Economic Valuation and Policy Priorities for Sustainable Management of Coral Reefs

Revised Edition 2005

Edited by

Mahfuzuddin Ahmed
Chiew Kieok Chong
Herman Cesar

ICRAN International Coral Reef Action Network
Sida
WorldFish CENTER

Economic Valuation and Policy Priorities for Sustainable Management of Coral Reefs
Revised Edition: 2005

Edited by
Mahfuzuddin Ahmed
Chiew Kieok Chong
Herman Cesar

First Edition: 2004
Revised Edition: 2005

Published by WorldFish Center
PO Box 500 GPO, 10670 Penang, Malaysia

Mahfuzuddin Ahmed, Chiew Kieok Chong and Herman Cesar (eds). 2005. Economic Valuation and Policy Priorities for Sustainable Management of Coral Reefs. Second Edition. WorldFish Center Conference Proceedings 70, XX p.

Perpustakaan Negara Malaysia. Cataloguing-in-Publication Data

Economic valuation and policy priorities sustainable management of coral reef / edited by Mahfuzuddin Ahmad, Chiew Kieok, Herman Cesar. - Rev. ed
ISBN 983-2346-44-4
1. Coral reef and island--Economic aspects. 2. Coral reef conservation.
3. Ecosystem management I. Mahfuzuddin Ahmad II. Chiew, Kieok Chong. II. Herman Cesar.
333.955316

Cover photos by: J. Oliver, J.L.N. Sivasothi, M. Blatus, Y. Yusuf and WorldFish Center photo collection

ISBN 983-2346-44-4

WorldFish Center Contribution No. 1758

Printed by Markono Digital Solutions (M) Sdn Bhd

CGIAR
FUTURE HARVEST

WorldFish Center is one of the 15 international research centers of the Consultative Group on International Agricultural Research (CGIAR) that has initiated the public awareness campaign, Future Harvest.

Contents

Preface

This revised edition incorporates changes to the section on overview of the earlier edition by updating key references. It also includes an additional case study on coral reefs in the Philippines. Having been brought more closely to the attention of researchers worldwide by the International Year of the Reef (1997), the issue of conservation of coral reefs has intensified. Stresses on coral reefs created by increased development and population adjacent to the coast call for relevant authorities to take immediate action to prevent additional irrecoverable damage occurring worldwide. As of 2001 it was estimated that 11 per cent of all coral reefs had been totally destroyed or damaged beyond recovery, another 16 per cent had been severely damaged in 1998 by coral bleaching related to climate change.[1]

Since the workshop that formed the basis of these proceedings, the Climate Prediction Center of the United States has reported that warmer than normal sea surface and subsurface temperatures were observed throughout most of the equatorial Pacific during April 2002. Sea surface temperature anomalies were up to 2°C warmer than average in the region between the Galapagos Islands and the South American coast, and more than 1°C warmer than average immediately to the west of 180°W. The Climate Prediction Center also forecast a slow evolution towards El Niño conditions throughout the remainder of 2002.[2]

The Australian Bureau of Meteorology, in a comparison study, reported that seven out of 12 reputable ocean or coupled ocean/atmosphere forecast models predicted "warm" temperatures from April to September 2002.[3] Such climate change would result in more coral reefs being destroyed. Furthermore, Talbot and Wilkinson (2001) concluded that, largely as a result of locally based rather than natural global stresses, a further 30 per cent of the world's reefs will be seriously damaged in the next 20 to 40 years.

Papers from the WorldFish workshop published in this report suggest that reef damage caused by human impacts needs to be addressed at local, national, regional and global levels. Coral reefs can be sustainably managed if reef uses are optimized and good policies are in place.

This volume is the outcome of the "International Consultative Workshop for Economic Valuation and Policy Priorities for Sustainable Management of Coral Reefs" held at the WorldFish Center's Headquarters, Penang, Malaysia, 8-10 December 2001. The overall goal of the workshop was to identify future economic and policy research directions relevant to the sustainable management of coral reefs. The directions were to be identified through review and discussion of the effectiveness of policy instruments; analysis of past research findings; and analysis of the interdependency of community livelihood, coral reefs and their resources. For more effective policy instruments to be introduced by any government, we believe that economic valuation and cost benefit analysis are important processes. They will provide information on the various values of coral reefs, which could allow decision-makers to devise policies that optimize the services and functions provided by the reef ecosystems and their capacity to support the livelihood of coastal communities.

The workshop was the final activity of the Valuation and Policy Analysis for Sustainable Management of Coral Reefs project sponsored by the Center's donors and the Swedish International Development Cooperation Agency (Sida), with additional support from the International Coral Reef Action Network (ICRAN), and support for selected participants from Southeast Asia by the Economy and Environment Program for Southeast Asia (EEPSEA) and the Australian Center for International Agricultural Research (ACIAR). A total of 48 participants from 15 countries located in Southeast and East Asia, the Caribbean, East Africa and the South Pacific Regional Seas attended the workshop. Seven keynote papers and 19 research papers were presented at the workshop.

[1] Talbot, F. and Wilkinson, C. 2001. Coral reefs, mangroves and sea grasses: A sourcebook for managers, Australian Institute of Marine Science, Townsville.
[2] National Oceanic and Atmosphere Administration (NOAA), El Niño/Southern Oscillation (ENSO) Diagnostic Discussion. Press Release, May 9, 2002.
[3] National Climate Data Center (NCDC) classifies the predicted NINO3 temperature anomaly (or the mean of a suite of forecasts known as an ensemble) as "warm" if it exceeds 0.8°C, which is about one standard deviation above average.

These proceedings are organized into four sections and three Appendices.

The Introduction – the first section – gives a brief account of current issues and problems in coral reef management.

The second section focuses on the economic valuation and socioeconomics of coral reefs and consists of two parts. Part A is made up of four keynote papers which provide an overview of the theory and practice of economic valuation and the socioeconomics of coral reefs; the role of economic valuation in coral reef management over the next decade; the use of modeling as a tool to estimate the economic values of coral reefs; and the need for and potential role of economic valuation in relation to coral reef use and management in the Pacific region. Part B of this section consists of four case studies relating to Malaysia, Tanzania (Zanzibar), Thailand, and Vietnam.

Section 3 relates to policy instruments and management techniques for coral reefs and marine resources – this section has two parts. Part A consists of three papers addressing the effectiveness of various policy instruments for coral reefs and fisheries management. Part B consists of case studies of policy implementation, climate change adaptation strategies, and coral reef management in the small and low-lying states of the Caribbean, China, Indonesia and Jamaica.

The final section of these proceedings consists of outcomes from the working group discussions. It sets out participants' recommendations on the preferable directions for future research. Recommendations are grouped into research relating to the economic valuation of coral reefs, coral reef policy analysis, and community participation in coral reef management.

The Appendices provide a list of workshop participants and their contact details, the workshop program, and an explaination of abbreviations and accronyms used.

The editors would like to thank Sida and ICRAN for their support. We would also like to thank EEPSEA and ACIAR for sponsoring participants from Vietnam and Indonesia, respectively. Special thanks are due to all the keynote presenters who provided a strong background for the working group discussions. Thanks also to the case study presenters who generously shared their experience and research findings in the workshop. Last, but not least, sincere thanks to Dr. Peter Gardiner for his generous time and valuable comments on the first draft of these proceedings.

Mahfuzuddin Ahmed
Chiew Kieok Chong
Herman Cesar
Editors

Section I

Introduction

An Overview of Problems and Issues of Coral Reef Management
Mahfuzuddin Ahmed, Chiew Kieok Chong and Hari Balasubramanian

An Overview of Problems and Issues of Coral Reef Management[1]

Mahfuzuddin Ahmed[2], Chiew Kieok Chong[3], and Hari Balasubramanian[4]

Abstract

This paper considers issues and problems of coral reef management for coastal communities. In particular, it looks at the links between coral reef management and livelihood dependence, poverty and the vulnerability of coastal communities. It also focuses on the risks and impacts of various scales of threat to coral reefs, and how these could affect the livelihoods of coastal communities.

The management of coral reefs can be influenced by valuation studies that reflect various forms of perceived and realized benefits from coral reefs. The paper describes how various methods to value and determine policy for coral reef management are used, with reference to a number of papers in this volume. Institutional issues of devolution and decentralized policy-making are considered with respect to the empowerment of economically poor coastal communities. In particular, there is a focus on the legal frameworks that help or hinder local stakeholders access resources and maintain their livelihoods. The paper concludes that research methods that improve people's understanding of coastal livelihoods, and that incorporate associated values should be encouraged. It further concludes that policy instruments and management tools that empower local stakeholders and support the livelihoods base of coastal communities dependent on coral reefs should be promoted.

Introduction

Coral reefs are a vital natural resource found in tropical waters throughout the world (Spalding et al. 2001). They are important not only to adjacent coastal communities, where they are often a source of livelihood, but also to national and international communities, where they contribute in various ways to oceanic production and deliver other significant benefits related to their role in tourism, recreation and coastal protection, and as indicators for climate change and waste treatment, to name a few (Fabres[5]). As more research findings indicate that the species richness and biodiversity contained in reef ecosystems may not regenerate once destroyed, the conservation of coral reefs has become a major concern.[6] Further, people dependent on coral reefs are some of the most vulnerable groups in many coastal and island communities, because reef and reef-based resources are often their primary means of food production, source of income and livelihood (Alcala 1988; Gomez et al. 1994; White 1987). In Southeast Asia, the South Pacific, parts of South Asia, East Africa and the Caribbean, where a high proportion of people live in coastal areas, an estimated one billion people currently depend on fish catches from shallow coastal waters dominated by coral reefs

[1] WorldFish Center Contribution No. 1720
[2] WorldFish Center, Batu Maung, Penang, Malaysia
[3] MEECON Research Sdn. Bhd. (formerly with WorldFish Center)
[4] Government of Canada's Youth Employment Strategy (implemented by the Marine Institute of Memorial University in Newfoundland and supported by the Department of Foreign Affairs)
[5] References cited in this paper without year of publication are contained in these proceedings.
[6] Although coral reefs represent less than 0.2 per cent of the total area of oceans it is believed that there are more species per unit area of coral reef than in any other ecosystem. Spalding, et al. (2001) reported that coral reefs support more than one million species of marine life, sustain tourism industries and provide food for islanders throughout the tropics. While the total area of coral reefs is unknown to date, it is estimated to exceed 600 000 km^2.

(Whittingham et. al. 2003). Declining reef health and coral cover lead not only to loss of income from recreational and fishing activities for coastal communities who have few or no livelihood alternatives, but also have far-reaching national and international consequences affecting the fragile marine ecosystem and its diverse bounties (Burke et al. 2002).

