

The Value of Volunteers: A Review of the Role of British Based Volunteer NGOs in the Establishment of Coral Reef Marine Protected Areas.

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Abstract Marine Protected Areas (MPAs) are increasingly becoming established to protect endangered marine ecosystems, particularly coral reef biodiversity and resources. For decision makers to be able to influence government, sound and comprehensive baseline data for tropical marine biological systems must be available to justify the reasoning that areas of coastline require protection. Non-specialist volunteer researchers have been used to great effect in a number of developing nations providing manpower that would be otherwise unavailable. In this paper a review of all available literature documenting such work was undertaken. To date, ten MPAs have been gazetted through assistance of three NGO's in five tropical coastal nations in tropical. These include: five Marine Reserves/Parks, in Tanzania, Belize and the Philippines; four National Marine Parks (NMP's), in Indonesia, Belize and Mozambique and one UNESCO World Heritage site in Belize. In total 5,500.4 km² of coral reefs and associated marine habitats have been gazetted as protected area since 1995. Volunteer labor mainly consisted of baseline marine plot-less belt transect surveys undertaken using a variety of methods to assess marine biodiversity. In some cases subsistence marine resource utilization assessments and surveys were also carried out. Capacity building and training of local counterparts is also a focus in most cases playing an important role in the empowerment of local people, and instilling increased environmental awareness in the inhabitants and users of such MPAs.

Key words Volunteers, Marine Protected Areas, Non Governmental Organization, Baseline survey.

Introduction.

Marine protected areas (MPAs) are acknowledged as an important means to prevent loss of marine and coastal diversity (Dixon *et al*, 1993). Evidence is mounting that MPAs, where fishing and other human activities are restricted or prohibited, conserve habitats and biodiversity (Pauly *et al*, 2002).

The establishment of MPAs is a costly operation, for example the cost of initial establishment of the Bonaire Marine Park was reported to be in excess of US \$ 518,000 (Dixon *et al*, 1993). Many of these costs are brought about as a result of initial biological baseline surveys carried out within the proposed protected areas.

Non professional research is widely regarded as an efficient means to generate data sets within a range of scientific disciplines, such as ornithology (Kepler and Scott, 1981) or mammal research. More recently, numerous authors have commented on the increasing use of data from non-professional "volunteers" researchers in marine science (Evans *et al*, 2001, Foster-Smith 1995), with a growing interest in tropical regions (Erdmann, *et al* 1997, Wells, 1995 and Keller, 2002). This trend has been largely driven by the popularity of SCUBA diving, along with the general growth of coastal tourism within the tropics (Hall, 2001).

Subsequently, many programs have been developed to utilize recreational divers' time spent on coral reefs in order to collect basic baseline data or undertake monitoring programs. Possibly the first systematic use of volunteer divers to collect data from coral reefs was the REEFWATCH program developed at the University of York and launched in 1982 (Wells, 1995), providing divers visiting coral reefs with standard data sheets to complete regarding the general health of the reef. The Reef Environmental Education Foundation (REEF), based in the USA (Keller, 2002), has developed a similar program. But the Reef Check program is probably the most successful use of volunteer divers using a standard methodology; collecting information contributing to a global database on the general health of coral reefs. This program was developed in 1997 (Hodgson, 2000 Hodgson, 1999). Reef Check has used teams as opposed to individuals, joining non-professionals with mentoring marine scientists to maintain rigorous training and data collection standard (Hodgson, *et al*., 2003).

The desire to focus on more specific projects has generally lead UK based Non Governmental Organization (NGOs) to adopt a model of establishing long term field bases in regions where coastal

management issues dictate that the collection of baseline data from local coral reef environments can aid decision making and protection are priorities (Gardiner and Harborne, 2000., Mumby and Harborne, 1999). The origins of this model owe much to the history of university expeditions within the UK (Coxon and Raines, 1987) and the apparent desire of primarily British volunteers to dedicate significant financial and time commitments to conservation work. This paper carries out a comprehensive literature review of the work undertaken by teams of volunteers from the three UK based NGOs Coral Cay Conservation (CCC), Frontier/The Society for Environmental Exploration (SEE) and Operation Wallacea. These volunteers were trained and supervised by professional marine scientists. The work has been guided by host country governmental departments or NGOs, and has ultimately aided the designation of MPAs within coral reefs environments and associated habitats, through the contribution of data and

management recommendations. To date, ten MPAs have been established as a result of such efforts.

Wakatobi Marine National Park, Indonesia

The Wakatobi Marine Park (Tukang Besi archipelago) is a remote island group comprised of four main islands, off the south east coast of Sulawesi, Indonesia. It extends over 1.39 million hectares (ha) between 05° 15'S and 123° 23' E and 06 08'S, 124° 37' E. The region exhibits all major reef formations (atolls, barrier, fringing and patch reefs) within a relatively small area of approximately 200,000 ha (UNEP/IUCN, 1988). Usher (1984) reported the area to be supporting a major trepang and giant clam fishery, with severe stock over exploitation. Reports suggest that the region has reasonably healthy hard coral cover and diversity (Soekarno, 1989). Before Operation Wallacea and WWF Indonesia undertook research, the biological knowledge of the region was generally considered to be inadequate (Erdmann et al. 1997, Erdmann 1998).

Table 1. Details of the survey program undertaken contributing to National Park Status of Wakatobi Marine Park.

Status	Size (Km ²)	NGO and collaborative Institutions involved in data collection for MPA status	Work program undertaken by UK based NGO.
National Marine Park	1,390	- Operation Wallacea - WWF Indonesia - Other local NGOs within S. Sulawesi.	- Operation Wallacea initiated a three-year pilot phase project in June 1995, using start up funds from the Hong Kong Bank Care-For-Nature Program (Erdmann et al. 1997). - The marine survey component was divided into three phases. Phase I involved a rapid reef assessment by volunteers using manta tow techniques and underwater visual census (UVC) using SCUBA collecting information on 11 data categories including topography, a quantitative description of live coral cover and abundance and size (to 10cm categories) of locally harvested fish using techniques adapted from English et al. (1994). - The results obtained were used to guide Phase II of the project to identify specific reefs worthy of more detailed investigations by taxonomic and fisheries specialists. These combined results formed the bases for a holistic management plan for the proposed Wakatobi Marine reserve (Erdmann et al. 1997). - Approximately 50% of the outer reefs of the Tukang Besi (348 km of reef) were surveyed using manta tow. Additionally SCUBA surveys were conducted at 196 sites and the data presented to the Indonesian sponsors of the project (Erdmann et al. 1997, Ecosurveys, 1996). - Wakatobi was declared a National Park in 1996. Additionally Operation Wallacea were instrumental in developing Indonesia's first community led no take zone, across a 500m stretch of reef within the Park (Curran, 2001). This was generally considered a local success (Belke pers comms).

