COMMUNITY ESSAY

Identifying management needs for sustainable coral-reef ecosystems

M. James Crabbe1*, Edwin Martinez2, Christina Garcia3, Juan Chub4, Leonardo Castro5, & Jason Guy6

1 Luton Institute of Research in the Applied Natural Sciences, Faculty of Creative Arts, Technologies and Science, University of Bedfordshire, Park Square, Luton, LU1 3JU UK (email: james.crabbe@beds.ac.uk)
2 Belize Regional Initiative, Earthwatch Institute, Joe Taylor Creek Bridge, Punta Gorda Town, Toledo, Belize
3 Toledo Association for Sustainable Tourism and Empowerment (TASTE), 53 Main Middle Street, PO Box 18, Punta Gorda Town, Toledo, Belize
4 Toledo Institute for Development and Environment (TIDE), PO Box 150, 1 Mile San Antonio Road, Punta Gorda Town, Belize
5 Friends of Nature, Belize, Village of Placencia, Stann Creek District, Belize
6 Belize Department of Fisheries, Coastal Zone Multi-Complex Building, Princess Margaret Drive, PO Box 148, Belize City, Belize

M. James Crabbe’s Personal Statement:

In 2007, I developed with the aid of the Earthwatch Institute and the Oak Foundation a capacity-building program in southern Belize to address issues of marine reserve management underpinned by science. The first component included group discussions on important issues related to the management of the reserves and review of scientific papers, strategic plans, and action plans. The second component included field research in the Sapodilla Cayes Marine Reserve and the Port Honduras Marine Reserve. The project’s overall objectives and outcomes were to increase the participants’ capacity to lead and educate regarding sustainable development and to promote networking among organizations that manage marine resources, enhancing their collective influence over policy decisions. From that program, the project group developed the concepts and management protocols for coral-reef sustainability elucidated below.

Introduction

Coral reefs are found predominantly between the Tropics of Capricorn and Cancer and provide homes for one-third of all marine fish species and many thousands of other species. The 6 million tons of fish caught annually in these waters provide an income for national and international fishing fleets as well as for local communities that rely on local fish stocks for sustenance. The reefs also act as barriers to wave action and storms by reducing the incident wave energy through reflection, dissipation, and shoaling, protecting the land and an estimated half a billion people that live within 100 kilometers of reefs. The coral-reef ecosystem forms part of a “seascape” that includes land-based ecosystems, such as mangroves, and ideally should provide a complete system for conservation and management (Mumby & Steneck, 2008).

Current challenges to coral-reef sustainability, that could destroy the world’s reefs by the middle of the current century, include overfishing, destructive fishing practices, coral bleaching, ocean acidification, sea-level rise, algal blooms, agricultural runoff, coastal and resort development, marine pollution, increasing coral diseases, invasive species, hurricane/cyclone damage, and, in Indo-Pacific regions, crown-of-thorns starfish outbreaks. Against this backdrop of natural and anthropogenic insults, an important initial question is: How can management practices maintain sustainable coral-reef ecosystems? We now know that, while many reef organisms and fish have largely local dispersal, reef ecosystems have large-scale interconnections, for example with seagrass and mangrove ecosystems (Mora et al. 2006; Lo-Yat et al. 2006; Vollmer & Palumbi, 2007). This observation leads to a second question, namely how useful is the concept of single marine reserves over a global scale?

Linking Management Policy to Scientific Monitoring

An important environmental concept is that management needs to be evidence based. However, some managers might say that we do not need any more science on coral reefs—we know what the problems are, all we need is the resources to fix them. While that contention is true up to a point, it does not take into account the regime shifts that can occur at
the ecosystem level where thresholds can all too easily be broken to produce an almost irreversible decline (Lyytimäki & Hildén, 2007).