Coral reefs are known to be among the most biologically productive and diverse ecosystems in the world, home to thousands of species of plants and animals, less than one tenth of which have been identified (Birkeland 1997; Serageldin 1998). The reef ecosystem provides habitat and food sources for a variety of marine organisms. The sheer diversity and beauty of these systems draws many tourists to areas around coral reefs, and the resulting income from tourism has increasingly become an integral part of many coastal communities' livelihood. Coral reef fisheries are a vital source of food, income and livelihood to coastal populations, and are also critical to the economic health of many coastal nations (Burke et al. 2002). Fish now constitute 22 per cent of world exports of agricultural commodities. With a total value of over US$50 billion, they are the most exported agricultural product (Ahmed et. al. 2003). The potential annual yield of coral reef fisheries worldwide has been estimated at nine million tonnes (reported in Birkeland 1997). It is, however, the attraction and bounty of coral reefs that leads to threats to these fragile ecosystems. Many of the world's coral reefs are over-fished and/or subject to destructive practices, such as irresponsible tourism or the use of dynamite or cyanide in fish harvesting. Added to this are the severe pressures of human-induced pollution and sedimentation caused by marine and coastal development, and by industrial and agricultural practices far inland.

Coral communities are extremely sensitive to pollution and can only survive within small ranges of salinity, temperature and sunlight. They are also sensitive to the changing climate. A 1998 survey indicated that 16 per cent of the world's reefs were destroyed during that year's El Nino event (Wilkinson 2000). Divers at locations on the Great Barrier Reef, in the Philippines, the Seychelles, Tanzania and Jamaica reported that 70 per cent or more of the corals had been bleached (Williams 1999). Overall, the focus of research has largely been on the total area of reefs destroyed due to climate change. No estimates of the impact of climate change-induced coral bleaching on the livelihoods of coastal communities have been made. Future research needs to focus on the impact of coral bleaching on the livelihoods of coastal communities, and to estimate the total loss of value caused by climate change.

The major stakeholders related to coral reefs are those people living adjacent to the reef, whose livelihood revolves around the direct extraction, processing and sale of reef resources, and whose homes and land are sheltered by the reefs from wave action (Whittingham et al. 2003). However, these people, and stakeholders in general, have diverse professional interests, and may at times include fishers, local communities, tourists, tourism industry operators, governments, local authorities, and civil society, all of whom are concerned with the management of coral reefs. The issue of coral reef management has captured the attention of this diverse range of stakeholders because reefs offer many diverse "values"[7] and benefits (many of which are non-market and unpriced). Thus, measuring and identifying the equitable distribution strategies for these values are critical factors in the management of reef systems. Such information may be a basis for management goals or performance indicators under certain policies, and help synthesize stakeholders' goals and ensure the sustainability of the resource (Zhang). This information could also be used to predict the likely impacts of different management strategies on various stakeholder groups.

The purpose of this paper is to provide an overview of the problems and issues of coral reefs relating to their sustainable management, and to identify the values and benefits from coral reefs. The paper also serves as an introduction to the other papers in these Proceedings. Jointly, we hope to identify and explore the links between economic and social values of coral reefs, national policies, and community and stakeholder participation, and hence assist the development of more efficient approaches to the sustainable management of coral reef ecosystems. The following sections of

[7] The term "value(s)" herein refers to all values supported by the coral reef ecosystem, including production and functional values, values derived from services provided, and social, cultural, optional, bequest and existence values. The term itself does not necessarily imply economic value, although we try to make the case that all of the above can be considered in economic terms.

this paper will discuss the values of coral reefs, the main issues in sustainable management of coral reefs, priorities for and links between research and practice, and the optimal direction for future research.

Main issues and priorities in the sustainable management of coral reefs

For thousands of years people have coexisted with coral reef ecosystems, enjoying the products, functions, services, protection, and contribution to coastal culture and lifestyle provided by these wonderfully diverse communities. However, increasingly, coral reef sites are reported to be at risk of damage arising from human-induced change. Talbot and Wilkinson (2001) reported that already 11 per cent of all coral reefs have been totally destroyed or damaged beyond recovery, and that a further 16 per cent were destroyed in 1998 by climate-change-related coral bleaching. They also reported that, without effective management, another 30 per cent of the world's reefs would become seriously depleted in the next 20 to 40 years. Bryant et al. (1998) observed that, in 1998, of the world's reefs at risk, 27 per cent (67 900 km^2) were at high risk, while 31 per cent and 42 per cent (79 000 km^2 and 108 400 km^2), respectively, were at medium and low risk.

Figure 1 shows the major threat factors to coral reefs. These can be classified as natural or human-induced. Besides fishing- and shipping-related activities, land-based activities such as land clearing, coastal development and agricultural activities are among the major causes of destruction to coral reef ecosystems. Talbot and Wilkinson (2001) cited the three major human stresses to coral reefs as sediment, inorganic and organic pollution, and over-fishing. Various other studies have reported that sediments and nutrients are among the greatest human-induced threats affecting coral reefs and tropical coastal ecosystems (Johannes 1975; Rogers 1983; Birkeland 1997). Birkeland (1997) noted: "Approximately 75 to 80 per cent of the sediment entering the world's ocean (from the Arctic to the Antarctic) comes off land in the tropical western Pacific, with half the global sediment discharge coming off continental high islands …"

Soil erosion and transport of sediment to the coastal marine ecosystems has increased tremendously in past decades due to farming practices, irrigation schemes, and other types of human activities (Doolette and Margarath 1990). Increased sedimentation and nutrient inputs have probably caused broad-scale changes in the biotic communities of coastal regions (Birkeland 1997).

Bryant et al. (1998) classify human-induced threats in four categories, namely: (1) coastal development; (2) over-exploitation and destructive fishing; (3) impacts of inland pollution and erosion; and (4) marine pollution. Analysis of data on 800 sites documented by ReefBase (Version 2) confirms that 80 per cent of degradation is, indeed, caused by human-induced factors. Globally, 36 per cent of all reefs were classified as threatened by over-exploitation, 30 per cent by coastal development, 22 per cent by inland pollution and erosion, and 12 per cent by marine pollution (Birkeland 1997).

The impacts of human-induced threats can be broadly classified into: (1) impacts on the bio-physical condition of the reef, as determined by the reef's health and measured by the percentage of reef damaged and/or dead, reduced bio-diversity and reduced fisheries abundance; and (2) impacts on coastal communities and reef users, measured by reduction in fishing and tourism activities, increase in expenses for shoreline protection, and greater vulnerability

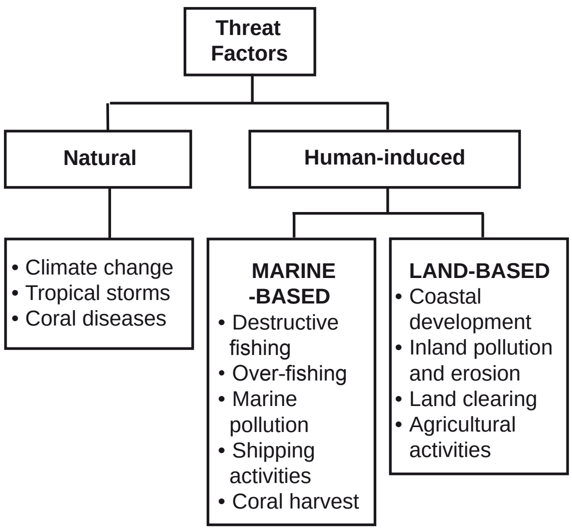


Figure 1. Natural and human-induced threats to coral reef ecosystems (Adapted and modified from Bryant et al. 1998)

of local communities due to loss of income, loss of employment, loss of livelihood and higher incidence of poverty and malnutrition (Lokina).

Damage to coral reefs is occurring at an alarming rate. It has been quantified using indicators in a number of studies (Johannes 1975; Hatcher et al. 1989; Doolette and Margarath 1990; Rogers 1983, 1990; Birkeland 1997; Bryant et al. 1998; Wilkinson 2000; Talbot and Wilkinson 2001). Their findings have brought about a surge of interest in the management of coral reefs, partially because of the variety of values reefs support. However, most policy decisions either dismiss these values or include misleading accounts of the value contained within healthy reef systems. An important policy priority is to highlight these values and present them accurately to policy-makers so as to foster better-informed management decisions (Lal; White; Lokina; Fabres; Figueroa). Incorporating stakeholder groups and coastal communities in research efforts and policy formulation will enhance the legitimacy of policy by enabling participation and education (Kuperan and Sutinen 1998). Legitimizing policy, in turn, increases compliance with regulations. Compliance to and monitoring of these regulations by adjacent communities and direct beneficiaries are essential if coral reefs are to be managed sustainably, especially when it is recognized that these groups are among the largest threats to reef survival. Further, educating beneficiaries about the values supported by coral reefs will increase global awareness and raise the issue of sustainable management of coral reefs on the policy agenda.

Values of coral reefs

As human society has increased, so too has the importance of coral reefs, with the diverse social and economic values of coral reefs being provided to distant as well as adjacent communities (Fabres). These values include marketable values (associated with products, functions and services), and non-marketable values (associated with opportunity, cultural significance, bequest and simple existence). All of these values can and should be considered in economic terms and used to guide the management of coral reefs. Despite the fact that coastal development and landuse decisions affect coral reef ecosystems and the ability of the reefs to provide services and benefits for human welfare, in most cases, decisions are made without considering the potential damage to coral reef ecosystems. For example, decisions about land clearing or logging often do not consider sedimentation, which damages the reef ecosystem. Thus, it is important for decision-makers to understand the need to consider what values to identify and assess when new developments are planned on islands and in coastal areas, and how these developments will influence coral reefs.

The values of reefs can be measured by methods broadly categorized as "revealed", and "stated" preference (see Bennett for explanation). Revealed preference values are observable transactions with a "behavioral trail" (Bateman et al. 2002). It is well recognized that the values generated by coral reefs should be evaluated in terms of the goods and services they provide. To most coastal communities, coral reef fisheries are an important source of food and income for local populations. For example, in the Philippines, coral reefs supply between 11 and 29 per cent of the total fisheries production.[8] Reef ecosystems also provide values from tourism, recreation, scientific research, and by way of their educational, medicinal and pharmaceutical uses. Economists also argue that non-use and intrinsic values provided by coral reef ecosystems, such as aesthetic, option and bequest values, should not be neglected. These values can only be measured by stated preference techniques because there are no observable market transactions for them, and they have no "behavioral trail" – that is, they have no effect on consumption patterns that lead to observable changes in the price or quantity of a resource traded (Bateman et al. 2002).

This section focuses on two main issues in the economic valuation of coral reefs. The first relates to identification, quantification and measurement of the economic values of coral reefs using revealed and stated preference techniques; the second to the varying determinants and concepts involved in dealing with the economic valuation of coral reefs.

[8] From "ICRI country report: Philippines", p. 1.

Identification, quantification and measurement

When discussing the economic values of coral reefs it is necessary to identify and quantify the values, and to identify standard practices for their measurement. That is, what are all of the values that coral reefs support, and what methods do we have to quantify these values?

As noted above, coral reefs are economically valuable through their direct and indirect use (the products, functions and services they offer) as well as intrinsically. They provide direct monetary value through the extraction and trade of resources and through recreation (Nam and Son), now and in the future. They also deliver social and cultural values to coastal communities; natural barriers and buffers to environmental hazards; intrinsic value to humans by virtue of their existence; and value for future generations (see Figure 2 for economic values supported by coral reefs).