Quirimbas National Park, Mozambique

Quirimbas National Park (QNP), in Mozambique's northern-most Cabo Delgado Province, close to the border with Tanzania, covers an area of

7,500 km², of which 1,550km² consists of the Quirimbas Archipelago. The archipelago includes eleven coral islands lying close offshore, stretching for 100 km along the coast (11° 59'S to 12° 41'S). Over 50 Genera of corals

have been recorded (Motta, 2002). The initiative to protect the Quirimbas area was headed by the Government of Cabo Delgado Province, local NGOs (KARIBU and GECORENA) and is strongly supported by the local community (Motta, 2002).

The establishment of the National Park is unique in that the community asked the Government of Mozambique to set it up, in an effort to protect subsistence fishing grounds from industrial trawlers causing over-fishing and widespread damage to key spawning habitats.

Table 2. Details of the survey program undertaken contributing to National Park Status of Quirimbas Marine Park.

Status	Size (Km ²)	NGO and collaborative Institutions involved in data collection for MPA status	Work program undertaken by UK based NGO.
National Park	1,550	• SEE “Frontier Mozambique” • WWF Mozambique • Ministry for the Co-ordination of Environmental Affairs • GECORENA	• Between 1996-1998 Frontier-Mozambique surveyed the marine fauna of the eleven coral islands. • Methods employed were based on the REEFWATCH (Wells, 1995) methods and those developed by English et al, (1994), Using a belt transect to survey a target species list of 73 reef associated fish (Whittingham and Myers, 1997) • Survey sites were selected using nautical charts and aerial imagery (Whittingham and Myers, 1997). • Simple transect surveys were undertaken within, intertidal zones and mangroves (Whittingham and Myers, 1997). • Separate surveys were also carried out on the seagrass fishery of Quirimba Island to establish the importance of these areas as breeding grounds for fish (Gell, 1997). Basic resource use surveys were undertaken (Whittingham and Myers, 1997). • Part of the Frontier-Mozambique project included training and involvement of people from relevant ministries and universities and the participation of 20 Mozambican scientists (Whittington & Myers, 1997). • WWF provided support to a local NGO, GECORENA, who worked with the Provincial staff to push for the gazettment of the national park. • QNP was officially gazetted on June 6th 2002 and is Mozambique's first national park since independence from Portugal in 1975.

Belize Barrier Reef, UNESCO World Heritage Site.

The Belize Barrier Reef (BBR), at over 260km in length is the largest barrier reef in the Western Hemisphere and comprises a rich diversity of reef types, including barrier, fringing, patch and faroe and associated habitats, including extensive mangrove forests. Farther offshore lie three of the Caribbean's largest atolls

(Turneffe, Lighthouse and Glovers) (Spalding et al, 2001). Traditionally, the inshore fishery has contributed significantly to the economy of Belize. Lobster (*Panulirus argus*) and conch (*Strombus gigas*) currently contribute most of the total value of exported wild caught seafood, estimated at over US\$10 million in 1995 (Raines et al, 2002).

Table 3. Details of the history behind the establishment of the BBR UNESCO World Heritage Site.

Status	Size (Km ²)	NGO and collaborative Institutions involved in data collection for MPA status	Work program undertaken by UK based NGO.
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<i>Continued</i>	963	• Coral Cay Conservation (CCC) • University College of Belize (UCB) • Belize Coastal Zone Management Unit (BCZMU)	• In 1986, the first CCC expedition visited Belize to investigate the effects of fishing and tourism on the reef. Findings were reported to the national Fisheries Department (Coxon & Raines, 1997). • Also concerned by this threat, the Belize government invited CCC to assist the development of a coastal management plan in 1989, with their newly-established BCZMU • CCC began a program of research in 1991 to aid the BCZMU, involving 1000 volunteers over 4 years to survey over 200km² of reefs and lagoons around the South Water Cay base, before extending work into other key locations such as the Sapodilla Cays and Laughing Bird Caye (O'Tool et al, 1991). • The CCC marine survey technique has been developed, tested and successfully implemented since 1989 (Mumby et al, 1995). Survey methods undertaken for all CCC work are based on those recommended by the South Pacific Commission (SPC)/United Nations Environment Program (UNEP) (1984), and Marine Nature Conservation Review of the Joint Nature Conservation Committee (Hiscock, 1990). • 1991 also saw the initiation of CCC's education and skills development agenda, collaborative events with host-country associations and provision of a Diving Scholarship Program with the Belize Fisheries Department. The establishment of the Marine Research Centre with the University College of Belize followed this. • Volunteer data formed an intrinsic part of the BBR being declared a World Heritage Site in 1996 (Harborne <i>et al</i>, 1998) - along with several new Marine Protected Areas (see below)
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Mafia Island Marine Park, Tanzania

Mafia Island is situated 120km south of Dar es Salaam (7° 40'S, 30° 40'E), on the east coast of Tanzania. Mafia is strategically located within the main flow of the dominating East African Coastal Current, which continues north through the coastal waters of Tanzania and Kenya (Horrill et al, 1996). The island was

reported to boast a high diversity of pristine marine habitats (UNEP, 1989). An attempt to gain special protection was developed as a result of pressure from increasing numbers of migrant fishermen employing destructive fishing techniques on the reefs of the island (UNEP, 1989 and Horrill, et al, 1996).

Table 4. Details of the survey program undertaken contributing to Marine Park Status of Mafia Island Marine Park.

Status	Size (Km ²)	NGO and collaborative Institutions involved in data collection for MPA status	Work program undertaken by UK based NGO.
Marine Park	822	• SEE "Frontier Tanzania" • Institute of Marine Science: University of Dar es Salaam (UDSM) • WWF Tanzania	• During 1989 the Institute of Marine Sciences of UDSM and SEE set up the "Frontier Tanzania" project to initiate studies to collate information necessary for the formation of a multi-user management plan for a marine park at Mafia Island, encompassing the south end of the Mafia and the associated Island (Horrill et al, 1996). • The work program was designed to provide information, as described by UNESCO (1987), on biological resources and resource use. • Reef surveys were undertaken following the techniques developed by the Great Barrier Reef Marine Park authority (GBRMPA, 1978) and the Tropical Marine Research Unit, University of York (Richmond and Gaudian, 1990). These included under water visual census of benthos and fish populations along plot less belt transects over developed coral reefs.