An integrated approach that conjoins biological and social sciences to guide management decisions and influence policy is required. To take account of management-policy changes, feedback is needed via monitoring mechanisms (Dietz et al. 2003; Kajikawa, 2008; Pachauri, 2008). For coral reefs, such observation includes assessments of coral cover, coral species diversity, and fish and invertebrates, as well as physical and chemical parameters such as nutrients and salinity. These measurements indicate the effectiveness of management policies. In addition, regular and well-maintained scientific monitoring over time enables the development of a knowledge database of ecosystems that can be accessible to all stakeholders. Such a database can lead not only to knowledge-based management decisions in the short term, but ultimately to medium- and long-term management forecasting.

An Example: Global Monitoring of Coral Bleaching to Inform Management Regimes

Reef-building corals contain dinoflagellate symbiotic algae called zooxanthellae. The predominant source of nutrition for corals is in the form of photosynthetic products produced by the zooxanthellae. The symbiotic relationship between zooxanthellae and corals is that the zooxanthellae provide the coral with photosynthetic carbon, which is often enough to supply the coral’s energy requirements, and in turn the coral provides protection and access to enough light for the zooxanthellae to photosynthesize. Coral bleaching is due to the loss of zooxanthellae by the coral. Most coral pigmentation is within the zooxanthellae, so when they are no longer present, the coral appears white, or bleached, because the calcium carbonate coral skeleton shows through the translucent living tissue. Bleaching occurs when the coral is exposed to prolonged above-normal temperatures that, together with increased solar irradiation, result in additional energy demands on the coral, depleted coral reserves, and reduced biomass (Lesser & Farrell, 2004).

Hoegh-Guldberg and colleagues have estimated the frequency of future coral bleaching using projected sea-surface temperatures (SSTs) from four different general circulation models (GCMs) of the Intergovernmental Panel on Climate Change’s (IPCC) IS92a emission scenario (Hoegh-Guldberg, 1999; Hoegh-Guldberg et al. 2007). These authors combine the SST projections with thermal thresholds for corals derived using the Integrated Global Ocean Services System (IGOSS) dataset¹ and from literature and Internet reports of bleaching events (bleaching tends to happen as a series of sudden “events” rather than as a gradual process). All SST projections indicate that the frequency of bleaching events is set to rise rapidly, with the highest estimates for Southeast Asia, the Caribbean Region, and the Great Barrier Reef and the lowest forecasts for the central Pacific Ocean (Hoegh-Guldberg, 1999; Hoegh-Guldberg et al. 2007). Some meteorologists predict that bleaching events will occur annually in most oceans by 2040 (see e.g., Hoegh-Guldberg et al. 2007). Southeast Asia and the Caribbean Region are projected to reach this point by 2020, triggered by seasonal changes in seawater temperature. El Niño events, themselves producing SST changes, would add to the problems.

To predict imminent rises in SSTs, the United States National Oceanic and Atmospheric Administration’s Coral Reef Watch (NOAA CRW) develops and operationally produces satellite-based coral bleaching “nowcasts” and alerts that are available on the Internet (Liu et al. 2006). These products are based on nighttime-only Advanced Very High Resolution Radiometer (AVHRR) sea-surface temperatures from NOAA polar-orbiting satellites. This system, for example, provided notification of the 2005 Caribbean mass-bleaching event, indicating that average ocean temperatures in the area during July to October 2005 exceeded temperatures at any time during the past 154 years (NOAA, 2008). Corals grow within a very narrow temperature range, so that a few degrees of positive or negative variability will cause bleaching, and ultimately mortality, as happened in the Caribbean Region in 2005. Similar monitoring systems are in use for the Great Barrier Reef and, as with the NOAA system, such information provides invaluable help to marine reserve managers and other stakeholders of coral-reef ecosystems (Maynard et al. 2008).