To represent accurately the total economic value of coral reefs, all of these factors should be considered (see Cesar and Chong, Spurgeon, Lal and Yeo for more on the concept of total economic value). A variety of methods can be used to estimate these values (Dixon 1998; Spurgeon 1992; Cesar and Chong). Where goods and services traded in a market result in a net producer surplus (revealed), the net factor income (NFI) method is the most appropriate (Ngazy et al.). The NFI method estimates the physical relationship between the coral reef area and economic activity. When estimating producer surplus, the replacement cost (RC) method can also be used. Here, considering the cost of providing marketable goods and services by alternate means generates a value attributable to the reef. However, there is some debate about whether or not this technique is misleading because producers do not necessarily use the alternative presented (Anderson and Rockel 1991; Woodward and Wui 2001). Nevertheless, the fact remains that the coral reef system is providing these goods and services that are of some value to coastal communities, and that damage to the system will affect these goods and services and the potential producer surplus generated from them. Therefore, this value should also be taken into account when estimating the total value of the system.

Non-market values are a little more complicated to estimate, as they do not rely on objective indicators of value. There are a few techniques that have been established to deal with this (see Bennett; Woodward and Wui 2001). Common methods used for non-market ecosystem valuation include the travel cost (TC) method (Ahmed et al. 2005; Nam and Son 2003) to implicitly value recreation (Freeman 1993); hedonic pricing (HP); and the contingent valuation method (CVM) (Ahmed et al. 2005; Bennett; Seenprachawong 2003; Yeo; Ngazy et al.; Woodward; and Wui 2001). The subjective nature of these methods causes substantial variability in outcomes (discussed in Freeman 1993), but they, at least, provide an avenue to estimate the non-market values supported by coral reefs. With consistent design and methodology, coral reef valuation studies will benefit from the use of these techniques in that they will be able to compare the relative value of non-market goods and services across sites, and better approximate the total value afforded by reef systems.

Varying determinants and concepts

Once the types of values offered by coral reefs and the methods to estimate them have been determined, it is necessary to look at issues that may influence the data collected. This is especially true for the less objective non-market valuation indicators. These often rely on personal interviews with respondents, based on hypothetical market scenarios, and estimates of willingness-to-pay for or accept certain conditions placed on the natural resources by management. The fact that coral reefs support a diversity of values raises at least two important issues which should be kept in mind when conducting valuation studies in any multiple use area. These issues include the different stakeholders involved; and the consistency of knowledge about the values the system supports.

The first issue, the many different stakeholders who use reefs for a variety of reasons, is especially troublesome because of the often considerable economic disparity between stakeholder groups. Researchers must be aware that this disparity exists if they are to get an accurate picture of the economic value provided by the reefs to all users. Contingent valuation relies on the respondent's willingness to pay for

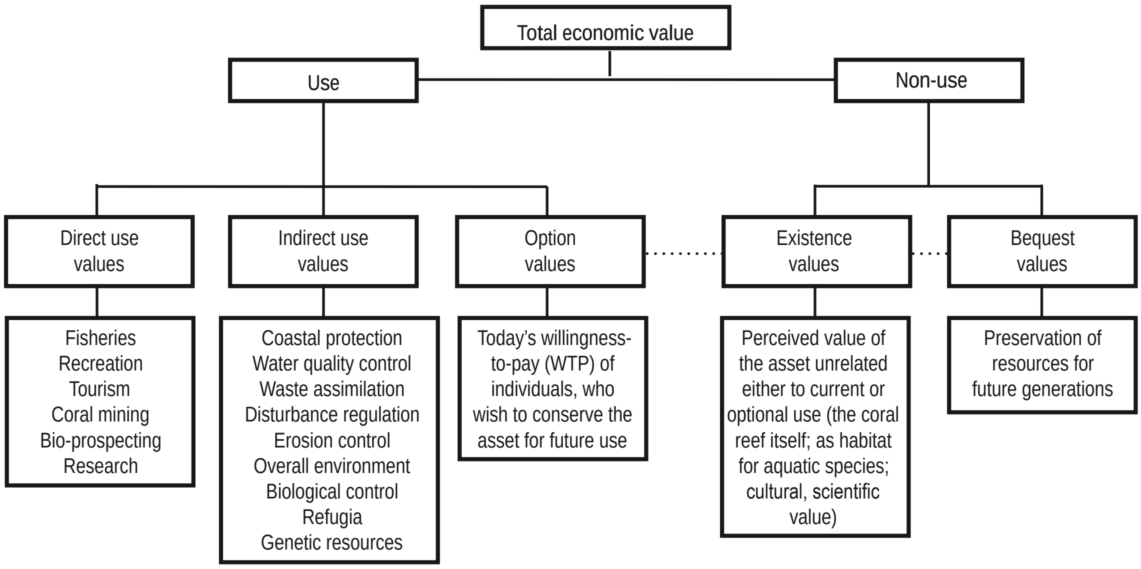


Figure 2. Total economic value of coral reefs (Adapted from Payoyo 1994; Woodward and Wui 2001; and Costanza et al. 1997)

or accept conditions described in the hypothetical scenario. Choices are made based on the respondent's perceived value of the resources. The amount a respondent is willing to pay often depends on the amount they are "able and willing" to pay (Freeman 1993). Consider a dive tourist and a subsistence fisher placing a dollar value on the existence of coral reefs. The values they place on this will most definitely be different because of the likely socioeconomic disparity, and the difference in the relative importance of the resource to the respondents. Cultural differences between stakeholder groups may also affect the economic value placed on certain goods and services provided by reefs. Social and cultural values, for example, may be viewed differently by different stakeholders and may be a source of considerable variability (see Spurgeon for a description of potential stakeholder roles in management).

The second constraint, the diversity in the conceptualization and appreciation of the values provided by coral reefs, is easier to deal with but still requires considerable attention. An understanding of the values supported by coral reefs may be lacking among resource users and other beneficiaries because many of the values are either taken for granted (coastal/storm protection, waste assimilation), simply unknown (see, for example, Nam and Son), or not considered in economic terms by users (global biodiversity, climate change indicators). These factors must be taken into account when researching the value people ascribe to coral reefs, as people who are more familiar with the types of values and those who consider more values, in economic terms will be likely to offer higher estimates. The fact that people are not familiar with the causal relationship between certain coral reef goods, services and functions and the economy does not mean that the relationship does not exist. However, estimates gathered through coral reef valuation studies that do not recognize the encumbering effect(s) of this lack of knowledge will misrepresent the total economic value of the system. Often this realization comes after the goods, services or functions disappear, by which time it is too late to save the resource, and other strategies must be employed to deal with the created needs. Contingent valuation research can deal with this problem by educating respondents about the multiplicity of values supported by coral reef systems. This assumes, however, that researchers themselves are aware of these values and are capable of explaining the link between the condition of the reef and the local economy.

Another area of concern relates to the spatial scale of coral reef influence (see Figure 3). Humans value coral reefs on three broad spatial scales – the local, national and international levels. The types of goods, services and functions valued differ at these spatial scales, as do the impacts of policy on the economic value of coral reefs. (Moosa; Walling; Weru; see White for coral reef management approaches at different scales.)

At the local community level, coral reefs may be valuable because they are a source of livelihood and subsistence, a part of peoples' lifestyle and a socio-cultural aspect of their life. As poor people's dependence on coral reefs may take the form of subsistence or lifestyle activities, many of the transactions carried out do not enter into the national cash economy (IMM Ltd. 2002). For example, in the South Pacific, 80 per cent of the total coastal fisheries production is from subsistence fishing, and slightly under half of the total annual commercial catch originates on coral reefs (Dalzell et al. 1995). A priority in coral reef management, therefore, lies in the assessment of "vulnerability" of coastal communities or stakeholders – how much of their livelihoods is dependent on coral reef ecosystems. The relative value of coral reef resources to coastal individuals is often extremely high because livelihood largely depends on the health of the reef. (At the same time, it is also important to measure the resilience and adaptability of coral reefs and coastal communities to stressors that may affect resources.) As options become available and accessible, the relative value of coral reefs to the livelihood of individuals in coastal communities decreases (see figure 4). This says nothing about the absolute value of coral reefs; it simply indicates the relative importance of the system to coastal communities with or without livelihood options.

To the national government, coral reef systems are a natural resource with direct input to the national gross domestic product (or GDP) through activities such as tourism and international fish trading. This requires governments to make trade-offs between sectors; for example, either to ban logging in order to conserve the biodiversity values of reef ecosystems, or to generate income from logging activities that degrade reef ecosystems. Thus, governments need to set priorities on the various activities in different sectors – in this context, on those activities that specifically affect coral reef health, including coastal development, industrialization, agriculture and logging. Economic valuation can help set these priorities by providing a base from which the optimal use of the nations' resources for national economic development can be ensured.

Globally, the indirect market values of reefs lie in the contribution they make to world fisheries by acting as an aggregating device and providing habitats of particular importance for many marine species. Further, some small island states exist primarily because of the protection from erosion, storms and flooding provided by coral reefs. Reefs also have significant impacts on and contribute to nature and biodiversity conservation, to the conservation of the global environment, and to the world, by acting as an indicator for global climate patterns.

All of these factors must be considered when conducting economic valuation studies of coral reefs and estimating how they would be affected by specific management decisions (Figure 5). They can also be used to predict and quantify the impact of new policy decisions on individual stakeholder groups and on the collective communities that rely on coral reef goods/ services/functions. Such an approach allows for equitable consideration of the allocation of resources derived from coral reefs under particular policy directions. It also clarifies the ramifications of sectoral trade-offs that may be necessary, and considers the effect(s) of policy decisions in a broader spatial context.

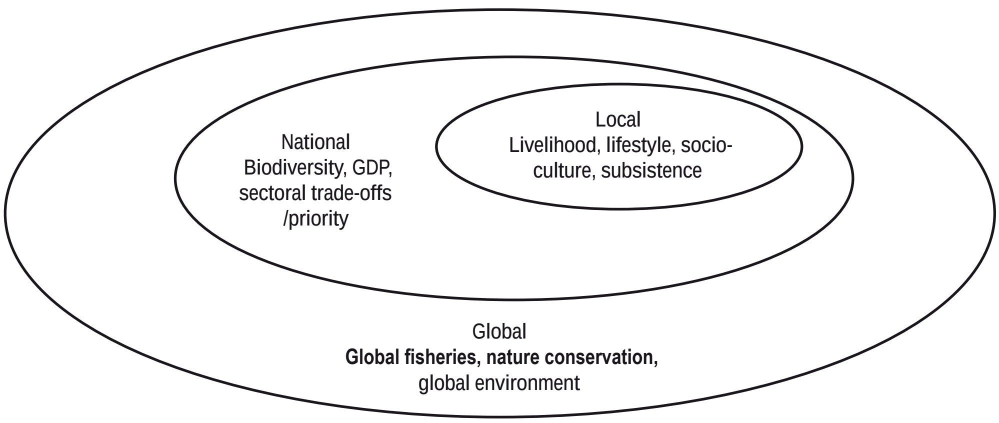


Figure 3. Values of coral reefs, different contexts and levels

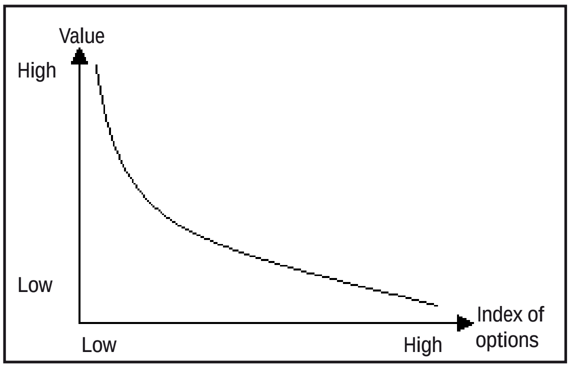


Figure 4. Value of coral reefs changes with options for livelihood

Future research directions

It is clear thus far that economic values of coral reefs should be incorporated in policy formulation processes – that these values should include the relative values perceived by different stakeholders, in particular local communities, that rely on coral reef ecosystems for their livelihoods. Policies should also look into ways of appropriating these values through the equitable use and sharing of resources. Therefore, future research relating to policies and institutions for coral reef management should look more closely into stakeholder participation in the management of these multiple use resources (Figure 5).