<i>Continued</i>	reefs. • Subtidal seagrass beds were surveyed, through visual census of randomly placed 0.5m² quadrats using a semi quantitative species abundance method, developed from Dahl (1982) • The diversity and density of mangroves were surveyed over 5m wide transects running perpendicular to the shoreline (Horrill and Ngoile, 1991). • All major resource uses were identified and evaluated on their methods, sites and scale of extraction, associated problems and future sustainability (Horrill et al, 1996 and Horrill and Ngoile, 1991). • To determine the patterns of linkage between local and regional habitats hydrographical surveys were conducted (Horrill et al, 1996 and Horrill and Ngoile, 1991). • A 1:100, 000 map of the bathymetry and hydrography of the area was produced from the results of the physical survey. Similar scale habitat maps were produced for the region, with the results of biological surveys showing that species diversity was generally high, with 400 species of fish, 46 genera of scleractinian coral recorded (Richmond and Gaudian, 1990, Horrill et al, 1996 and Horrill and Ngoile, 1991). • The results of the above surveys were compiled into a report (Horrill and Ngoile, 1991), and presented to a steering committee with management recommendations. • Mafia Island Marine Park was established on 1st July 1995 by a resolution of the Tanzanian National Assembly (Rubens and Kazimoto, 2003).
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South Water Cay Marine Reserve, Belize

South Water Cay Marine Reserve (SWCMR) includes 22 named sand cays, mangrove cays and mangrove ranges. The areas conservation importance stems from its diverse marine habitats (Rutzler and Macintyre, 1982), and many of the cays serve as active nest sites for species of marine birds. The barrier reef

section known as Tobacco reef is a continuous exposed reef crest that extends approximately 9km. Many South water cays have been identified as a critical habitat (Rutzler and Macintyre, 1982), and before protection it was feared that unregulated tourist development could threaten the area.

Table 5. Details of the survey program undertaken contributing to Marine Park Status of South Water Cay Marine Reserve.

Status	Size (Km ²)	NGO and collaborative Institutions involved in data collection for MPA status	Work program undertaken by UK based NGO.
Marine reserve	298	• CCC • UCB • BCZMU	• Between 1990 and 1992, in collaboration with the BCZMU, CCC volunteers undertook standard CCC marine surveys in the 180km² area surrounding SWCMR (Raines et al, 1992). • Subsequently CCC undertook surveys to encompass a further 300km² immediately south of South Water Cay. • In 1993 CCC produced a draft management plan for the SWCMR (McCorry et al, 1993), to include GISs to be used in regional marine resource utilisation. • During 1996 SWCMR was officially gazetted as a marine reserve.

Mnazi Bay Marine Park, Tanzania

The Mnazi Bay Marine Park is located in the Mtwara District in Southern Tanzania along the border with Mozambique (40°23'E, 10°18'S). A habitat assessment undertaken in November 2003 indicated that a total of 258

species (the highest number recorded in East Africa) of reef building corals and 369 species of reef fish occupy

this region, thus highlighting the ecological importance of this site (Obura et al., 2004).

Table 6. Details of the survey program undertaken contributing to Marine Park Status of Mnazi Bay Marine Park.

Status	Size (Km ²)	NGO and collaborative Institutions involved in data collection for MPA status	Work program undertaken by UK based NGO.
Marine Park	200	• SEE “Frontier Tanzania” • UDSM • Coral Reef Degradation in the Indian Ocean (CORDIO) • Swedish Agency for Research Cooperation with Developing Countries (SAREC)	• Base line surveys were carried out by Frontier Tanzania between October 1996 and September 1999 (Muhando and Francis, 2000). • Funding was provided by SAREC and formed part of a wider CORDIO program, which focused on assessment of changes on reefs following the coral bleaching event of 1998. • Visual census of reef fish populations were undertaken using methods adapted from REEFWATCH (Wells, 1995). Fifty-six pre-selected reef fish species were recorded along 5m wide transects perpendicular to the reef within a depth category of 1-10m and 10-20m (Guard et.al, 1998a) • Benthic invertebrate counts were taken within 3 x 50m² quadrats, positioned along the reef profile from deep to shallow water. Invertebrates were identified to species level where possible (Guard et.al, 1998a) • In September 1999, in collaboration with the Institute of Marine Sciences in Dar es Salaam, permanent monitoring sites were developed to carry out a coral reef monitoring effort (Muhando and Frances, 2000). • Subtidal habitat and profile mapping and subtidal spot surveys were conducted along parallel and perpendicular transect lines both within and between reef areas. This involved the collection of information relating to the type and percentage cover of underlying substratum, sessile benthic community, live hard coral hard coral forms and dominant coral form (Guard et.al, 1998a) • Intertidal surveys were also carried out using visual census measurement of 0.5² quadrats from the low water mark to high water mark of % cover of underlying substratum, algal species, seagrass species, sponges, soft corals and hard corals (Guard et.al, 1998b) • Reef impacts – including coral bleaching and anchor damage, sedimentation were measured (Guard et.al, 1998b) • Mnazi Bay Marine Park was gazetted in July 2000 under the Marine Park and Reserve Act No. 29 of 1994. This was following a resolution passed by the local coastal communities together with representatives from the government, private sector and NGO’s at a meeting held in the parish hall in Mtwara .

Sapodilla Cays Marine Reserve, Belize.

Lying at the southern most end of the Belize Barrier Reef, The Sapodilla Cayes Marine Reserve (SCMR) (88° W, 16° 30’ N) itself consists of 14 named cayes and two unnamed ephemeral islands and covers an area of 33,401 acres (Harborne et.al 2000.). The SCMR

is a site of great geological importance, with a unique J-formation that contains numerous channels and large shoal patches, and provides the second most important nesting site for the Hawksbill turtle (*Eretmochelys imbricata*) in Belize (Harborne et al., 2000). The seagrass bed in the SCMR lagoon is also rich with conch \$.

gigas) and lobster (*P. argus*), while the outer reef represents a significant spawning ground for mutton

snapper (*Lutjanus analis*) and grouper (Harborne et al, 2000).

Table 7. Details of the survey program undertaken contributing to Marine reserve status of Sapodilla Cays Marine Reserve.

Status	Size (Km ²)	NGO and collaborative Institutions involved in data collection for MPA status	Work program undertaken by UK based NGO.
Marine Reserve	127	• CCC • UCB • BCZMU	• Between 1992 and 1994 CCC satellite expeditions from South Water Caye, and undertook standard CCC baseline survey (CCC, 1995) work at Sapodilla Caye. • This data contributed to a management plan for the reserve in 1994 (Harborne, et al., 2000). • Sapodilla Caye was designated as a Marine Reserve in 1996.

Bacalar Chico National Park and Marine Reserve, Belize.

The Bacalar Chico region, a narrow, partly man made channel that forms a natural border between Belize and Mexico in North Ambergris Cay, encompasses barrier reef, seagrass beds, mangrove wetlands, lagoons and higher cay forest (87° 45'W, 18° 10'N) The area contains unusual raised reef of exposed Pleistocene coral, important nassau and yellowfin grouper (*Epinephelus striatus* and *Mycteroperca interstitialis*) spawning areas (Perkins, 1983) and nesting sites for loggerhead and green turtles (*Caretta caretta* and *Chelonia mydas*). The mangroves provide important refuge and breeding

grounds for manatees (*Trichechus manatus*), crocodiles (*Crocodylus spp*) and many species of wading birds. The area holds strong biological as well as archaeological importance.

In order to protect Bacalar Chico the European Community (EC) funded a collaborative endeavor between three NGOs: CCC, The International Tropical Conservation Foundation (ITCF) and the World Conservation Union (IUCN). CCC was commissioned with collection of biological and physical survey data for the development of the marine reserve component of the project.

