mohéli Marine Park and core (no-take) reserve boundaries. The dotted area is the Mohéli Marine Park and the dark polygons are the 10 core reserves (names refer to reserves).

the villages in the region of the park had previously participated in environmental education and limited monitoring activities as a result of U.S. Peace Corps projects (Woodworth 1992; E.F.G., personal observation). The diversity of shallow habitats, including mangrove forests, sand flats and channels, sea grass beds, coral patch and fringing reefs, and multiple uninhabited islands, some of which contain seabird colonies, were of biological interest in this area.

### Park Design

Project Biodiversity considered a comprehensive problem definition (Clarke et al. 2002) that reflected potential economic, cultural, and political challenges which could influence conservation measures for Mohéli Marine Park. The financial, technical, and personnel assets of the Comorian government were inadequate to address issues of conservation concern; thus, creation of a co-managed park relied on significant participation from local communities. Community members were included in the processes of park boundary delineation and guideline creation and were responsible for coordinating monitoring and enforcement within the park.

Initially, Project Biodiversity worked in coordination with the Direction Nationale de l'Environnement (DNE, the federal agency responsible for matters of the envi-

ronment) to host co-management workshops with representatives of the 10 villages adjacent to the park that would be directly affected by the park's existence. Through discussions of natural resource ownership, oversight, and utilization, participants voiced their preference for local communities to significantly contribute to the design, implementation, and enforcement of regional marine-resource-use regulations (Table 1). Consensus was reached among the national and regional Directions de l'Environnement (DRE, the regional branch of the DNE) and representatives of the villages adjacent to the future park for a co-management approach that included participation from both government and local community organizations (specifically village environmental associations, referred to hereafter as *Ulanga*, the Comorian name for the environment) and fishers' associations. The proposed goals of the park and its inclusive core reserves were to protect Comorian biodiversity and improve local and regional fisheries.

The project acknowledged and valued stakeholder participation in and contribution to the process (Mascia 2003; Roberts et al. 2003). The next step involved meetings in each village that focused on all potential stakeholders: subsistence fishers, subsistence farmers, *Ulanga* members, and women (Table 1). Comorian society is patriarchal (although matrilineal), and women have been excluded from local decision making. Because women

**Table 1.** Timeline of the Mohéli Marine Park co-management process.

Date	Participants	Activity/purpose	Result
Jul.-Oct. 1999	V	consideration of management approaches	co-management accepted by communities
Winter 1999/2000	V, U, P	ecoguards selected by villages	villages selected 12 ecoguards for the park
Nov.-Dec. 1999	F, W, U, V	park regulations decided	consensus reached on park regulations
Jan. 2000	F, U	delineation of park and no-take reserves	agreed on boundary of park and of 10 no-take reserves
Jan.-Mar. 2000	P, D, U, E	marine ecology training manual and pamphlets created	manuals printed and distributed to ecoguards, <i>Ulanga</i> associations, and government officials
Feb., Jun. 2000	E	ecoguards trained in marine ecology	ecoguards learned basic marine ecology and local taxa
Mar. 2000	E, F, W, U	ecoguards lead 10 village workshops on marine ecology	ecoguards participated in environmental education
Jul. 2000	V	public information sessions	recommended park regulations and boundaries presented to communities
Jul. 2000	V	public comment period for park decree	community input led to boundary change of one no-take reserve
Mar.-Jul. 2000	S	school-based education, including minimagazine <i>Mwana wa Nyamba</i> and Turtle Day, <i>Journée de la Tortue</i>	Mohéli elementary school children learned about sea turtles and marine ecology
Feb. 2000 to present	F, U, E	monitoring and surveillance of MMP	perpetrators in park caught and brought to authorities; released with warning
Jul.-Dec. 2000	U, W, V	alternative income-generating activities initiated	bungalows constructed in three villages and fruit bat education center constructed
Aug. 2000	G	Mohéli governor signs executive order to temporarily legalize park rules	provided communities with a legal basis for enforcing park regulations
Apr. 2001	C	president signs MMP decree	park legally designated

Abbreviations: V, villages; U, *Ulanga* associations; P, Project Biodiversity; F, fishers; W, women; D, National and Regional Direction de l'Environnement; E, ecoguards; S, schoolchildren; G, Mohéli governor; C, president of Comoros; MMP, marine protected area.

regularly engage in nearshore resource extraction, the project recognized that participation of this underrepresented stakeholder group would be critical to long-term success of conservation efforts in the Comoros. To incorporate stakeholder ideas and alleviate concerns in a safe and nonthreatening forum, each "user group" met individually with Project Biodiversity staff to identify key marine resources of their respective village, boundaries of these resources, changes in resource availability over time, and current challenges with respect to preserving marine resources (Mascia 2003).