Guidelines for standard valuation techniques are necessary to help researchers or reef managers come up with better estimates of the total value of the resources, based on both use and non-use values. The effectiveness of policy instruments in the management of coral reef ecosystems should be examined to better understand the factors contributing to the success or failure of reef management. The effectiveness and legitimacy of policy would be better understood if research were based on stakeholder participation in the management of resources (see Figure 5).

To ensure the sustainable management of coral reefs, greater participation of users and stakeholders in the decision-making processes, with particular interest in formulating policies, must be encouraged. Increased emphasis on stakeholder participation in research activities on coral reefs would lead to increased knowledge and awareness among coastal communities. Through a participatory approach, coastal communities would have more opportunities to provide feedback on economic, environmental, social and institutional interventions designed by the local authorities or government. Stakeholder participation would also help to promote consensus building and, through the knowledge acquired on the economic value of coral reefs, be more likely to lead to increased legitimacy and compliance (Kuperan and Sutinen 1998).

This would identify value sets and priority sites needing immediate conservation or protection. Economic valuation also provides a good basis for developing policy options.

At the same time, a participatory approach encouraging community participation and awareness in decision-making processes would lead to the empowerment of poorer stakeholders.

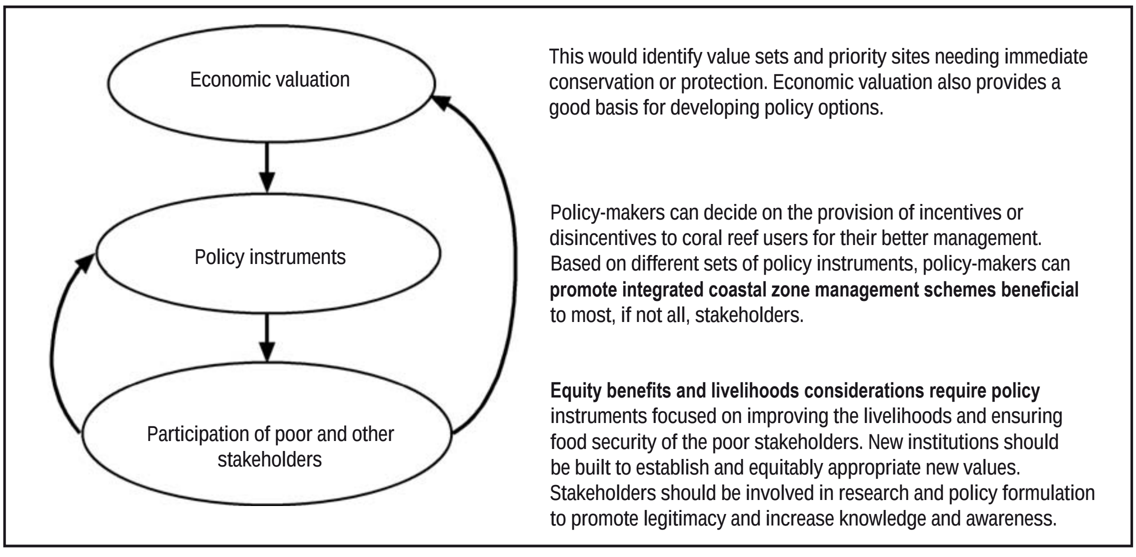


Figure 5. The role of economic valuation in coral reef policy

This would offer them a stronger platform from which to participate in the negotiation of property rights, resource rights, and rules and sanctions with regards to the natural resources (coral reefs) on which they depend. Researchers, planners and policy-makers should, as much as possible, identify conditions for choices that benefit entire communities while ensuring the equity of different stakeholders.

Summary

Economic valuation is a useful tool for coral reef management, but studies need to be conducted in a more thorough and cohesive fashion. Specifically, more values should be considered in order to better estimate the total economic value of coral reefs; common methods should be established and used to increase comparability across studies; and the conditions and input of multiple and participating stakeholders must be taken into account to establish equitable and legitimate policy.

The research on understanding and assessing policies for the sustainable management of coral reefs should incorporate the following three inter-related approaches:

- economic valuation, which attempts to capture many of the economic values supported by coral reefs, to set priorities for the use of coral reefs, and to suggest policy options for reef management based on economic drivers;
- application of policy instruments that promote integrated coastal zone management by creating awareness among all stakeholders of the economic effects of specific management options designed to better manage the coral reefs; and
- participation of stakeholders, including poor coastal communities, with a focus on increasing awareness of the economic goods, services and functions provided by reefs; encouragement of livelihood security; the building of new institutions; the establishment of values for coral reefs; and the potential for poverty alleviation through the equitable use of coral reef resources.

These Proceedings include some of the most recent work on the economic valuation of coral reefs. The Proceedings first outline the importance of valuation in coral reef management, and then provide studies that look at the economic input of coral reefs in specific areas. Following this, the proceedings move into more general policy and management measures and explore the role of economic valuation in this context. The Conference identified many areas for research. These are outlined in the last section of these Proceedings. Coral reefs provide us with a plethora of values through goods, services, functions, and through their existence. What is needed is a cohesive approach to identifying and quantifying these values and using these estimates to develop and implement positive and sustainable policy.

References

Ahmed, M., G.M. Umali, C.K. Chong, M.F. Rull and M.C. Garcia. 2005. Valuing recreational and conservation benefits of coral reefs in Bolinao, Philiphines. *In* these Proceedings.

Ahmed, M., M.A. Rab and M.M. Dey. 2003. Changing structure of fish supply, demand and trade in developing countries – issues and needs. *In* Proceedings of IIFET 2002, Wellington, New Zealand.

Alcala, A.C. 1988 Effects of protective management of marine reserves on fish abundances and fish yields in the Philippines. Ambio 17:194-199.

Anderson, R. and M. Rockel. 1991. Economic valuation of wetlands. Discussion paper #065. American Petroleum Institute, Washington DC.

Bateman, I.J, R.T. Carson, B. Day, M. Hanemann, N. Hanley, T. Hett, M. Jones-Lee, G. Loomes, S. Mourato, E. Ozdemiroglu, D.W. Pearce, R. Sugden and J. Swanson. 2002. Economic valuation with stated preference techniques. Edward Elger. Cheltenham, UK/Northampton, Massachusetts, USA.

Bennett, J. 2004. Estimating the value of coral reef management options. *In* these Proceedings.

Birkeland, C. 1997. (eds.) Life and death of coral reefs. International Thomson Publishing.

Bryant, D., L. Burke, J. McManus and M. Spalding. 1998. Reefs at risk. World Resources Institute,USA.

Burke, L., E. Selig and M. Spalding. 2002. Reefs at risk in Southeast Asia. Washington DC.

Cesar, H. and C.K. Chong. 2004. Economic valuation and socioeconomics of coral reefs: Methodological issues and three case studies. *In* these Proceedings.

Costanza, R., R. d'Arge, de Groot, S. Farber, M. Grasso, B. Hannon, K. Limbur, S. Naeem, R.V. O'Neill, J. Paruelo, R.G. Raskin, P. Sutton and M. van den Belt. 1997. The value of the world's ecosystem services and natural capital. Nature 387:253-260.

Dalzell, P., T. Adams and N. Polunin. 1995. Coastal Fisheries of the South Pacific Islands. *In* South Pacific Commission and Forum Fisheries Agency Workshop on the Management of South Pacific Inshore Fisheries. South Pacific Commission, Manuscript collection of country statements and background papers, Vol 2, 9 p.

Dixon, J.A., 1998. Economic values of coral reefs: what are the issues? In Proceedings of an Associated Event of the Fifth Annual World Bank Conference on Environmentally and Socially Sustainable Development. 9-11 October 1997. World Bank, Washington, DC.

Doolette, J.B. and W.B. Margarath. (eds.) 1990. Watershed development in Asia: Strategies and technologies. World Bank Technical Paper 127.

Fabres, B. 2004. Policy issues and Caribbean coral reefs – surfing in the perfect storm. *In* these Proceedings.

Figueroa, M. 2004. Coral reef management in the Caribbean – A Jamaican NGO perspective. *In* these Proceedings.

Freeman III, A.M. 1993. The measurement of environmental and resource values. Resources for the Future, Washington DC.

Gomez, E.D., P.M. Alino, H.T. Yap and W.Y. Licuanan. 1994. A review of the status of Philippines reefs. Marine Pollution Bulletin 29(1-3):62-68.

Hatcher, B. G., R.E. Johannes, A.I. Robertson. 1989. Review of research relevant to the conservation of shallow tropical marine ecosystems. *In* M. Barnes (ed.) Occanogr. Mar. Bio. Annu. Rev. 27:337-414.

IMM Ltd. 2002. Reef livelihoods assessment (RLA) project: Global overview of reef dependent livelihoods and the poor. University of Exeter, UK. Available at www.ex.ac.uk/imm/rla_discussion_group.htm[22 March 2002].

Johannes, R.E. 1975. Pollution and degradation of coral reef communities, p. 13-51. *In* E.J. Ferguson Wood and R.E. Johannes (eds.) Tropical marine pollution. Elsevier Oceanogr. Ser. 12. Elsevier, Amsterdam.

Kuperan, K. and J.G. Sutinen. 1998. Blue water crime: Deterrence, legitimacy, and compliance in fisheries. Law and Society Review 32(2):309-338.

Lal, P. 2004. Coral reef use and management – the need, role and prospects of economic valuation in the Pacific. *In* these Proceedings.

Lokina, R. 2004. Instruments for fisheries management in developing countries with a particular reference to Tanzania. *In* these Proceedings.

Moosa, K. 2004. Implementing policy and strategy for coral reef rehabilitation and management: Lessons learnt from Indonesian Effort. *In* these Proceedings.

Nam, P.K. and T.V.H. Son. 2004. Analysis of the recreational value of the coral-surrounded Hon Mun islands in Vietnam. *In* these Proceedings.

Ngazy, Z., N. Jiddawi and H. Cesar. 2004. Coral bleaching and the demand for coral reefs: A marine recreation case in Zanzibar. *In* these Proceedings.

Payoyo, P.B. 1994. Ocean governance: Sustainable development of the seas. United Nations University Press, Tokyo.

Rogers, C.S. 1983. Sublethal and lethal effects of sediments applied to common Caribbean corals in the field. Marine Pollution Bulletin 14:378-382.