Some Routes Toward Integrated Coastal Zone Management and the Development of Learning Outcomes for Sustainable Coral Reefs

Since the 1992 Rio Declaration on Environment and Development, emphasis on the transfer of technological knowledge and scientific understanding has encompassed four areas: legal and administrative, financial, technical, and human resources (Cicin-Sain & Knecht, 1998). While in exceptional cases devel-

¹ Data are compiled by a collaborative initiative undertaken by the World Meteorological Organization (WMO), the United Nations Educational, Scientific, and Cultural Organization (UNESCO), and the Joint Intergovernmental Oceanographic Commission’s (JCOMM) Technical Commission for Oceanography and Marine Meteorology.
ICZM is a complex worldwide governance issue requiring an integrated and coordinated approach. It involves many relevant stakeholders and policy initiatives need to be developed over long time scales. Ideally, marine ecosystems (i.e., corals and seagrass beds) should be closely linked to terrestrial ecosystems such as mangroves and coastal forests. In developing management policies, education and training to enhance human skills and institutional capacity in resource management is critical (Wescott, 2002; Balgos, 2005). Such instruction has engaged many communities with inherent and long-standing challenges to sustainability and has been carried out within the context of marine protected areas (MPAs) (Chircop, 1998; Crabbe, 2006), indigenous community-based conservation (Mutandwa & Gadzirayi, 2007; Tai, 2007), waste management (Agamuthu & Hansen, 2007), health (Tang et al. 2005; Raeburn et al. 2006), and disaster preparedness (Allen, 2006). Both developed and developing countries have used capacity-building programs (Eakin & Lemos, 2006; Kaplan et al. 2006; Rogers et al. 2007). While many, if not all, of these programs involve building competencies and empowerment in local communities, few of them involve policy makers or government officials (Mequenant & Taylor, 2007). Moreover, increased community capacity can potentially empower local communities to mitigate socioeconomic impacts of environmental change; however, evaluations of ICZM performance have revealed limited interest in furthering community development. Partnerships can be vital for ICZM, particularly where government policies link to local stakeholders (e.g., beach clean-up groups and marine wildlife associations) to produce collaborations that can involve people with vested interests in the coastal ecosystem (e.g., fishers, tour operators) and in ongoing management frameworks (Stojanovic & Barker, 2008).

The effective application of ICZM to coral-reef ecosystems entails the development of learning outcomes for sustainable coral reefs and stakeholders. These should address a number of themes, including:

1. The use of ecosystem and economic parameters to quantify the needs of marine reserves.
2. The development of tactics for leading, educating, and supporting issues regarding sustainable development of coral-reef ecosystems.
3. The incorporation of all relevant stakeholders into the formulation of policy issues pertaining to marine resource management-zoning plans.

Stakeholders can employ a number of methodologies to produce learning outcomes for management (May, 1993; Becker & Ostrom, 1995; McCance et al. 2007; Fletcher et al. 2008; Potete & Ostrom, 2008). Box 1 identifies a set of twelve management needs derived from sustainability science that involve partnerships among government, nongovernmental or-

| Box 1 Management needs derived from sustainability science. |
|-------------------------------------------------------------|
| 1. Ecosystem zoning redesignated to balance stakeholders’ wishes and evidence-based fisheries catches. |
| 2. A community-based research program developed via participants. This should involve local fishers with qualitative and/or quantitative research methods. |
| 3. Data of high accuracy. Quantitative ecosystem data needs to be verified statistically. |
| 4. Comanagement plans between nongovernmental organizations (NGOs), communities, and fisheries departments developed to address problems of illegal fishers from states or countries outside the governance of the MPAs. This is a significant problem in reef areas close to more than one country or state. |
| 5. Foster regular public meetings of stakeholders, as well as regular education events. Action plans need to be developed and monitored by staff and stakeholders alike. |
| 6. Effectiveness of zoning monitored and quantified. This point relates to fishing practices, as well as to ecosystem health. |
| 7. Encourage and maintain alternative livelihoods for fishers (e.g., in the tourist industry). Government agencies need to be involved in linking tourism and economic development. |
| 8. Tourists monitored and sustainability encouraged. All stakeholders need to be involved, with penalties for unsustainable practices. |
| 9. Effective management linked to the country’s economy. Progress toward this objective is encouraged if fishing or another coral-related industry (e.g., tourism) is an important part of the country’s gross domestic product (GDP). Politicians should be engaged at all steps in management discussions. |
| 10. NGOs and marine protected areas (MPAs) link together. In areas where different NGOs are responsible for MPA management (e.g., in the MesoAmerican Barrier Reef), and where MPAs are distant from one another, it is helpful to link both NGOs and MPAs so that a greater area of reef can be managed. |
| 11. Maintain regular information to all stakeholders, from the politicians to the local communities. Communication linked to the communities served (e.g., some oral, some printed, some via Internet) is important. |
| 12. Management plans passed into law. The involvement of government officers (e.g., fisheries officers) as partners is key to this important outcome, which should ensure appropriate policing if resources are made available. |
ganizations (NGOs), and communities to improve ICZM.