Table 8. Details of the survey program undertaken contributing to National Park status of Bacalar Chico National Park and Marine Reserve.

Status	Size (Km ²)	NGO and collaborative Institutions involved in data collection for MPA status	Work program undertaken by UK based NGO.
National Park and Marine Reserve	107	• CCC • UCB • BCZMU	• Periods of fieldwork were undertaken by CCC volunteers during June/July 1994 and July/August 1995, after an intensive training period. • Forty-eight volunteers undertook 56 plot-less belt transects starting at 30m depth along the profile of the reef towards the reef crest, during June/July 1994 and July/ August 1995 over an area of 107 km². The survey program consisted of 204 individual dives, recording semi quantitative data on 303 individual habitats. This habitat data consisted of 14,000 separate species records (Gill, et al. 1996a). • Analysis of the data collected during these surveys resulted in detailed biological and physical descriptions that was overlaid onto a geo-rectified and geo-referenced base map developed by CCC to produce a habitat description map (Fig. 1) • All the data collected were subsequently applied to a coastal zone management framework to develop recommendations for the management of the area, including zone planning detailing user activity within the proposed MPA (Gill, et al. 1996a).

Continued

- Bacalar Chico National Park and Marine Reserve was officially opened August 23, 1996 and is seen as an example of NGO and governmental collaboration (Harborne et al, 1995).

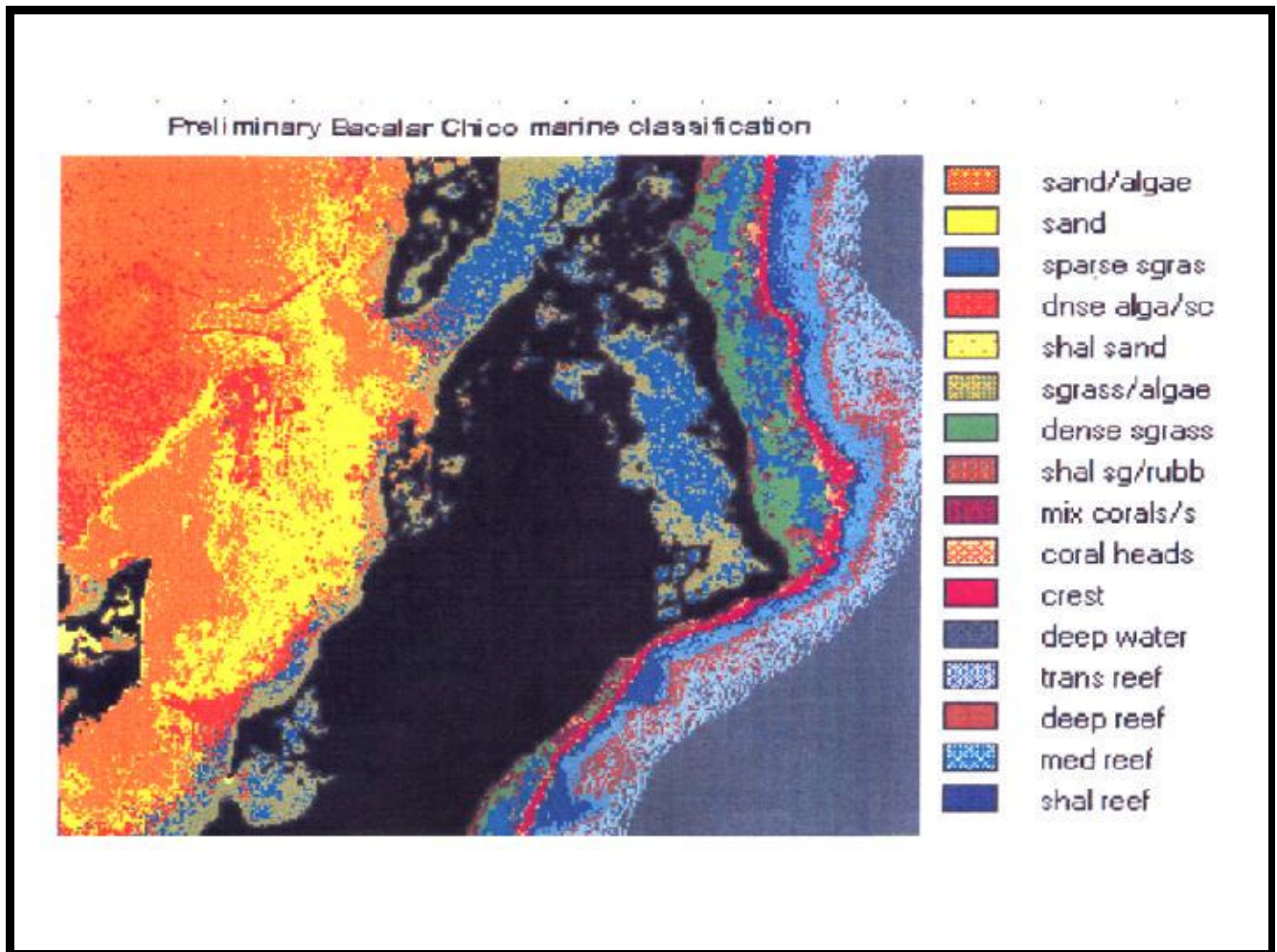


Fig. 1. Benthic habitat classification map created for BCMR (Gill et al., 1996a), resulting from surveys undertaken as described by Mumby et al., (1995).

Laughing bird Caye National Park; Belize

Laughing Bird Caye is situated on the western side of Victoria Channel, 11 miles off the coast of Belize (16°27' N - 88°12' W). Laughing Bird Caye is the southern most island in the central lagoon of the Belize Barrier Reef. This long narrow isle stands on an

elongated ridge of reef (faro). The Laughing Bird Faro is separated from the mainland, the barrier reef and other cayes by deep channels on all sides. The uniqueness of this structure contributes to both the abundance and variety of coral habitats and marine life.

Table 9. Details of the survey program undertaken contributing to National Park status of Laughing bird Caye National Park.

Status	Size (Km ²)	NGO and collaborative Institutions involved in data collection for MPA status	Work program undertaken by UK based NGO.
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<i>Continued</i>	43	• CCC • UCB • BCZMU	• Between 1992 and 1994 CCC satellite expeditions from South Water Caye undertook baseline survey work at Laughing Bird Caye, employing standard CCC methods (UNEP 1984, Hiscock, 1990). • The Caye was declared a protected area in 1991 under the National Parks System Act and encompassed only the Caye. This area was later extended. • On 21 December 1991, Laughing Bird Caye National Park was declared. Finally, in 1996 the Belize Barrier Reef Reserve System was inscribed on the World Heritage List with Laughing Bird Caye National Park designated as one of the premiere protected areas within the World Heritage Site. • A management plan for the national park was completed in 1994 (Harborne, et al. 2000).
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Danjungan Island, Philippines

Danjungan Island (9°52" N 122°22" E) is part of the Negros Occidental in central Philippines, and known through anecdotal reports to be a site of high biodiversity (Beger, et al. 2000). This small island, measuring approximately 1.5km long with a maximum width of 0.5km, has from deforestation for coconut production, combined with increased fishing pressure and use of

destructive fisheries practices (Gill et al, 1996b). The island supports a continuous fringing reef to a depth of approximately 30m. Survey work suggests that the fringing reefs of Danjungan Island are amongst the world's most diverse small reefs, with at least 236 scleractinians and hydrocorals and 229 fish species documented. Of the coral species recorded, 20 are regarded as being rare in the Philippines (Alino et al, 2002).