### Ecoguards

Co-management requires representation by the community in the process of management, monitoring, and education (UNDP 1997; Rudd et al. 2003). As a result, villages nominated representatives to serve as "ecoguards," who would be responsible for monitoring their marine resources, enforcing park regulations, and representing the interests of the community. The ecoguards were selected based on the following criteria: motivated by, enthused with, and committed to conservation; previously involved in *Ulanga* or related activities; trusted by village members to act as a liaison and communicator between the community, the DRE, and other ecoguards and to foster community participation; and possessing villagers' confidence to patrol their zone of the park, enforce park regulations, and educate visitors. Project Biodiversity facilitated the village-based selection of an ecoguard for each of the 10 adjacent villages. (Two villages have offshore islets within their marine territory. These two villages were invited to select two ecoguards each to ensure better monitoring of their larger and complex marine zone.) In three pilot villages, five ecoguards were nominated and all began working for the nascent marine park in September 1999 (Table 1).

Project Biodiversity provided the *Ulanga* associations (volunteer associations with limited funds) with a grant to support ecoguard salaries for the first 4 years of the process. Employment of ecoguards by the *Ulanga* associations created an incentive for these ecoguards to remain responsive to local needs. Accountability to the *Ulanga* associations was intended to reduce potential outside influences, including political or economic pressures. Concurrently the project has worked to create an environmental trust fund to guarantee ecoguard salaries in the future and support park and equipment maintenance, staff salaries, and ongoing monitoring and surveillance (Bayon 1999; Mishra et al. 2003) (this fund is still being developed [M. Vely, personal communication]).

### Community Education

To optimize the contributions of local communities to the co-management of the park, community education was

a major component of the project (Jacobson 1995; Mucunguzi 1995). Training tools and references included a manual of marine ecology and pamphlets on the biology and ecology of sea turtles and coral reefs. The ecoguards were trained and subsequently assisted in executing marine ecology workshops for 25 invited participants in each of the 10 villages to build local interest, involvement, environmental literacy and knowledge, and capacity. Participants included *Ulanga* association members, farmers, fishers, and female leaders from each village (Table 1). Upon workshop completion, the participants assumed responsibility for communicating the information to the rest of the village by organizing public information sessions.

Public education is imperative in these villages. Attendance in primary school is < 50% (World Bank Group 2000; Fukuda-Parr 2003) and scientific literacy is lacking. One widely held misconception in the villages is that coral is nonliving. Therefore, there is little recognition of impacts associated with fishing, such as walking on the reef at low tide or breaking apart coral heads to catch cephalopods. Despite the challenge of changing commonly held perceptions, the recently trained ecoguards raised awareness and dispelled many local myths (Machlis et al. 1999). They also infused the communities with a sense of pride for their unique marine heritage and ownership of Mohéli's natural resources. Community members were educated by project staff on the park's potential to increase local fisheries and enhance the area for ecotourism. This process empowered the ecoguards and instilled confidence in their ability to educate others. Many fishermen with traditional resource knowledge of local marine fauna and behavior were also instrumental in this education process and were empowered to participate in park planning (Mucunguzi 1995).

In 2000 an environmental education magazine, *Mwana wa Nyamba (The Baby Turtle)*, was designed for elementary school children. The minimagazine was distributed to primary schools, and several weeks later, members of the Project Biodiversity staff visited schools to discuss the material with students. A *Journée de la Tortue (Turtle Day)* was also organized in 2000 to provide students with the opportunity to witness female turtles nesting on beaches within the park (Table 1).