Rogers, C. S. 1990. Responses of coral reefs and reef organisms to sedimentation. Mar. Ecol. Prog. Ser. 62:185-202.

Seenprachawong, U. 2004. An economic analysis of coral reefs in the Andaman Sea of Thailand. *In* these Proceedings.

Serageldin, I. 1998. Coral reef conservation: Science, economics, and law in Hatziolos. *In* M.E. Hooten, A.J. and M. Fodor (eds.) Coral reefs: Challenges and opportunities for sustainable management. World Bank, Washington DC.

Spalding, M.D., C. Ravilious and E.P. Green. 2001. World atlas of coral reefs. UNEP World Conservation Monitoring Center, University of California Press, Berkeley, USA, 424 p.

Spurgeon, J. 2004. Valuation of coral reefs: The next ten years. *In* these Proceedings.

Spurgeon, J. 1992. The economic valuation of coral reefs. Marine Pollution Bulletin 24(11):529-536.

Talbot, F. and C. Wilkinson. 2001. Coral reefs, mangroves and seagrasses: A sourcebook for managers. Australian Institute of Marine Science, Townsville, Australia.

Walling, L.J. 2004. Coral reef monitoring for climate change impacts assessment and climate change adaptation policy development. *In* these Proceedings.

Weru, S. 2004. Policy implications in the management of Kenya's marine protected areas. *In* these Proceedings.

White, A.T. 2004. Policy instruments for coral reef management and their effectiveness. *In* these Proceedings.

White, A.T. 1987. Coral reefs: Valuable resources of Southeast Asia. ICLARM Education Series 1, 36 p.

Whittingham, E., J. Campbell and P. Townsley. 2003. Poverty and reefs - a global overview. DFID-IMM. IMM Ltd. Innovation Center, Exeter University, Exeter, UK, 101 p.

Wilkinson, C. 2000. Status of coral reefs of the world: 2000. Australian Institute of Marine Science, Townsville, Australia.

Williams, M. 1999. The omen? http://martinwilliams.tripod.com/coralbleaching/coralbleaching.html [22 March 2002]

Woodward, R.T. and Y-S. Wui. 2001. The economic value of wetland services: A meta-analysis. Ecological Economics 37:257-270.

Yeo, B.H. 2004. The recreational benefits of coral reefs: A case study of Pulau Payar Marine Park, Kedah, Malaysia. *In* these Proceedings.

Zhang, Q. 2004. Coral reefs conservation and management in China . *In* these Proceedings.

Section II

Economic Valuation and Socioeconomics of Coral Reefs

Overview

Case Studies

Economic Valuation and Socioeconomics of Coral Reefs: Methodological Issues and Three Case Studies[1]

Herman Cesar and Chiew Kieok Chong

Abstract

In most tropical countries, coral reef ecosystems provide coastal populations with a number of goods and services. However, a variety of anthropogenic practices threatens reef health and therefore jeopardizes the benefits flowing from these goods and services. These threats range from local pollution, sedimentation, destructive fishing practices and coral mining, to global issues such as coral bleaching.

By "getting some of the numbers on the table", economic valuation can help shed light on the importance of the goods and services and show the costs of inaction in the face of threats. Creating markets for sustainable resource use can highlight the value of these goods and services to local populations.

This paper gives an overview of economic valuation (total economic value, cost benefit analysis) and the techniques supporting it (contingent valuation, travel cost, effect on production, etc.) as they are applied to coral reef ecosystems.

The paper also highlights some of the socioeconomic issues of reef degradation and conservation and shows the importance of economic issues involved in stakeholder analysis. Stakeholder analysis helps to show who gains and who loses from threats to the coral reef and from conservation measures. Together with economic valuation, it thereby helps to determine what drives unsustainable practices and how such practices can best be mediated given the local social situation.

Three case study examples are explored. The first examines the total economic value of a specific area, namely Jamaica, and the costs and benefits of this area when coastal management is introduced. The second demonstrates cost benefit and stakeholder analysis of a threat to coral reefs. The third estimates the economic costs of climate change (coral bleaching, erosion, etc.).

The paper concludes with an up-to-date summary of economic valuation studies on coral reefs.

Introduction

Coral reefs form a unique ecosystem, richer in biodiversity than any other ecosystem in the world. Reefs are productive, shallow water, marine ecosystems that are based on rigid lime skeletons; themselves formed through successive growth, deposition and consolidation of the remains of reef-building corals and coralline algae. The basic units of reef growth are the coral polyps and the associated symbiotic algae that live in the coral tissues. This symbiotic relationship is the key factor explaining both the productivity of reefs and the rather strict environmental requirements of corals.

Coral reefs have important ecosystem functions that provide crucial goods and services to hundreds of millions of people. These goods and services often form an important source of income for local populations (through fishing, mariculture, etc.), and sustenance to those living at subsistence levels. They are also a tourist attraction, contributing to local income and foreign exchange. In addition, they form a unique natural ecosystem, with important biodiversity

[1] WorldFish Center Contribution No. 1721

value as well as scientific and educational values. In addition, coral reefs form a natural protection against wave erosion.

Currently, however, coral reefs are rapidly being depleted in many locations around the world as a result of, amongst other things, destructive fishing practices (poison fishing, blast fishing, muro-ami, etc.), coral mining, marine pollution, sedimentation and coral bleaching. Often, these destructive impacts are the result of externalities – the people who cause the damage benefit from unsustainable economic activities, but the costs are borne by others who depend in some way or other on coral reefs. Economists argue that this is often due to the absence of a well-functioning market for environmental goods and services. Hodgson and Dixon (1988) describe an externality situation in which logging causes sedimentation that results in reef degradation (affecting tourism) and fishery losses. For the logging company, these tourism and fishery losses are not part of their profit calculation. In the absence of government policy and/or public outcry, logging would continue even if the external costs to society were much higher than the net profits of the logging industry, as was the case in the example of Hodgson and Dixon.

This example indicates two things. First, it shows the importance of a stakeholder analysis of who is gaining and who is losing from a situation and the potential for a possible intervention; and, second, it shows the importance of obtaining economic values for the various reef goods and services, e.g. a fishery value and a coastal protection value. Some of these goods and services involve concrete marketable products, such as shellfish, for which the value can be determined based on the demand, supply, price and costs. Other services depend on the possible future uses of yet unknown biodiversity on reefs for which, sometimes, markets can be created. The values of all these goods and services together form the total economic value (TEV) of reef ecosystems (e.g. Spurgeon 1992). This TEV can be calculated for a specific area or for other uses (e.g. preservation area, tourism area, multiple use area, etc.). Economic valuation can also be used to calculate the economic losses due to destruction of reef functions, as in blast fishing (Pet-Soede et al. 1999), coral mining (Berg et al. 1998) or bleaching (Westmacott et al. 2000c). The three case studies in this paper discuss each of these points. These case studies are briefly summarized here.

Case study 1 The TEV of the Portland Bight area (Jamaica) and a cost benefit analysis (CBA) of establishing a marine protected area (MPA)

Establishing a marine protected area (MPA) is a costly affair and a government needs to be well informed about the pros and cons of an additional MPA (McClanahan 1999). Evaluating the costs and benefits of establishing and running an MPA is a crucial step for an economist involved in MPAs. The net benefits of establishing a park are defined as the net increase in the value of the ecosystem due to the establishment and management of the park minus the costs of managing the park. Pendleton (1995, p.119) states: "Past valuations of tropical marine parks inaccurately measure their economic value because they value the resource protected and not the protection provided". For the Portland Bight Protected Area (Jamaica), a combined marine and terrestrial multiple use area, the cost-benefit analysis (CBA) of establishing the protected area was carried out as part of attempts to obtain international donor money to run the protected area.

Case study 2 Benefit cost and stakeholder analysis of coral mining in Lombok (Indonesia)

Coral mining for lime production is a source of income and subsistence in many developing countries. The associated damage to the reef is, however, significant, both in physical and monetary terms. The economic benefits from reef destruction are often used to justify continuation of this damage. Accordingly, it is important to quantify the costs associated with coral reef degradation if a balanced assessment of the benefits and costs of various practices is to be made. To do this, a CBA is carried out where the net benefits of coral mining to the people causing the damage are compared with the net societal costs plus the enforcement costs of eliminating coral mining in a specific location. In this case study the CBA relates to Lombok, Indonesia.

Case study 3 Economic losses due to coral bleaching in the Indian Ocean

Climate change may, in the long run, be the most important threat to coral reefs. The massive 1998 coral bleaching event was only one of recent hints of what may happen in the future. Bleaching can have severe impacts on both fisheries and tourism. In the longer run, if the balance between reef growth and bio-erosion shifts as a result of coral die-off, it can also lead to reduced levels of coastal protection. For this threat, a cost-benefit framework is not appropriate at the local level as there are no local gains from bleaching. Hence, the focus is on the economic costs of reef destruction alone.

This paper combines a background on the valuation and socioeconomics of coral reefs with these three case studies. The goods and services of coral reefs are described in Section 2. The basic concepts of economic valuation and their techniques are discussed in Sections 3 and 4, respectively. Section 5 focuses on the socio-economics of coral reefs, which is discussed with specific reference to stakeholder analysis. The next three sections (6-8) describe case studies on the TEV and the costs and benefits of marine parks, the CBA and stakeholder analysis of a threat, and an estimation of the economic costs of climate change (coral bleaching, erosion, etc.). The paper concludes with a discussion of the issues raised. The Annex brings together the most well-known valuation studies on coral reefs.

Goods and services of reefs[2]

Ecosystems provide a great many functions, goods and services. The terms "functions", "goods" and "services" have, in this context, slightly different meanings, although many authors use these terms interchangeably in the environmental economics literature. Costanza et al. (1997) define functions, services and goods in the following way: "Ecosystem functions refer variously to the habitat, biological or system properties or processes of ecosystems. Ecosystem goods (such as food) and services (such as waste assimilation) represent the benefits human populations derive, directly or indirectly, from ecosystem services". For example, a forest on steep slopes provides the function of water retention and an associated service of water supply. Upland deforestation leads to dry season water shortages in the lowlands and deterioration in the ecosystem service of water supply.

Moberg and Folke (1999) systematically presented the most important goods and services of coral reef ecosystems (see Table 1). The authors categorized goods as renewable resources (fish, seaweed, etc.) and materials obtained from the mining of reefs (sand, coral, etc.). The services of coral reefs are categorized into: (i) physical

Table 1. Goods and ecological services of coral reef ecosystems identified in Moberg and Folke (1999)

Goods		Ecological services					
Renewable resources	Mining of reefs	Physical structure services	Biotic services (within ecosystem)	Biotic services (between ecosystems)	Bio-geochemical services	Information services	Social and cultural services
Sea food products	Coral blocks, rubble/sand for building	Shoreline protection	Maintenance of habitats				
Raw materials and medicines	Raw materials for lime and cement production	Build up of land	Maintenance of biodiversity and a genetic library	Biological support through "mobile links"	Nitrogen fixation	Monitoring and pollution record	Support of recreation
Other raw materials (e.g. seaweed)	Mineral oil and gas	Promoting growth of mangroves and seagrass beds	Regulation of ecosystem processes and functions	Export of organic production, etc., to pelagic food webs	CO_2/Ca budget control	Climate control	Aesthetic value and artistic inspiration
Curios and jewelery		Generation of coral sand	Biological maintenance of resilience		Waste assimilation		Sustaining the livelihood of communities
Live fish and coral collected for the aquarium trade							Support of cultural, religious and spiritual values

Source: Adapted from Moberg and Folke (1999).