Table 10. Details of the survey program undertaken contributing Marine Reserve and Sanctuary status of Danjungan Is.

Status	Size (Km ²)	NGO and collaborative Institutions involved in data collection for MPA status	Work program undertaken by UK based NGO.
Marine Reserve and Sanctuary	0.43	• CCC • Silliman University • Philippine Reef and Rainforest Conservation Foundation Inc (PRRCFI)	• In 1994 CCC, PRRCFI and the World Land Trust (WLT) began work on Danjungan Island. Danjungan was recognized unofficially as a Wildlife Sanctuary in March 1994, and the Island was purchased by the three partners in 1995 (Beger et al, 2000). • Between August and November 1995 and May and July 1996 CCC and PRRCFI volunteers carried out 51 plot-less belt survey transects (using methods as described by CCC, 1995; Mumby et al, 1995) on the fringing reef around Danjungan Island and two nearby reef complexes to assess their physical and biological characteristics (Gill et al, 1996b). • The work by the volunteers formed the scientific basis for management recommendations and the identification of sanctuary zones in accordance with IUCN (Salm and Clark, 1989). The Silliman University Marine Laboratory also conducted coral reef assessments for the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES) project in 1995. • The work by the volunteers formed the scientific basis for management recommendations and the identification of sanctuary zones in accordance with IUCN (Salm and Clark, 1989). • In addition to the standard baseline surveys, a study into the key anthropogenic and physical impacts of the reefs Danjungan was undertaken (Solandt and Beger, 2001), sedimentation characteristics were investigated (Solandt et al, 2001). Finally a coral bleaching study was undertaken (Beger et al, 2001). • Collaborative research by CCC and the University of Newcastle, using a RoxAnn signal processor in October 1997

Newcastle, using a RoxAnn signal processor in October 1997, collected acoustic data of the sublittoral sea floor. Four habitat maps were created, at different descriptive resolutions (White et al, 2003).

- On the 9th April 1999 Danjungan Island Wildlife Sanctuary, as officially gazetted as Danjungan Island Marine Reserve and Sanctuary.

Discussion

Since 1995 over 5,500 Km² of coastal and marine habitats in Belize, Tanzania, Mozambique, The Philippines and Indonesia have been awarded some status of management and protection as a result of surveying, monitoring and subsequent reporting by three UK based NGOs. These organizations all used self-financing, non-specialists, who were trained, supervised and guided by marine scientists. The organizations claim to operate at the non-profit level, with conservation their primary goal.

Much of the concern surrounding the use of volunteers in collecting data for use in research arises from the perceived idea that their lack of scientific knowledge will prohibit them from providing a valid data set. Numerous studies have demonstrated that trained non specialists can collect data sets that are both sufficiently accurate and applicable to coastal management decision making (Foster-Smith and Evans 2002., Fore et al 2001., Halusky et al. 1994., Darwall and Dulvy 1996). Mumby et al. (1995) demonstrate that trained non-specialists are able to achieve an accuracy level of 52 – 70% in field identification of species through underwater visual census on a reef. The level of accuracy of non-specialist was 70 – 90%, and >90% when assessing substrate composition and biological cover in reef sites and seagrass beds, respectively. Mumby et al. (1995), show that taxonomic resolution and data accuracy were sufficient for habitat mapping using remotely sensed imagery as shown in Figure 1. In many developing coastal regions manpower and financial resources for conservation purposes are not being met (Hodgson 1999). Many developing countries lack the funds to conduct essential research on marine resources. This impedes the protection of such resources, which may have considerable economic value. This makes such volunteer derived data collection programs important in these regions of the developing world.

In all ten cases reviewed in this paper there is no doubt that the effort invested and the subsequent results have added to the biological knowledge of the regions surveyed, but the direct contribution of the work in each of the ten cases in the actual establishment of protected area status is very difficult to quantify. In the case of Wakatobi National Park in Indonesia, one can probably deduce that the work Operation Wallacea undertook had little effect on the formation of the Park. The survey work began in June 1995 (Edrman, et al, 1997) and little over a year later the 1,390km² park was formally gazetted as a National

Park, so the decision making process to award National Park status would have been made before survey work had been undertaken. In support of the effort undertaken by Operation Wallacea the organization collected baseline data for the first park management plan (Ecosurveys, 1996), and were instrumental in developing Indonesia's first community led no take zone, across a 500m stretch of reef within the Park (Curran, 2001, J. Belke, pers comms). Indeed, the impact made by CCC and their host country project partners on Danjungan Island is probably the best example of how such NGOs can have a positive impact on gaining protection for an area. CCC was involved in the management of the Island from the outset, being one of the three project partners to purchase the island and save it from development in 1994 (Beger et al, 2000). Management has subsequently been passed over to PRRFI. With Danjungan and the example of the no take area in Wakatobi one could argue that such organization could be more effective in gaining outputs such as protected areas in smaller more "community based" environments, where there are fewer stakeholder interests and other considerations. Indeed, in some cases large ambitious data collection programs by such volunteer based NGOs have invariably failed in their aim of protected area establishment in many areas of the world. The focus of these projects has been to collect huge amounts biological information but ignoring the education, training and capacity building needed in local communities for protected areas to be established and remain successful through the support of local people (A. Finlay and D. Afzal pers comms).

The results of this review show there is some degree of bias in terms of geographical regions that have received volunteer labor, with East Africa and Belize gaining the most attention. Frontier/SEE have a long history of working along side institutions such as the University of Dar es Salaam in Tanzania, and The Mozambique Ministry for the Co-ordination of Environmental Affairs. Similarly, CCC has invested ten years of effort assisting the BCZMU. As well as providing essential scientific data, host nations have benefited from the involvement of such NGOs in many other ways, such as the training and provision of environmental education opportunities for local counterparts, including students (Raines et al, 2002., Solandt 1999., Stanwell-Smith, 1999) and local school children (Raines et al, 2002). In most cases some local community members have been trained in skills such as SCUBA diving and boat handling and maintenance, that can be applied professionally when the research is complete and the project moves on. The CCC projects

in Belize yielded several environmental education tools that were developed for use within country, such as a CD-ROM, and posters (Raines et al, 2002. Harborne & Gill. 1996). Data resulting from the projects reviewed has also been disseminated within the wider scientific community, in the form of peer review publications and conference proceedings (Raines, et al., 1992a., Raines, et al., 1992b., Dulvy, et al., 1996., Horrill, 1996., Barnes, 1997 and Clifton, 2000). The large volume of data collected over a relatively short period of time can yield results not only for partner institutions and agencies within country, but also international agencies that compile annual global or regional assessments of the general condition of the world's reefs. For example Reef Check and The Atlantic and Gulf Rapid Reef Assessment (AGRRA)(Taylor & Harborne, 1999 and Turnbull & Harborne, 2000) both gained large data sets from work in Belize to use in decision and policy making.