After preliminary discussions with village members, Project Biodiversity staff drafted a questionnaire on marine resource use to facilitate discussion on local fishing techniques. At meetings in each of the 10 park villages, fishers and *Ulanga* association members discussed the impacts of various fishing methods and resource uses to determine what should be permitted and restricted in the park (see also Friedlander et al. 2003). Each village reached consensus on the list of permitted fishing techniques within the park with only one discrepancy among the 10 village lists (lamp fishing whereby lamps on multiple boats are used to attract fish and then a net

is closed around the fish). Representatives then determined whether and where to locate a core (no-take) reserve within their marine territory. Eight of the 10 villages reached consensus on establishment of core reserves to further address biodiversity conservation, habitat protection, and fisheries management goals. Of these 8, the 2 villages with offshore islets each proposed 2 core reserves (for a total of 10 reserves) because of the diversity of habitat types within their waters (Palumbi 2002).

Reserve locations were determined using anecdotal data from fishermen. With reserve goals of protecting biodiversity and enhancing fisheries, sites were selected to represent the diversity of regional habitat types (rocky shores, mangroves, channels, reefs, sand flats, sea-grass beds, and islets). Sites of biological importance were also reserve targets; these included juvenile fish habitat, spawning grounds, and rare marine habitat types (Airmé et al. 2003; Palumbi 2003) known by local fishermen. Fishers recognized the potential of these core reserves to enhance the fisheries outside the reserve through spillover of adults to areas beyond reserve boundaries (Palumbi 2002; Halpern 2003).

### Park Implementation

To delineate boundaries for the marine park and the 10 core reserves nested within the park boundaries (Fig. 2), the Project Biodiversity team conducted site visits with several fishermen and an *Ulanga* association member from each village. Subsequently, a map was created to accompany the draft park decree for the public comment period.

Fishers and local communities proposed the restrictions for integration into park regulations. These included prohibition within Mohéli Marine Park boundaries of poisons, drift nets, spears, dynamite, and fishing at low tide on the reef. Casting net, line, and trap artisanal fishing is permitted within park boundaries except within the core reserve zones. Scientific research and nonextractive tourist activities such as snorkeling and scuba diving are also allowed. Consensus was not reached on the use of lamps for net fishing at night. This technique was left unregulated until establishment of a Park Management Committee (Mascia 2003). Within the 10 core (no-take) reserves, all extractive and destructive activities are prohibited, including crossing in a motorized boat (Direction Nationale de l'Environnement 2001). The park boundaries and 10 core reserve locations are also defined in the official decree (Fig. 2).

Once the park decree was drafted, public information sessions were held in each adjacent village and in the regional capital to present objectives, restrictions, and boundaries of the park. Villagers were invited to participate in a subsequent week-long public comment period. The process was transparent and open to ensure accurate dissemination of information, alleviate potential

problems, and facilitate communication. An independent observer was sent to each village for a week to register public comment to the park decree, respond to questions, and provide additional information. The comment period produced many benefits, including identification of the need to redraw boundaries of one core reserve to ensure beach access to local fishermen without significantly reducing the size of the no-take reserve.

Consensus-driven recommendations for park regulations were drafted into legislation and presented to the Council of Ministers for consideration as national decree. Government processes delayed final park implementation for approximately 2 years. During this period, two villages took the initiative to enforce regulations outlined in the decree. Because there was no existing legal support for villages to enforce park regulations, in August 2000, the governor of Mohéli issued an executive order temporarily legalizing the decree at a regional level. In April 2001, the president signed the decree into national law (Table 1).

Project Biodiversity provided seed money for alternative income-generating activities in three pilot villages to alleviate economic limitations imposed by establishment of the park and to increase potential for local financial benefits from the park. Three ecotourist projects were sponsored by the *Ulanga* association and funded by Project Biodiversity, including accommodations for park visitors and an environmental science information center. As a condition of these grants, local communities were required to contribute a minimum of 25% of the project cost. In all cases, these were in-kind contributions of local natural resources and services. Park benefits anticipated by local communities include enhanced fisheries and increased economic opportunities through increased ecotourism associated with the newly created park. Ecotourism is expected to help reduce socioeconomic pressure on existing marine resources and may provide a sustainable option for future economic growth.

### Results

Mohéli Marine Park designation and implementation were limited by available science, technical and financial resources, and federal personnel (UNDP 1997). To compensate, the strength and interest of local communities participating in regional natural resource management were maximized through a combination of local capacity building, community education, village representation, and funding of alternative income-generating activities (Mucunguzi 1995; Mascia 2003; Mishra et al. 2003;). Additional benefits derived from the process include development of a local conservation ethic, introduction of sustainability considerations, and recognition of the utility of national parks, which has fostered the development of a second national park.