**Sustainable Marine Reserves**

Marine reserves are an important tool in the sustainable management of many coral reefs (Williams & Polunin, 2000; Cho, 2005). However, it is important that the reef ecosystems share regulatory guidelines, enforcement practices and resources, and conservation initiatives and management, underpinned by scientific research. An excellent example of an effective single marine reserve is the Great Barrier Reef in Australia operated and managed solely by the Great Barrier Reef Marine Park Authority (GBRMPA). In contrast, the second largest barrier reef in the world, the Meso-American Barrier Reef, is bounded by four countries (Mexico, Belize, Guatemala, and Honduras), each with its own laws and policies. Here, a number of single and separated marine reserves exist along the barrier reef. The authors of this essay have successfully transferred scientific expertise in Belize to local participants to generate scientific evidence to underpin future management and conservation decisions. Our scientific findings on the impact of hurricanes on reefs in Belize suggested that hurricanes and severe storms limited the recruitment and survival of nonbranching corals of the Mesoamerican barrier reef and advised marine park managers to assist coral recruitment in years where there are hurricanes or severe storms (Crabbe et al. 2008; 2009b; 2009c).

The MPAs need to share the guidelines, practices and resources mentioned above, justified by scientific research (see, e.g., Hills et al. 2006). Cooperative studies and networking across all levels improves capacity building and encourages innovative approaches to management, particularly across coral reef, seagrass, and mangrove and forest ecosystems (Christie & White, 2007; Johnson & van Densen, 2007; Poulsen, 2007; Crabbe, 2009c).

This essay has addressed the two questions advanced in the introduction and has postulated a number of outcomes important for the sustainable management of coral-reef ecosystems. We and others (see, e.g., Mumby & Steneck, 2008) contend that the establishment of protected areas and policy development for sustainable conservation practices are key to sustainable ecosystems. Developing ICZM in the future will require both resources and iteration over many years to forge sustainable management processes and outcomes (McDuff, 2001; Wescott, 2002; Coffin, 2005; Mow et al. 2007). In cases where stakeholders have unresolved differences, clear and disinterested leadership and a widely respected decision-making process are important to reduce the possibility that divergence does not deteriorate into conflict. The different backgrounds and imperatives of stakeholders are important in management negotiations, particularly if the model used is outcome-driven rather than process-oriented (Norris-Raynbird, 2004).

While climate change, through rising SSTs and coral bleaching, has the potential to destroy the majority of reefs by 2050, application of some, if not all, of the learning outcomes mentioned above will help in the resilience of the corals to anthropogenic and other insults. There are some examples of successful management, not least from the Caribbean Region, which has suffered overfishing and reef decline for many years. Several years ago, the Discovery Bay Marine Laboratory, working with the University of the West Indies, launched a number of initiatives (encompassing points 3-6 and point 9 from Box 1) on Dairy Bull Reef, on the north coast of Jamaica. This policy program resulted in a turnaround, leading to reef recovery (Idjadi et al. 2006). Most interestingly, following the Caribbean-wide bleaching event of 2005, live coral cover dropped to about 13% (from 46% in the previous year) and Acropora species branching coral to about 2% (from 33% in the previous year). Three years later, the coral cover at Dairy Bull Reef had increased to over 30% and Acropora species branching coral to over 20%. The recovery to near-prebleaching levels suggests that application of ICZM can lead to reef resilience, even in the face of climate change. The further application of sustainability science and ICZM for coral reefs, in cooperation with grassroots organizations (Sobeck, 2008), will need enhancement from all stakeholders. As Gandhi said, “The world has enough for everybody’s need but not for anybody’s greed.”