Project sites from where survey work is conducted can have a direct benefit to the local economy, through the purchasing of goods, but in the same instances can create a false economy that leaves a large gap in the local economy when the work is finished and the project site moves on. Large groups of mainly western visitors to developing coastal areas inevitably cause some form of impact, whether it is physical, by trash production, water use, or wastewater production, or impacts more of a social nature. This can include insensitivity towards local cultures and custom, given that many volunteers are young and lack experience of foreign societies. Reporting and data and dissemination has been brought into question with regard to some work undertaken in East Africa, with reports being difficult for decision makers to obtain, unclear results, and in some cases even payments required for data (D. Obura, pers comms). This suggests a need for better consultation with project partners and those receiving outputs in the project-planning phase. Standardizing the work that such organizations undertake also needs to be considered. At present, survey methods vary with each organization, a rapid quantitative method needs to be developed, possibly using established methods suitable for trained non specialist to undertake (Hill & Wilkinson, 2004). This, added to a standardized operational procedure, would improve the clarity of the work undertaken and if reviewed would improve credibility. Currently, the only research referred to in this paper that underwent any formal peer review process is in Belize (Turner, 1995). This work resulted in data contributing to the gazettelement of two National parks, two Marine Reserves and the Belizean Barrier Reef gaining UNESCO World Heritage Site status.

Using volunteers can attract publicity and thus heightens the impact and awareness of particular research projects both to the public and to regulatory bodies, thus influencing the decisions of policy makers (Evans et.al., 2000). On a much wider level, the involvement of inexperienced volunteers seeks to

broaden the understanding of the general public (including the volunteers themselves) to the plights of tropical coastal environments, instilling in them a need to preserve threatened environments. Holding these values in high esteem thus raises the level of importance of environmental issues in the eyes of local politicians and decision makers.

Conclusion

There is no doubt that tropical coastal environments are under severe threat from a variety of anthropogenic forces (Spalding et al., 2001) and that rapid action must be taken to ensure the preservation of these valuable resources. The introduction of MPAs, and especially 'no Fishing' zones, has been shown to substantially increase the levels of fish abundances and diversity within MPAs (Roberts & Hawkins 2000). Many developing countries do not have the necessary resources to collect sufficient reliable data which can be used in the decision making process for the development of MPAs and sustainable management plans. The use of volunteer based NGO's therefore provides a valuable service to developing coastal regions who rely on marine resources for their subsistence. The use of volunteers may also be the only way that developing countries can uphold their obligations under The United Nations Agenda 21 International agreement, with regard to sustainable use of marine and coastal resources (Newman et al., 2002). It has been suggested that in order to achieve these aims of sustainable marine conservation, between one and two fifths of the world's seas need protection (Roberts & Hawkins 2000). Currently MPAs account for only 0.5% of the oceans, and only one ten thousandth of the sea is legally protected from all fishing. The vital role of volunteer NGOs in helping to establish MPAs should, therefore, not be underestimated.

Footnote: Since this work was presented at the 10ICRS, and reviewed, 13 community managed MPAs have been gazetted on the Coral Coast of Viti Levu, Fiji. This work was a result of 8 months of resource assessment survey work by CCC in collaboration with the Integrated Coastal Management Committee of Fiji. CCC produced a set of conservation management value maps as part of a GIS of the fringing reefs. A total of approximately 20km² of fringing reef is now under the guardianship of the respective local villages, protected through traditional law. The first round of designations took place in September 2004, with the second round in April 2005.

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Reference

- Alino PM, Miclat EFB, Nanola CL, Roa-Quiaoit HA, and Campos RT, (eds) (2002) Atlas of Philippines Coral Reefs. Philippine Coral Reef Information (Philreefs). Goodwill Trading Co., (Goodwill Bookstore), Quezon City, Philippines. Xvi 264pp.
- Barnes DKA (1997) Ecology of tropical hermit crabs at Quirimba Island, Mozambique: distribution, abundance and activity. *Marine Ecology Progress Series* 154: 133-142.
- Beger M, Harborne AR, Ledesma G, Page AWM, & Raines PS, (2000) Danjungan Island: A unique integrated approach to establish a community based marine protected area in the Philippines. 9th International Coral Reef Symposium, Bali, Indonesia.
- Beger M, Solandt JL, & Dacles T (2001) Coral Reef Bleaching at Danjungan Island, Negros Occidental, Philippines. A two year monitoring program. Danjungan Island Survey Summary Report 2 to the Philippines Reef and Rainforest Conservation Foundation Inc.
- Burke RB (1982) Reconnaissance study of the geomorphology and benthic communities of the outer barrier reef platform, Belize. Pp509-526. In: Rutzler K, Macintyre IG, (eds) Atlantic barrier Reef Ecosystem at Carrie Bow Cay, Belize I: Structure and communities, Smithsonian Contributions to the Marine Sciences 12.
- CCC (1995) An Overview of the Methods Used by Coral Cay Conservation for Mapping of Marine Habitats. Coral Cay Conservation. London.
- Clifton J (2000) Management issues affecting conservation and tourism in marine national parks: an example from Indonesia. Paper presented at the 5th International Congress on Marine Science, 4-8 December 2000, Havana, Cuba.
- Coxon C and Raines PS (1997) Belize Expedition Report. Coral Cay Conservation. London.
- Curran S (2001) First community led no take fishing zone in Indonesia opens in the Tukang Besi Islands. *Reef Encounter* 29: 19-20.
- Dahl A (1982) A Coral Reef Monitoring Handbook. Noumea, South Pacific Commission.
- Darwell WRT and Dulvy NK (1996) An evaluation of the suitability of non-specialist volunteer researchers for coral reef fish surveys. Mafia Island, Tanzania – A case Study. *Biological Conservation* 78 (1996) 223 – 231
- Dixon JA, Fallon Scura L, & van't Hof T (1993) Meeting ecological and Economic goals: marine park in the Caribbean. *AMBIO* 22. 117-125.
- Dulvy NK, Stanwell-Smith D, Darwall WRT, & Horrill, JC (1996) Coral mining at Mafia Island, Tanzania: a management dilemma. *Ambio* 24 (6):358-365.
- Ecosurveys (1996) Operation Wallacea: Summary results of the 1995 marine survey of the Wakatobi Islands, SE Sulawesi and proposed survey program for 1996. Report to the LIPI/PHPA/WDI Steering Committee Lincolnshire, UK.
- English SA, Wilkinson C, and Baker VJ (eds) (1994) Survey manual for tropical marine resources. ASEAN-Australia Marine Science Project: Living Coastal Resources, Townsville.
- Erdman MV, Metha A, Newman H, and Sukarno (1997) Operation Wallacea: Low cost reef assessment using volunteer divers. *Proceedings of the 8th International Coral Reef Symposium* 2. 1515-1520.
- Erdmann MV (1997) Operation Wallacea. *Inside Indonesia* 54: 56-57.
- Erseus C (1990) The marine Tubicifidae (Oligochaeta) of the barrier reef ecosystems at Carrie Bow Cay, Belize, and other parts of the Caribbean Sea, with descriptions of twenty-seven new species and revision of *Heterodrilus*, *Thalassodrilus* and *Smithsonodrilus*. *Zoologica Scripta* 19 (3), 243-303.
- Evans SM, Birchenough AC, and Fletcher H (2000) The value and validity of community-based Research: TBT Contamination of the North Sea.
- Evans SM, Foster-Smith J, and Welsh R (2001) Volunteers assess marine biodiversity. *Biologist* 48 (4) 168 – 72.
- Fenner D (1999) New observations on the stony coral (*Scleritinia*, *Milleporidae*, and *Stylasteridae*) species (Central America) and *Conzumel* (Mexico). *Bulletin of Marine Science* 64 (1), 143-154.
- For L, Paulsen K, and O'Laughlin K (2001) Assessing the performance of volunteers in monitoring streams. *Freshwater Biology* 46, 109 – 123
- Foster-Smith J and Evan SM (2002) The Value of marine ecological data collected by volunteers. *Biological Conservation* 113 199 – 213
- Foster-Smith RL (1995) SEASEARCH Starter Pack. Scottish Natural Heritage, Edinburgh. ISBN 1 85397 1219.
- Gardner R, and Harborne AR (2000) Summary of Coral Cay Conservations data on commercially important reef fish and invertebrates from the Turneffe Atoll. Belize. Coral Cay Conservation, London.
- GBRMPA (1978) Workshop on reef fish assessment and monitoring. GBRMPA workshop series No. 2.
- Gell FR. (1997) Technical Report 5: The Seagrass fishery of Quirimba Island, Interim report. Marine Biological and Resource Use Surveys of the Quirimba Archipelago, Mozambique. Society for Environmental Exploration, London and the