The co-management approach benefited the Mohéli Marine Park. Strengths of this approach included the following:

1. Co-management that integrated education, use of local knowledge, capacity building, and community commitment partially mitigated a lack of resources, weak government enforcement, and inadequate scientific data. Local empowerment contributed to the development of a conservation ethic that provides potential for long-term success partially through local interest in park success.
2. The ecoguard training and monitoring approach created a communication network previously absent among neighboring villages. It fostered trust among the ecoguards and village associations in recognition of common goals more easily attained through collaboration. The region had a previous history of inter-village conflict, often involving natural resource utilization issues.
3. Co-management empowered community leaders and circumvented traditional hierarchical political structure. The selection process focused on individuals who had previously participated in conservation efforts and had demonstrated enthusiasm for natural resource management rather than those with political and social rank. This may be particularly important in situations in which traditional government lacks the resources needed to focus on long-term conservation efforts.
4. Traditional knowledge served as a substitute for limited ecological data and provided an impetus for local monitoring to enhance future conservation efforts. The park implementation inspired local interest in tracking the park's success. This has led to greater village participation in monitoring local resources including attainment of park goals.
3. Building trust and achieving consensus is time consuming. Consensus building, however, generates significant local support and thus daily monitoring by the entire community.
4. Larger political and economic issues such as overpopulation may undermine conservation efforts through co-management. If the population continues to grow at the current rate, despite the existence of the park the demand on resources will continue to increase, poaching will be more difficult to control, and the stress on natural resources will inevitably increase. Co-management is a partial solution, but it cannot fully address these larger issues.
5. If the level of tourism is inadequate to fully fund conservation efforts, alternate funding resources will be necessary. External funding sources provided through Project Biodiversity are depleted. Revenue from tourism is increasing but remains inadequate to fully fund the park. Environmental trust funds or similar external funding mechanisms are necessary to ensure long-term financial support for the park (Ahamada et al. 2002; Mishra et al. 2003).

The following are potential shortcomings of the co-management approach used in the Mohéli Marine Park process:

1. Park design based on limited scientific data may impede effectiveness. Limited understanding of ecological processes (e.g., larval movement) within the park may affect success (the core reserves were not designed as a network) (Dethier et al. 2003). A lack of baseline data limits the ability of future researchers to quantitatively measure success and to use an adaptive approach to improve park efficacy (Mascia 2003).
2. Inadequate government resources can affect park success. Although communities police the park, inadequate government enforcement continues to affect park success. In the first few months, the ecoguards and fishermen from two villages caught turtle poachers and individuals illegally fishing with spears. The perpetrators were brought to the authorities, but were released with only a warning.

Mohéli Marine Park has been operational since 2001, with 10 ecoguards on staff monitoring and patrolling the park, conducting turtle nesting surveys, collecting fisheries data from local fishers, and educating visitors on the natural history of the park. The ecoguards are accountable to local communities, with direct oversight by a park manager, who coordinates the daily functioning of the park, maintains the boat and equipment, and keeps records of visitation. Although Project Biodiversity was terminated in July 2003, the park continues to be fully operational, but long-term funding issues are not resolved. Efforts are still in progress to establish an environmental trust fund. Full funding for the park ended in December 2004, but a core staff has been maintained through funding from park visitor fees and an award. Creation of the environmental trust fund is in progress because a stable source of nongovernmental funding is essential for the continued employment of sufficient park staff and the upkeep of park resources.

The park has seen a notable increase in ecotourism, with an average of 200 visitors per year. These visitors contribute to park maintenance through an entry fee. Visitors also support local community development through the purchase of food, lodging, and artisanal crafts (B. & J. Davies, personal communication).

In 2002 the Mohéli Marine Park received the U.N. Development Programme Equator Initiative Award, announced at the World Summit on Sustainable Development. A US\$30,000 prize to support the development of park infrastructure accompanied this award. The creation of the Mohéli Marine Park has led to active efforts on Grande Comore by local communities to establish a similar marine park to protect the coelacanth and its habitat. Furthermore, the co-management approach used to

implement the Mohéli Marine Park has served as a template for the Coelacanth Marine Park that is in developmental stages on Grande Comore (S. Ahamada, personal communication).