**Acknowledgement**

We thank the Earthwatch Institute and the Oak Foundation (USA) for funding.

---

2 It is apparent from our study that, despite the chronic and acute disturbances between 2002 and 2008, demographic data indicate good levels of coral resilience on the fringing reefs around Discovery Bay in Jamaica. The bleaching event of 2005 resulted in mass bleaching, but relatively low levels of mortality, unlike corals in the United States Virgin Islands where there was extensive mortality. Our work suggests that marine park managers may need to assist coral recruitment and settlement in years with severe acute disturbances, including hurricanes and bleaching events, by setting up coral nurseries and/or natural or artificial high rugosity substrate on the reef (Crabbe, 2009a).
References

Agamuthu, P. & Hansen, J. 2007. Universities in capacity building in sustainable development: focus on solid-waste management and technology. *Waste Management and Research* 25(3):241–246.

Allen, K. 2006. Community-based disaster preparedness and climate adaptation: local capacity-building in the Philippines. *Disasters* 30(1):81–101.

Balgo, M. 2005. Integrated coastal management and marine protected areas in the Philippines: concurrent developments. *Ocean and Coastal Management* 48(7–8):972–995.

Becker, C. & Ostrom, E. 1995. Human-ecology and resource sustainability: the importance of institutional diversity. *Annual Review of Ecology and Systematics* 26(1):113–133.

Cernea, M. 1995. Social integration and population displacement: the contribution of social science. *International Social Science Journal* 47(1):91–112.

Chircop, A. 1998. Introduction to capacity building. *Ocean and Coastal Management* 38(1):67–68.

Cho, L. 2005. Marine protected areas: a tool for integrated coastal management in Belize. *Ocean and Coastal Management* 48(11–12):932–947.

Christie, P. & White, A. 2007. Best practices for improved governance of coral reef marine protected areas. *Coral Reefs* 26(4):1047–1056.

Cicin-Sain, B. & Knecht, R. 1998. Integrated Coastal and Ocean Management: Concepts and Practices. Washington, DC: Island Press.

Coffin, B. 2005. Building ethical capacity for collaborative research. *Nonprofit and Voluntary Sector Quarterly* 34(4):531–539.

Crabbe, M. 2006. Challenges for sustainability in cultures where regard for the future may not be present. *Sustainability: Science, Practice, & Policy* 2(2):57–61.

Crabbe, M., Martinez, E., Garcia, C., Chub, J., Castro, L., & Guy, J. 2008. Growth modelling indicates hurricanes and severe storms are linked to low coral recruitment in the Caribbean. *Marine Environmental Research* 65(4):364–368.

Crabbe, M. 2009a. Scleractinian coral population size structures and growth rates indicate coral resilience on the fringing reefs of North Jamaica. *Marine Environmental Research* (in press; doi:10.1016/j.marenvres.2009.01.003).

Crabbe, M., Martinez, E., Garcia, C., Chub, J., Castro, L., & Guy, J. 2009b. Is capacity building important in policy development for sustainability? A case study using action plans for sustainable Marine Protected Areas in Belize. *Society and Natural Resources* (in press).

Crabbe, M. 2009c. Climate change and tropical marine agriculture. *Journal of Experimental Botany* (in press; doi:10.1093/jxb/erp004).

Dietz, T., Ostrom, E., & Stern, P. 2003. The struggle to govern the commons. *Science* 302(5652):1907–1912.

Eakin, H. & Lemos, M. 2006. Community-based disaster preparedness and climate adaptation: local capacity-building in the Philippines. *Disasters* 30(1):81–101.