2 This section is an abbreviated version of Cesar (2000).

structure services, such as coastal protection; (ii) biotic services, both within ecosystems (e.g. habitat maintenance) and between ecosystems (e.g. biological support through mobile links, such as fish that move from mangroves in their juvenile stages to coral reefs in their adult life); (iii) biogeochemical services, such as nitrogen fixation; (iv) information services (e.g. climate record); and (v) social and cultural services, such as aesthetic values, recreation and gaming. Note that this categorization differs slightly from that of Costanza et al. (1997).

Economic valuation of coral reefs[3]

The economic value of a reef ecosystem is often defined as the total value of its instruments, that is, the goods and ecological services that it provides. We, therefore, need to know what these major goods and services of reef ecosystems are, as well as how they interact with other ecosystems. Next, these goods and services need to be quantified and evaluated in dollar terms. For goods sold in the market place, this is simply achieved by looking at their market price, but for ecological services, this is not possible. Instead, complex valuation techniques are used to determine the economic value of these services. Note that, in principle, markets could be established for each of the goods and ecological services where no markets currently exist, although this might be very costly and impractical.

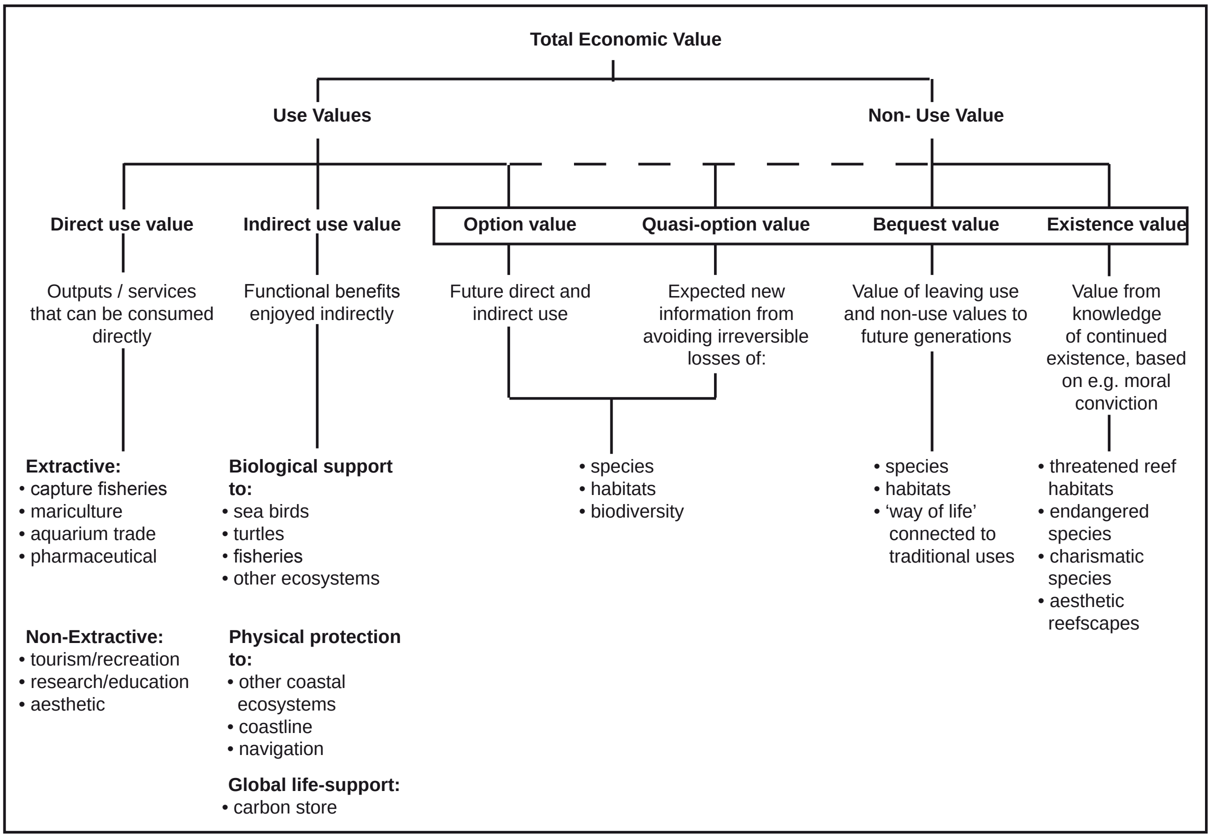
The value of all the compatible goods and services combined gives the TEV for an ecosystem.[4] Each of the goods and services of coral reefs presented in Table 1 above generate economic value. For example, fishery resources can be harvested and sold, and the coastal marine area enables sea transportation that creates profits. Similarly, preservation and ecotourism create value. The mapping between the goods and services on the one hand and their values on the other hand is straightforward, as is shown in Figure 1.

As indicated in Figure 1, there are six categories of values. These are (i) direct use value; (ii) indirect use value; (iii) option value; (iv) quasi-option value; (v) bequest value; and (vi) existence value. Direct use values come from both extractive uses (fisheries, pharmaceuticals, etc.) and from non-extractive uses. Indirect use values are, for example, the biological support provided in the form of nutrients and fish habitat and coastline protection. The concept of option value can be seen as the current value of potential future direct and indirect uses of the coral reef ecosystem. An example is the potential of deriving a cure for cancer from biological substances found on reefs. Bio-prospecting is a way of deriving money from this option value. The quasi-option value is related to the option value and captures the fact that avoiding irreversible destruction of a potential future use gives value today. The bequest value is related to preserving the natural heritage for generations to come where the value today is derived from knowing that the coral reef ecosystem exists and can be used by future generations. The large donations that are given to environmental non-government organizations (NGOs) in wills are an example of the importance of the bequest concept. The existence value reflects the idea that an ecosystem has value to humans irrespective of whether or not it is used. In the Annex, examples of the different values in the literature are presented.

One purpose of obtaining the TEV of coral reefs and using CBA is to get some numbers on the table for policy discussions. For instance, a government might consider proclaiming a specific bay an MPA. The management costs of running MPAs are significant and the government may want to know in economic terms whether the management costs are justified. Or a government might get complaints from NGOs about certain unsustainable coastal activities; these activities constitute a threat but, at the same time, they generate quite some cash, and so the government needs to be convinced that it is worthwhile to curb the threat. Indeed, powerful economic forces are often driving destructive patterns of coral reef use, rendering short-term economic profits, sometimes very large, to selected individuals.

Coral reef protection is presumed to conflict with economic development, and to require a sacrifice of economic growth. However, this perception stems mainly from a failure to recognize the magnitude of costs to the present and future economy resulting from reef degradation. To illustrate this point, Table 2 shows estimates of the benefits to individuals and losses to society

[3] This section is an abbreviated version of Cesar (2000).
[4] The neo-classical foundations of economic value and its relationship with willingness to pay and consumer surplus are not discussed here (however, see Pearce and Turner (1990) for a general discussion and Barton (1994) and Pendleton (1995) for a specific discussion on the neo-classical economic value of coral reefs).



Source: Barton (1994).

Figure 1. Total economic value and attributes of economic values for coral reefs

from each square kilometer of coral reef destruction, and thus provides a basis for an economic rationale for preventative or remedial efforts. For coastal protection and tourism losses, there are both "high" and a "low" scenario estimates (shown as extremes of a range), depending on the types of coastal construction and tourism potential. "High" cost scenarios are indicative of sites with high tourism potential and high coastal protection value. The opposite holds for "low" cost scenarios.

Valuation techniques[5]

A host of valuation techniques have been developed in recent decades. Standard techniques in micro-economics and welfare economics rely on market information to estimate value. However, most of the time, the externalities inherent in environmental issues prevent these techniques from being used. For an elaboration of this issue for non-economists, see Dixon (1998). Specifically for tropical coastal ecosystems, Barton (1994) gives a detailed overview of 15

Table 2. Total net benefits and losses due to threats to coral reefs in Indonesia (Net present value; 10% discount rate; 25 year time-span; in US$'000; per km²)

	Net return to beneficiaries	Net losses to society				
Threat \ Function	Total net benefits	Fishery	Coastal protection	Tourism	Others	Total net losses (quantifiable)
Poison fishing	33	40	0	3-436	n.q.	43-476
Blast fishing	15	86	9-193	3-482	n.q.	98-761
Coral mining	121	94	12-260	3-482	> 67.0	176-903
Sedimentation from logging	98	81	–	192	n.q.	273
Over-fishing	39	109	–	n.q.	n.q.	109

Source: Adapted from Cesar et al. (1997) n.q. = not quantified

[5] This section is an abbreviated version of Cesar (2000).

different valuation techniques. Spurgeon (1992) gives an interesting summary of this topic with many actual numbers. Table 3 gives a listing of the most common techniques used for valuing the goods and services of coral reef ecosystems. Three general categories are distinguished. The first includes generally applicable techniques that use the market directly to obtain information about the value of the affected goods and services or of direct expenditures. The second includes a number of potentially applicable techniques, which use the market indirectly to obtain information about values and expenditures. The third general category involves survey-based methods that use hypothetical markets and situations.

Valuation techniques enable us to estimate in money terms the direct and indirect use value, as well as the option, quasi-option, bequest and existence values. Specifically discussed here are five methods, which are also used in many of the chapters that follow. These techniques are: (i) Effect on Production (EoP); Replacement Costs (RC); Damage Costs (DC); Travel Costs (TC); and the Contingent Valuation Method (CVM). These techniques correspond to the various types of values, as shown in Table 3. For details on other techniques, see Barton (1994). Note that both TC and CVM have many shortcomings, including problems of designing, implementing and interpreting questionnaires. However, in the cases where they are used, they are typically the only techniques available, as Table 3 shows.

Effect on Production (EoP): This technique, also referred to as the "change in productivity" method, uses the difference in output (production) as the basis for valuing reef services. The technique mainly applies here to fisheries and tourism (producer surplus) and estimates the difference in value of productive output before and after the impact of a threat or a management intervention. Coral bleaching may, for instance, lead to fewer dive tourists and, therefore, lower tourism revenues. Hence, the change in net profit (i.e. effect on production) can be calculated, and this can be used as a proxy for the loss in tourism value. For fisheries, the technique is used to calculate the loss in the fisheries value from a specific threat, such as coral mining, or the gain in the fisheries value from a management intervention, such as the introduction of a marine reserve. The main challenge is the calculation of the changes in productivity in physical terms between the "with" and "without" scenario.

An examples of the EoP method is provided in Alcala and Russ (1990), who report on a decline of US$54 000 in the total yield of reef fishes off Sumilon Island (Philippines) after the breakdown of protective management. McAllister (1998) gives estimates of reef productivity for reefs in excellent condition (18 mt/km^2/yr), in good condition (13 mt/km^2/yr) and in fair condition (8 mt/km^2/yr). Based on changes in condition over time and estimates of net profits associated with these yields, McAllister estimates the fisheries loss in the Philippines at US$80 million per year.