- Ministry for the Co-ordination of Environmental Affairs, Maputo. 27 pp. ISSN 1369-0493
- Gill A, Harborne AR, Raines PS, and Ridley JM (1996b) The Danjungan Island Marine Reserve: A Preliminary Report to the Philippine Reef and Rainforest Conservation Foundation Inc. Coral Cay Conservation. London.
- Gill AB, Harborne AR, Vierros M, Raines PS, & Ridley JM (1996a) Bacalar Chico Marine Reserve Project. Final Report to the European Union.
- Guard MC, Muller C, Evans D (1998) Marine Biological And Marine Resource Use Surveys In The Mtwara District, Tanzania Report No. 2 Detailed Descriptions Of Fringing And Coral Patch Reefs Within And Adjacent To Mnazi Bay Volume 1: Msimbati Outer, Ruvula, Chamba Cha Matenga, Mnazi Bay South. Frontier-Tanzania Marine Research Program. The Society for Environmental Exploration and the University of Dar es Salaam. 100pp.
- Guard MC, Muller C, Evans D, (1998) Marine Biological And Marine Resource Use Surveys In The Mtwara District, Tanzania, Report No. 1 Comparative Summary Report Fringing And Coral Patch Reefs Within And Adjacent To Mnazi Bay Msimbati Outer, Ruvula, Chamba Cha Matenga, Mnazi Bay South, Chamba Cha Chumbo, Chamba Cha Lusale, Island Complex. Frontier-Tanzania Marine Research Program. The Society for Environmental Exploration and the University of Dar es Salaam. 63pp.
- Hall CM (2001) Trends in ocean and coastal tourism: the end of the last frontier? *Ocean and Coastal Management* 44. 601-618.
- Halusky JG, Seaman W Jr., and Strawbridge EW (1994) Effectiveness of trained volunteer divers in scientific documentation of artificial aquatic habitats. *Bulletin of Marine Science*, 55 (2-3): 939-959.
- Harborne AR, & Gill AB (1996) Coral Cay Conservation: A case study of conservation and coastal zone management in Belize. RGS Digital Fieldwork for Expeditions Workshop, London, UK.
- Harborne AR, Mumby PJ, Raines PS, & Ridley JM (1995) The Bacalar Chico Reserve: A case study in government and NGO collaboration in conservation projects. Blake GB, Hildesley WJ, Pratt MA, Ridley RJ & Schofield CH (eds) *The peaceful management of transboundary resources*. Athaeum Press.
- Harborne AR, Raines PS, Ridley JM, & Withey SC. (1998). Coral Cay Expeditions: the use of self-financing volunteer divers to assist coastal zone management and conservation education in Belize. 23rd Annual Conference of the Caribbean Studies Association, Antigua.
- Harborne AR., McFeild MD, and Delany EK (2000) Belize. In: Shepard C, (Ed) *Seas at the Millennium*. Elsevier Science.
- Hill J, and Wilkinson C (2004) *Methods for Ecological Monitoring of Coral reefs: A Resource for Managers*. Australian Institute of Marine Science. ISBN 0 642 322 376.
- Hiscock K (1990) *Marine Nature Conservation Review Methods*. Nature Conservancy Council CSD Report no. 1072.
- Hodgson G (1999). A Global Assessment of Human Effects on Coral Reefs. *Marine Pollution Bulletin*. 38/5: 345-355.
- Hodgson G (2000). *Coral Reef Monitoring and Management Using Reef Check*. Integrated Coastal Zone Management. 1: 169 - 179.
- Hodgson GL, Mohajerani J, Liebeler D, Ochavillo CS, Shuman C (2003) MAQTRAC: Marine Aquarium Trade Coral Reef Monitoring Protocol. Reef Check, Institute of the Environment, University of California, Los Angeles, Los Angeles, CA. 55 p.
- Horrill JC (1996) To formulate a practical management strategy for the conservation of Mafia's coral reefs. In: Proc. Workshop on Conservation of Biodiversity in Africa. Nat. Mus. Kenya.
- Horrill JC and Ngoile MAK (1991) Mafia Island Report No. 2: Results of the Physical, Biological and Resource Use Surveys: Rational for the Development of a Management Strategy. The Society for Environmental Exploration, London.
- Horrill JC, Darwall WRT, & Ngoile MAK (1996) Development of a Marine Protected Area: Mafia Island, Tanzania. *Ambio* 25(1): 50-57.
- Keller BD (2002) Monitoring protected zones in the Florida Keys. *The Volunteer Monitor*. 14 18-19.
- Kelper C and Scott JM (1981) Reducing bird count variability by trained observers. *Studies in Avian Biology*. 366-371.
- McCorry D, Mumby PJ, Raines PS, & Ridley JM (1993) South Water Cay Marine Reserve Management Plan. Coral Cay Conservation. London.
- Motta, H. (2002) Gift to the Earth – Mozambique establishes the Quirimbas National Park. WWF Gift to the Earth. 78. 1-2.
- Muhando CA and Francis J (2000) The status of coral reefs in the Dar-se-Salaam Marine Reserves System and the state of reefs in other marine protected areas in Tanzania. ICRAN Report. United Nations Environment Program.
- Mumby PJ and Harborne AR (1999) Classification Scheme for Marine habitats of Belize. Report for the UNEP/GEF coastal management project, Belize.
- Mumby PJ, Harborne AR, Raines PS, and Ridley JM (1995) A critical assessment of data derived from Coral Cay Conservation volunteers. *Bulletin of Marine Science*. 56(3): 737-751.
- National Parks of Belize series, (1999) – Laughing Bird Caye. Natural light Productions Ltd., Belize
- Newman C, Buesching CD, and MacDonald DW (2002) Validating mammal monitoring methods and assessing the performance of volunteers in