## Discussion

The Mohéli Marine Park illustrates use of area-based management tools, namely marine reserves nested within a marine park, for biodiversity conservation and local fisheries management. The circumstances in the Comoros Islands provide a practical example in which threats are imminent and immediate action is necessary. This has larger implications because many global biodiversity hotspots are also undergoing species declines and are located in areas with high population growth rates and limited federal and local resources for conservation and education (Olson & Dinerstein 1998; Rudd et al. 2003).

Co-management is not a panacea for incomplete scientific data and broader economic and political problems, but it offers a potential alternative in situations faced with limited resources for addressing biodiversity conservation and natural resource loss. Lack of government enforcement and underlying socioeconomic stresses, including overpopulation and poverty, are continuing threats, although the co-management approach takes steps to address these shortcomings. Alternative income-generating activities are in place, and ecoguards and local fishermen are trained in monitoring and patrolling the park. Inadequate enforcement mechanisms include few federal personnel to support park regulations. Active community involvement, however, partially compensates for this through social peer pressure to respect the marine ecosystem as a common resource. Park visitor fees and alternative income-generating activities alleviate some park expenses, but the relatively small scale of ecotourism in Comoros is insufficient to cover all park costs. Environmental trust funds or similar external financial assistance is pivotal to long-term conservation efforts both within the Mohéli Marine Park and in future marine and terrestrial parks in the Comoros (Bayon 1999).

The park's existence provides greater opportunity for improving biodiversity conservation and sustainable development of Comorian marine resources. The ecoguards are now trained in basic monitoring techniques, including sea turtle measurements and nesting counts to record changes in turtle populations over time. Baseline data on coral cover and reef health were collected before implementation, and subsequent and ongoing monitoring indicates successful coral recovery in parts of the park (Ahamada et al. 2002). The fishing community, recognizing that success of the park will affect their livelihood, has been more cognizant of catch rates and is qualitatively tracking changes in local fisheries, although no formal fisheries monitoring was implemented as a tool for measuring success. Trained ecoguards and supportive ad-

acent villages are now more prepared to work with international researchers, and park infrastructure is in place to support research. Research data compiled by scientists could provide valuable information for future adaptive-management practices in the park. The process of co-management has created opportunities, has strengthened local capacity and networks, and serves as a model for future conservation efforts in the country.

Although sound science is an important foundation for the design of marine protected areas, conservation is often a crisis-oriented science with limited resources and technical knowledge to conduct long-term research or even rapid assessments. This frequently necessitates prompt responses despite missing information (Soule 1985). In the developing world, insufficient training within local communities is common (Mucunguzi 1995; Fukuda-Parr 2003). In these instances rapid assessments on the scale necessary to provide sufficient data for decision making on reserve placement may not be practical. In such crisis cases the co-management approach may add value and partially mitigate the effects of limited science by incorporating local knowledge and identifying key sites that are supported by communities. This technique allowed for identifying a diversity of habitats to be incorporated into the core reserves. The approach is valuable because it develops local capacity and a conservation ethic, incorporates local knowledge in park design and reserve siting, instills a sense of community responsibility for natural resource management, and serves as a template for future parks and reserves in the country.

Project Biodiversity acknowledged the challenges of conservation in the Comoros, including the paucity of scientific data and limited government resources, both financial and technical. The project workers recognized that the social situation was suitable for community-based conservation and that the state of the marine environment, compounded by the widespread use of destructive fishing methods, necessitated immediate action. The community-empowering co-management approach was selected as the best available alternative for the Mohéli Marine Park. Its application in Mohéli is a template for an inclusive process of marine management when resources for scientific analyses are limited but local interest and participation are assets. The utility of this approach includes initiation of a conservation process adapted to the existing circumstances and development of a local marine conservation and sustainability ethic. It provides opportunities for future community-led monitoring and basic scientific data collection and may attract scientists to conduct marine research in the Comoros. This approach does not negate the importance of grounding conservation in solid science or the value of government participation and enforcement, but co-management may be a practical alternative tool when such conditions are absent. Education and local capacity building provide a foundation for co-management and reduce the susceptibility of local marine resources to outside economic influences and political

instability. A comparable process may be appropriate for other developing countries.

The co-management approach offers valuable lessons for international conservation efforts, notably in developing regions, and has broad applicability to such situations. A flexible project that incorporates local knowledge and participation as well as education and capacity building of all stakeholders is a viable approach. Our case study of co-management in the Mohéli Marine Park offers insight on feasible solutions to difficult and urgent conservation problems where scientific, financial, and governmental resources are limited.

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