Replacement Costs (RC): The replacement cost approach is used to value the ecosystem service of coastal protection. Data on investments to control coastal erosion are used as a proxy for the coastal protection service of a healthy coral reef. The cost of replacing the coral reef with protective

Table 3. Correspondence between the types of value and the valuation methods

Type of Value	Valuation Method
Direct Use Values	
tourism (consumer surplus)	Travel Cost (TC)
tourism (producer surplus)	Effect on Production (EoP)
fisheries	Effect on Production (EoP)
Indirect Use Values coastal protection	Replacement Costs (RC); Damage Costs (DC)
Non-use values	
Option Values	Contingent Valuation Method (CVM)
Quasi-option Values	Contingent Valuation Method (CVM)
Bequest Values	Contingent Valuation Method (CVM)
Existence Values	Contingent Valuation Method (CVM)

constructions, such as revetments and underwater wave breakers, is used.

A study quoted in Spurgeon (1992) indicates that on Tarawa Atoll in Kiribati, coastal defences costing US$90 720 had to be built to prevent coastal erosion. Berg et al. (1998) give a detailed analysis of the replacement costs following years of coral mining in Sri Lanka. The average cost varies between US$246 000 and US$836 000/km of protected coastline. Cesar (1996) quotes a case in Bali, Indonesia, where coastal protection expenditures of US$1 million were spent over several years for 500 m of coastline protection. Finally, Riopelle (1995) cites information on a hotel in West Lombok which has spent US$880 000 over a seven-year period to restore their beach stretch of around 250 m, allegedly damaged by past coral mining.

Damage Costs (DC): In the absence of coastal protection, the monetary damage to property and infrastructure from surge and storms can be enormous. Hence, the damage cost approach uses the value of the expected loss of the "stock at risk" as a straightforward proxy for the value of the coastal protection service.

Berg et al. (1998) use the cost of land loss as a proxy for the annual cost of coastal erosion due to coral mining in Sri Lanka. Depending on land price and use, these costs are between US$160 and US$172 000/km of reef per year. Cesar (1996) uses a combination of the value of agricultural land and the costs of coastal infrastructure and houses to arrive at a range of US$90 up to US$110 000/km of reef per year for the value of coastal protection afforded by the reef.

Travel Costs (TC): This approach is often used to estimate the welfare associated with the recreational use of a national park. With this technique, the travel time or travel costs are used as an indicator of the total "entry fee" and, therefore, a person's willingness to pay to visit a park. The further away people live from the park, the higher the costs are to visit it. Because of the variation in these costs among visitors, the demand for different prices can be determined, a "demand curve" for the park can be constructed, and the associated consumers' surplus can be determined. This surplus represents an estimate of the value of the environmental good in question (e.g. the National Park).

Pendleton (1995) provided an example of TC. He used this method to estimate the value of the Bonaire Marine Park. To obtain the welfare estimate, Pendleton divides the number of visitors from each state/country by the population of the corresponding origin. This visitation rate is then regressed upon travel costs, giving the demand curve for reef-oriented vacations to Bonaire (visitation rate = [0.0725 – 0.0000373] x travel costs). Based on this estimated demand curve, on the travel costs from each region and on an assumption of 20 000 annual visits to the marine park, the total consumer surplus of visitors to the Bonaire Marine Park is approximately US$19.2 million annually. Another example is a TC study reported in Hundloe et al. (1987), which attributes a value of AU$144 million per year for tourists visiting the Great Barrier Reef.

Contingent Valuation Method (CVM): Where people's preferences are not revealed by markets, CVM uses direct questions about willingness to pay (and/or willingness to accept as compensation) to estimate consumers' preferences. It basically asks people what they are willing to pay for a benefit, or what they are willing to accept by way of compensation to tolerate a loss. This process of obtaining information may be carried out either through a direct questionnaire/survey or by experimental techniques in which subjects respond to different stimuli in "laboratory" conditions. CVM seeks to obtain the respondent's personal valuations of increases or decreases in the quantity of some goods, contingent upon a hypothetical market. Spash (2000) gave an example of CVM from a survey in Montego Bay (Jamaica) and Curaçao (Netherlands Antilles) to investigate the consumer surplus, or individual utility, of coral reef improvement. The survey instrument was designed to capture the "non-use" benefits of marine biodiversity, for both local residents and for visitors. The question to respondents dealt with their willingness to pay (WTP) for more coral cover in the park. Expected WTP for coral reef improvement was US$3.24 per person in a sample of 1 058 respondents for Montego Bay. For Curaçao, the number was US$2.08 per person. But this value was heavily dependent on whether or not respondents believed that marine systems possessed inherent rights, and that humans had inherent duties to protect marine systems.

There are a number of biases associated with CVM that are important to note. These biases have given CVM a bad name in the eyes of some. Careful use of CVM is therefore necessary. Barton (1994) summarizes the following biases, described in the literature:

- Hypothetical bias: This refers to the potential error inherent in the process that is not an actual situation. Respondents may not take the interview seriously enough to give bids reflecting their true preferences.
- Strategic bias: People may answer strategically if they feel that their reply will influence real events, i.e. if they feel that their willingness-to-pay bid may entail actual payment, their values will be lower than otherwise.
- Information bias: The way in which the hypothetical situation is described can have a powerful effect on the reply, and involve several aspects. Design bias refers to how the questions are structured. Instrument bias will result if the respondent reacts (positively or negatively) to the hypothetical instrument or vehicle of payment that is suggested (e.g. entry fee). Starting-point bias refers to the observation that the starting bid may affect the final outcome in a converging bidding process.

An important issue in economic valuation of natural resources is the concept of benefit transfer. It is often quite costly to carry out studies to determine the precise TEV of coral reefs in each location, e.g. a specific marine park. However, it is sometimes possible to use a meta-analysis of studies carried out in other, comparable, areas. For example, if an extensive study has been carried out for the fisheries and tourism potential in one marine reserve in the Philippines, then it is not unlikely that these values can form a proxy for another marine reserve elsewhere in the Philippines. This practice of transferring monetary values is referred to as "benefit transfer".

The TEV gives the economic value of an area at a certain moment. Often, we would like instead to know the costs and benefits of coral reef protection. In such situations, the costs of government interventions need to be compared with the net benefits of such interventions. Economists tend to use extended cost benefit analysis (extended CBA) to evaluate the interventions. For a background to extended CBA, see Belli et al. (2001).

Review of literature

The literature related to the economic valuation of coral reefs shows that past research has focused very much on direct use values of coral reefs and, to a lesser extent, on indirect use and non-use values. Research on the TEV of coral reefs is limited. It is not surprising that most of the past studies focused on use values of coral reefs as these are the easiest to measure and also are probably of most interest to stakeholders, in particular, policy decision-makers.

The literature review indicates that most of the studies on direct use values of coral reefs focus on the values generated from fish production, recreation or tourism, and research and education. Most of these studies used the productivity change (EoP) method to estimate the use value (in terms of revenue) generated. The other method that is commonly used to estimate the use values of coral reefs generated from recreational or tourism activities is the TC method. The third method being used to estimate the use value generated from coral reef ecosystems is CBA.

The productivity change (EoP) method is also used to estimate indirect use values provided by coral reefs, e.g. their coastal protection value. Most studies using EoP estimate the net present value (NPV) of the stock at risk (e.g. infrastructure) linked to a loss in coastal protection. This net present value is used as an approximation of the coastal protection value of the reef. The other method commonly used to estimate indirect use values generated from coral reef ecosystems is the RC method. For example, Cesar (1996) used RC to estimate that the reef's loss of protective capability is linked linearly to its protective value.

In contrast, Ruitenbeek and Cartier (1999) estimated the value of Montego Bay coral reef using a model incorporating drug values, local bio-prospecting costs, institutional costs, discovery success rates for marine extracts, and a hypothetical bio-prospecting program for the area using National Cancer Institute sampling protocols. De Groot (1992) used shadow pricing to estimate the cost of biodiversity maintenance for the Galapagos National Park.

Of all the valuation techniques developed to estimate the non-use value of coral reefs, the CVM is the most commonly used. De Groot (1992) also used sales of books and films to estimate the cultural/artistic inspirational use value of coral reefs. In the same study, he also considered the level of donations to estimate the spiritual use value of Galapagos National Park in Ecuador.

De Groot (1992) also provided an estimate of the TEV based on the total annual monetary returns from direct and indirect use of Galapagos National Park. In the same study, benefit transfer was used to estimate the annual value of the reefs based on the similarities between the Dutch Wadden Sea and Galapagos estuarine areas, with the assumption that 10 per cent of fishery in Galapagos depend on the nursery function provided by inlets and mangrove lagoons.

Socioeconomics of coral reefs

Economic analysis of coral reefs goes considerably beyond pure monetary valuation (Cesar, 2000). It includes consideration of at least the following four issues:

- **The extent of poverty and income deterioration due to coral reef degradation;**
- **The degree to which local populations rely on reef fisheries for subsistence purposes;**
- **The existence (or otherwise) of other income generating activities in reef areas; and**
- **Stakeholder analysis of which social group wins and which loses from various threats and management actions.**

In this paper the focus is on stakeholder analysis and other income generating activities. To illustrate the stakeholder analysis, Table 4 shows the private benefits that accrue to the various groups of stakeholders involved in causing threats to the coral reefs of Indonesia as well as to each of the persons/families/boats/companies involved.[6] The aggregated numbers (last column of Table 4) correspond with the total benefits presented in Table 2 (second column).

Interestingly, at US$0.121 million, net benefits per square kilometer to stakeholder groups are highest for coral mining. Yet, private benefits per stakeholder (person/boat/company/etc.) are highest to those involved in poison fishing and logging-induced sedimentation, ranging from US$2 million per company in the case of logging to over US$0.4 million per boat in the case of poison fishing. Side-payments are also particularly high, very roughly estimated at some US$0.3 to 1.5 million for some receivers. At the other extreme, coral mining is a rather marginal activity for the mining families involved (for a discussion, see Cesar et al. 1997).

Case study one: Total economic value of a coastal area (Jamaica's Portland Bight)

Introduction and study area

On 2 April (Earth Day) 1999, the Jamaican government declared its largest environmental conservation area, the Portland Bight Protected Area (PBPA). The PBPA is situated along Jamaica's southern coast, just west of Kingston (Jamaica's capital). Its marine region runs due south into the Caribbean Sea along the 200-meter depth contour. The area has a number of valuable ecological resources, including coral reefs, wetland systems, dry limestone forests, and a number of endangered species. Some of these resources are currently under threat of over-fishing, dynamite fishing, pollutants (such as industrial waste, oil and sewage), charcoal burning, wood cutting and marijuana cultivation. The PBPA is classified as a

Table 4. Net benefits to stakeholder groups: (NPV at 10% discount rate over 25 years in US$'000; per km^2. Benefits per stakeholder in parentheses)

Threat \ Individuals	Fishers	Miners, Loggers	Others (payments)	Total per km^2
Poison fishing	29 *(468.6 per boat)* *(23.4 per diver)*	-	4 *(317-1 585 per person)*	33
Blast fishing	15 *(7.3 per fisher)*	-	?	15
Mining	-	67 *(1.4 per mining family)*	54 *(18-54 per person)*	121
Sedimentation due to logging	-	98 *(1 990 per logging family)*	?	98
Over-fishing	39 *(0.2 per fisher)*	-	-	39

Source: Adapted from Cesar (1996) and Cesar et al. (1997).