Edmunds, P. 2006. Rapid phase-shift reversal on a Jamaican reef. *Marine Environmental Research* 65(4):364–368.

Eakin, H. & Lemos, M. 2006. Adaptation and the state: Latin America and the challenge of capacity-building under globalization. *Global Environmental Change* 16(1):7–18.

Fletcher, S., Potts, J., & Ballinger, R. 2008. The pedagogy of integrated coastal management. *Geographical Journal* 174(4):374–386.

Hills, J., Alcock, D., Higham, T., Kirkman, H., LeTissier, M., Pagdilao, C., Samonte, P., & Smith, T. 2006. Capacity building for integrated coastal management in Asia-Pacific: the case for case studies. *Coastal Management* 34(3):323–337.

Hoegh-Guldberg, O. 1999. Climate change, coral bleaching and the future of the world’s coral reefs. *Marine and Freshwater Research* 50(8):839–866.

Hoegh-Guldberg, O., Mumby, P., Hooten, A., Steneck, R., Greenfield, P., Gomez, E., Harvell, C., Sale, P., Edwards, A., Caldeira, K., Knowlton, N., Eakin, C., Iglesias-Prieto, R., Muthiga, N., Bradbury, R., Dubi, A., & Hatzior, M. 2007. Coral reefs under rapid climate change and ocean acidification. *Science* 318(5857):1737–1742.

Idjadi, J., Lee, S., Bruno, J., Precht, W., Allen-Requa, L., & Edmunds, P. 2006. Rapid phase-shift reversal on a Jamaican coral reef. *Coral Reefs* 25(2):209–211.

Johnson, T. & van Densen, W. 2007. Benefits and organisation of cooperative research for fisheries management. *ICES Journal of Marine Science* 64(8):834–840.

Jorge, M. 1997. Developing capacity for coastal management in the absence of the government: a case study in the Dominican Republic. *Ocean and Coastal Management* 36(1–3):47–72.

Kajikawa, Y. 2008. Research core and framework of sustainability science. *Sustainability Science* 3(2):215–239.

Kaplan, M., Liu, S., & Hannan, P. 2006. Intergenerational engagement in retirement communities: a case study of a community capacity-building model. *Journal of Applied Gerontology* 25(5):406–426.

Lesser, M. & Farrell, J. 2004. Exposure to solar radiation increases damage to both host tissues and algal symbionts of corals during thermal stress. *Coral Reefs* 23(3):367–377.

Liu, G., Strong, A., Skirving, W., & Arvanitidis, L. 2006. Overview of NOAA Coral Reef Watch Program’s Near-Real-Time Satellite Global Coral Bleaching Monitoring Activities. *Proceedings of the 10th International Coral Reef Symposium*. June 28–July 2. Okinawa: Japanese Coral Reef Society.

Lo-Yat, A., Meekan, M., Carleton, J., & Galzin, R. 2006. Large-scale dispersal of the larvae of nearshore and pelagic fishes in the tropical ocean of French Polynesia. *Marine Ecology Progress Series* 325(1):195–203.

Lyytimäki, J. & Hildén, M. 2007. Thresholds of sustainability: policy challenges of regime shifts in coastal areas. *Sustainability: Science, Practice, & Policy* 3(2):61–69.

May, P. 1993. Mandate design and implementation-enhancing implementation efforts and shaping regulatory styles. *Journal of Policy Analysis and Management* 4(4):634–663.

Maynard, J., Turner, P., Anthony, K., Baird, A., Berkelmans, R., Eakin, C., Johnson, J., Marshall, P., Packer, G., Rea, A., & Willis, B. 2008. ReefTemp: an interactive monitoring system for coral bleaching using high-resolution SST and improved stress predictors. *Geophysical Research Letters* 35(5):L05603.

McCance, T., Fritsimons, D., Keeney, S., Hasson, F., & McKenna, H. 2007. Capacity building in nursing and midwifery research and development: an old priority with a new perspective. *Journal of Advanced Nursing* 59(1):57–67.