- wildlife conservation – “Sed quis custodiet ipsos custodies?” .Biological conservation 113 (2003) 189 – 197.
- O’ Tool L, Raines PS, & Ridley J (1991) Coral Cay Conservation – Belize ’90 Expedition Report. Report to the Royal Geographical Society.
- Obura D, Ngowo R, Church J, Nur M, and Mbije N (2004) The current Ecological status of Coral Reef Ecosystems in Mnazi Bay – Ruvuma Estuary Marine Park. Poster presentation: 10th Symposium of the International Society for Reef Studies, Okinawa, Japan June 28th- July 2nd.
- Pauly D, Christainson V, Guenette S, Pitcher TR, Sumalila UR, Walters CJ, Watson R, & Zeller D (2002) Towards sustainability in world fisheries. Nature 406, 882-695.
- Perkins JS (1983) The Belize Barrier Reef ecosystem: An Assessment of its Resources, Conservation Status and Management. New York Zoological Society.
- Raines PS, Harborne AR, and Ridley JM (2002) Coastal zone management and the conservation education in Belize: The role of Coral Cay Conservation. Journal of Belizean Affairs. Vol. 4 No. 2. 118-128.
- Raines PS, Ridley JM, McCorry D, & Mumby PJ (1992a) Coral Cay Conservation – Survey Techniques and their application in Belize. Proceedings of the 7th International Coral Reef Symposium. 1: 122-126.
- Raines PS, Ridley JM, & McCorry D (1992b). The role of Coral Cay Conservation in marine parks management in Belize. IUCN 4th World Congress on National Parks and Protected Areas, 10-21 February, Caracas.
- Richmond M and Gaudian G (1990) Frontier Tanzania Mafia Island Marine Survey: Interim Report. Society for Environmental Exploration, London and the University of Dar es Salaam.
- Roberts CM, and Hawkins JP (2000) Fully protected marine reserves: a guide, WWF Endangered Seas Campaign, Washington USA and Environment Department, University of York, UK
- Rubens J and Kazimoto S (2003) WCPA-Marine and WWF Marine Protected Areas Management Effectiveness Initiative: Mafia Island, A Demonstration Case. WCPA-Marine and WWF.
- Rutzler K, and Macintyre IG (1982) Atlantic Barrier Reef ecosystem at Carrie Bow Cay, Belize. Smithsonian Institution Press. Washington.
- Salm RV, and Clark JR (1989) Marine and Coastal Protected Areas: A Guide for Planners and Managers (2nd Edition). International Union for the Conservation of Nature, Gland, Switzerland.
- Soekarno R (1989) Comparative studies on the status of Indonesian coral reefs. Netherlands Journal of Sea Research. 23: 215-222.
- Solandt JL & Beger M (2001) A study of the key anthropological and physical impacts that occur on the reefs of Danjungan Island, Negros Occidental.
- Danjungan Island Survey Summary Report 1 to the Philippines Reef and Rainforest Conservation Foundation Inc.
- Solandt JL (1999) Tanzanian student training program in Marine Survey Methods. Final report to the British Council, Dar es Salaam, Frontier-Tanzania Marine Research Program. The Society for Environmental Exploration and the University of Dar es Salaam. 13 pp.
- Solandt JL, Beger M, & Harborne AR (2001) Reef fish populations around Danjungan Island, Negros Occidental, Philippines. Danjungan Island Survey Summary Report 3 to the Philippines Reef and Rainforest Conservation Foundation Inc.
- Spalding MDC, Ravilious C, & Green EP (2001) UNEP-WCMC World Atlas of Coral Reefs. University of California Press, Berkeley, California, USA.
- SPC/UNEP (1984) Coral reef monitoring handbook. Reference Methods for Marine Pollution Studies 25, UNEP 1984.
- Stanwell-Smith D (Ed.) (1999) The BHC / WWF marine training project: compilation report. The Society for Environmental Exploration and the University of Dar es Salaam. 130 pp.
- Taylor D, & Harborne AR, (1999) Summary of Coral Cay Conservation’s Reef Check data (1997 and 1998) from Turneffe Atoll, Belize.
- Turnbull CG, & Harborne AR (2000) Summary of Coral Cay Conservation’s Atlantic and Gulf Rapid Reef Assessment data from Turneffe Atoll, Belize.
- Turner J (1995) A review of current methodologies employed in Belize to classify sub-tidal marine habitats, their validity for coastal zone management, and coral reef monitoring. Reports to the United Nations Development Program and Global Environment facility. P 27.
- UNDP (2004) Regional Bureau for Latin America and the Caribbean, Belize – Training and Equipping Fishermen who use the Sapodilla Cayes Marine Reserve.
- UNEP (1989) Coastal and marine environmental problems of the United Republic of Tanzania. UNEP Regional Seas Reports and Studies No. 106.
- UNEP/IUCN (1988) Coral reefs of the World. Vol. 2: Indian Ocean, Red Sea and Gulf. UNEP Regional Seas Directories, Nairobi, IUCN Gland, Switzerland.
- UNESCO (1987) Coral Reef Management Handbook, 2nd Edition. Kenchington RA and Hudson BET (eds) UNESCO ROSTEA, Jakarta.
- Usher GF (1994) Coral reef invertebrates in Indonesia: their Exploitation and conservation needs. IUCN/WWF Report, Bogor.
- Wells SM (1995) Reef assessment and monitoring using volunteers and non-professionals. University of Miami.
- White WH, Harborne AR, Sotheran IS, Walton R, and Foster-Smith RL (2003) Using an acoustic ground discrimination system to map coral reef benthic

classes. International Journal of Remote Sensing
24. 13 2641-2660.

Whittington MW, and Myers M (1997) Technical
Report 1: Introduction and Methods. Marine
Biological and Resource Use Surveys of the
Quirimba Archipelago, Mozambique. Society for
Environmental Exploration, London and the
Ministry for the Co-ordination of Environmental
Affairs, Maputo. 47pp. ISSN.