McDuff, M. 2001. Building the capacity of grassroots conservation organisations to conduct participatory evaluation. *Environmental Management* 27(5):715–727.

Mequenat, G. & Taylor, D. 2007. The big push approach to African development and local capacity building: understanding the issue. *Canadian Journal of Development Studies* 28(1):9–26.

Mora, C., Andreoufet, S., Costello, M., Kransenburg, C., Rollo, A., Veron, J., Gaston, K., & Myers, R. 2006. Coral reefs and the global network of marine protected areas. *Science* 312(5781):1750–1751.

Mow, J., Taylor, E., Howard, M., Baine, M., Connolly, E., & McDuff, M. 2001. Collaborative planning and management of the San Andres Archipielago’s coastal and marine resources: a short communication on the evolution of the Seaflower Marine Protected Area. *Ocean and Coastal Management* 50(3–4):209–222.

Mumby, P. & Steneck, R. 2008. Coral reef management and conservation in light of rapidly evolving ecological paradigms. *Trends in Ecology and Evolution* 23(10):555–563.

Mutandwa, E. & Gadzirayi, C. 2007. Impact of community-based approaches to wildlife management: a case study of the...
CAMPFIRE programme in Zimbabwe. *International Journal of Sustainable Development and World Ecology* 14(4):336–344.

National Oceanic and Atmospheric Administration (NOAA). 2008. NOAA Extended Reconstructed Sea Surface Temperature (SST) V2. http://www.cdc.noaa.gov/cdc/data.noaa.ersst.html. December 4, 2008.

Norris-Raynbird, C. 2004. Mediation-fostered equality? An examination of environmental negotiations from a power/process perspective. *Proceedings of the Gulf and Caribbean Fisheries Institute* 55(1):155–177.

Pachauri, R. 2008. Climate change and sustainability science. *Sustainability Science* 3(1):1–3.

Poteete, A. & Ostrom, E. 2008. Fifteen years of empirical research on collective action in natural resource management: struggling to build large-N databases based on qualitative research. *World Development* 36(1):176–195.

Poulsen, S. 2007. Examples of capacity building cooperation. *Waste Management and Research* 25(3):283–287.

Raeburn, J., Akerman, M., Chuengsatiansup, K., Meija, F., & Oladejo, O. 2006. Community capacity building and health promotion in a globalized world. *Health Promotion International* 21(S1):84–90.

Rogers, J., Johnson, T., Warner, P., Thorson, J., & Punch, M. 2007. Building a sustainable comprehensive Women’s Health program: the Michigan model. *Journal of Women’s Health* 16(6):919–925.

Sobeck, J. 2008. How cost-effective is capacity building in grassroots organisations? *Administration in Social Work* 32(1):49–68.

Stojanovic, T. & Barker, N. 2008. Improving governance through local coastal partnerships in the UK. *Geographical Journal* 174(7):344–360.

Tai, H.-S. 2007. Development through conservation: an institutional analysis of indigenous community-based conservation in Taiwan. *World Development* 35(7):1186–1203.

Tang, K., Nutbeam, D., Kong, L., Wang, R., & Yan, J. 2005. Building capacity for health promotion: a case study from China. *Health Promotion International* 20(3):285–295.

Tuler, S., Wehler, T., Shockey, I., & Stern, P. 2002. Factors influencing the participation of local government officials in the National Estuary Program. *Coastal Management* 30(1):101–120.

Vollmer, S. & Palumbi, S. 2007. Restricted gene flow in the Caribbean staghorn coral Acropora cervicornis: implications for the recovery of endangered reefs. *Journal of Heredity* 98(1):40–50.

Wescott, G. 2002. Partnerships for capacity building: community, governments, and universities working together. *Ocean and Coastal Management* 45(9–10):549–571.

Williams, I. & Polunin, N. 2000. Differences between protected and unprotected reefs of the Western Caribbean in attributes preferred by dive tourists. *Environmental Conservation* 27(4):382–391.