6 The column "Others" presents the payments to third persons, sometimes referred to as "political rents".

"multi-use conservation area", combining private and public lands and activities such as agriculture and industry alongside residential and wilderness areas. The goal of the Portland Bight Management Plan is to ensure the sustainable use of natural resources and the conservation of threatened species and ecosystems, while at the same time meeting the needs of the current generation in terms of physical and social infrastructure, services, and income generation (CCAM, 1999).

The PBPA covers 520 km^2 of land (which includes 82 km^2 of wetlands and 210 km^2 of forests), and a marine area of 1 356 km^2. The land area of the PBPA is 4.7 per cent of Jamaica's total land mass, an area larger than the entire island of Barbados. Coral cays and reefs occur sporadically throughout the marine area of Portland Bight, notably at the edge of the island shelf. Mangrove wetlands predominate along much of the coastline. Shoreward, benthic regions of the Bight are dominated by mudflats. The Bight functions as habitat for a number of marine organisms, including the endangered West Indian Manatee (*Trichecus manatus*). The PBPA also contains four prominent examples of tropical dry limestone forest, containing a unique evergreen forest as well as cactus scrubs. The approximately 60 km^2 Hellshire Hills area is the largest remaining pristine dry limestone forest in Central America and the Caribbean. The Hills are home to the last of the remaining Jamaican Iguana (*Cyclura collei*), which is an endangered species endemic to the island.

Resources, services and functions

The various ecosystems in the PBPA support a host of different resources, services and functions (RSFs). The most important ones are discussed below.

Direct uses: These include fisheries, harvesting pelagic and demersal fish that feed along the coral reefs and the rest of the island shelf of Portland Bight. The fishing grounds of South Jamaica cover an area of almost 2 586 km^2. Lobster, shrimp and conch stocks, although severely depleted, are an economically valuable resource. A second direct use is forestry; products from the limestone woods of the PBPA satisfy local demand for timber products such as fuel wood and charcoal. Mangrove wood is also valued as a source of poles for fences, stakes, scaffolds, and yamsticks, and is used in housing construction. In addition, the mangroves and dry limestone forests provide a host of non-timber products, such as honey, orchids and medicinal plants.

Indirect uses: The tourism and recreation sector is a fundamental component of the Jamaican economy, in 1997 attracting 1.8 million visitors and over US$1.3 billion. In comparison with the north coast, tourism along Jamaica's south coast is very undeveloped. The Portland Bight region, like the rest of Jamaica, appeals to tourists interested in relaxation, touring, swimming and sunbathing, and enjoying natural surroundings (Halcrow 1998). Other indirect uses relate to the PBPA's navigation function. Two major ports located within the Bight are major alumina storage and shipping complexes and are also used for the export of goods and the import of oil, grain, etc. The wetlands allow for natural waste treatment, sediment retention and coastal protection. The latter is important to prevent coastal erosion. The mangrove and limestone forests fix carbon dioxide, a process referred to as carbon sequestration. This is increasingly recognized as an important ecosystem service whereby mangroves offset CO_2 emissions, thus helping to slow down the greenhouse effect (Sathirathai 1998).

Non-uses: Some ecosystem functions are remote and not accounted for as either direct or indirect use. The many unique ecosystems contained within the PBPA make an important contribution to the biological diversity of the island, and provide habitat or nesting areas for endangered species, several of which are endemic to Jamaica. This non-use function is related to use-functions. Tourists come to enjoy the biodiversity and culture, but the idea of "non-use value" is the intrinsic existence of these functions independent of human use.

The PBPA management plan and its associated costs

The management plan for the Portland Bight Protected Area (PBPA) prepared by the (CCAM) Caribbean Coastal Area Management was published in May 1999 and approved by the Natural Resources Conservation Authority (NRCA). The plan delineates the boundaries, defines the management objectives, and outlines specific management plans for almost every natural resource in the PBPA. The management plan describes the 28 different zones, and explains the plans for community environmental education, enforcement and tourism development within the PBPA. It contains a preliminary assessment of the resources needed to manage the PBPA, as well as suggestions as to how the PBPA might be sustainably financed. CCAM intends to take a co-management approach, promoting the management of the resources in the project area as a joint effort of the stakeholders, including the government. In the model being pursued, co-management takes place through resource management councils, made up of representatives of the stakeholders in the resource – including government agencies, resource users, the private sector and NGOs.

Operational expenses of the PBPA will be financed from government subvention, user fees, income from a trust fund and profits from tourism activities and merchandizing. Grant funds will play a large part in financing the necessary capital expenditures. The recurrent costs of the PBPA Management Plan are estimated at US$1.496 million per year, while the capital investments are estimated at US$2.422 million. The capital budget consists of many items (computers, GPS equipment, vehicles) that are typically written off in a five-year period. Using this five-year write-off period, the combined recurrent and capital costs of managing the PBPA are roughly US$19.2 million over 25 years in net present value terms (10 per cent discount rate). This information is used in the following comparison of the costs and benefits of the PBPA.

Economic valuation

Each of the resources, services and functions (RSFs) for the three categories of ecosystems (marine; wetland; terrestrial) has an economic value. The main problem with the valuation of these RSFs is that their measurement in monetary terms is time-consuming, and in some cases impossible. Table 5 suggests a very rough first guesstimate of the most relevant values for the

Table 5. Categories of ecosystems in PBPA and their perceived economic values*

	Values	← Direct economic value →						← Indirect economic value →				← Non-use →		
Services & Functions / Eco-systems	Area (km²)	Fishery (habitat; catch)	Forestry (charcoal, etc.)	Forestry (non-timber)	Tourism	Recreation (Game, etc.)	Navigation	Waste treatment	Sediment retention	Coastal protection	Carbon fixation	Biodiversity	Cultural heritage	Etc.
Marine	1356	xxx	-	-	xxx	xx	xxx	xx	xx	xxx	-	xxx	x	
Seagrass	?	xxx	-	-	-	-	-	xx	xx	x	-	xxx	-	
Coral reefs	?	xxx	-	-	xx	xx	-	x	x	xx	-	xx	-	
Islets	1	-	-	-	xxx	-	-	-	-	xxx	-	-	xx	
Rest of the shelf	?	x	-	-	x	xx	xxx	x	x	x	-	-	-	
Wetlands	82	xx	x	x	xx	xx	-	xxx	xxx	xx	xx	xxx	-	
Mangroves	55	xxx	x	x	xx	xx	-	xxx	xxx	xxx	xx	xxx	-	
Tidal marsh	12	xx	-	-	x	-	-	xxx	xxx	x	-	x	-	
Saline pools	15	x	-	-	x	-	-	x	x	x	-	x	-	
Terrestrial	438	-	x	x	xxx	xx	-	x	xx	x	x	xxx	xx	
Forest	210	-	x	x	xxx	xx	-	x	xx	x	x	xxx	x	
Shrubs, etc.	20	-	x	x	x	-	-	-	-	x	x	-	-	
Agriculture	168	-	-	-	-	-	-	-	-		-	-	x	
Human/ Industry	40	-	-	-	-	-	-	-	-		-	-	xx	
Total	1876	xxx	x	x	xxx	x	xxx	x	xx	xxx	x	xxx	xx	

* The higher the guesstimated value of the function, the larger the number of stars (x) – from 0 to 3 stars. The circles around a set of stars indicate that the specific value for a function/resource can only be calculated for a set of ecosystems combined. The circles in the "Total" row indicate the functions and resources for which a monetary valuation is given in the text.

various ecosystems in the PBPA. This is achieved by giving every value for each of the ecosystems a number of stars (0, 1, 2, or 3) depending on the likely contribution of the ecosystem to the RSFs. Not only is measurement of RSFs difficult, but also certain values can only be calculated for a set of ecosystems combined. In Table 5, this is indicated by a circle around a set of ecosystems. For instance, it is very hard to discuss the fisheries for mangroves, reefs, sea-grass and tidal marshes separately given the complex interrelationships between these ecosystems. For the tourism and recreation function, a somewhat similar situation exists; most tourists are interested in a package of cultural and natural experiences, rather than in individual elements of the package.

Fisheries: The total yield of the Portland Bight fishery in 1997 was 1 088.4 t. This corresponds to 0.8 mt/km^2/yr. Haughton (1988) suggested that the maximum sustainable yield (MSY) for the south Jamaican fishery is 2.2 t/km^2 (Cesar et al. 2000). Given the relatively low capital intensity, this is close to the maximum economic yield (MEY). At low levels of capital, MEY and MSY are close, while at high levels of capital, the MEY can be much smaller than the MSY. The discrepancy between actual yields and the MEY (or MSY) shows the enormous level of over-fishing. Given the open access nature of Jamaican coastal fisheries, it is assumed that current yields equal the open access equilibrium (OAE), where all economic rents are squeezed out of the market. Espeut and Grant (1990) show reasonable profit margins for south-shelf fishers of 50 per cent (pot fishers) and 54 per cent (net fishers). With growing piracy, fish pot stealing and over-fishing, we assume that profits have declined to zero over the last decade. This shows that the actual economic value added has been squeezed out of the fisheries over the last 10 years. Cesar et al. (2000) estimated that MSY profits are US$5000/ km^2 /yr or US$6.78 million for the PBPA at an average fish price of US$2.8/kg. In the OAE, the fishery value would be zero.

Forestry: In the mangrove and limestone forests, trees are cut for construction material, fuel wood and charcoal production. Though some level of mangrove thinning is sustainable if regulated properly, wood extraction in the dry limestone forests is unsustainable due to the absence of topsoil. In the Hellshire Hills, some 60 people are involved in charcoal production[7], creating a total gross value per year of US$100 000. Harvesting of non-timber products takes place at such a small-scale that, here, the value of these non-timber resources is put at zero.

Tourism and recreation: With the exception of Hellshire Bay, a popular beach day-trip destination for local Kingston residents, the number of tourists currently visiting the PBPA is very small.[8] Eco-tourism development possibilities in the PBPA are suggested in Halcrow (1998). The extent to which tourism develops depends on expansion of facilities, marketing, and on reduction of possible violence and tourism harassment (Halcrow 1998). Two scenarios are identified in this case study. In the first, these constraints are not adequately dealt with, while, in the second, gradual and sustainable expansion of eco-tourism is realized. In the latter scenario, the value of tourism and recreation is taken to be US$0.75/ km^2/yr based on benefit transfers (Costanza et al. 1997)[9] of US$4.7 million for the whole PBPA (assuming that one third of the area is of interest to tourists). In the former scenario, we assume (tentatively) that tourism profits are one tenth of this amount (US$470 000), the same as in the future "without PBPA" case. We further assume that, currently, the value added from tourism is zero.

Carbon fixation: Growing forests can sequester carbon. The net growth of dry limestone forests is very limited and net carbon fixation is assumed to be zero. Mangroves have a much larger potential. Sathirathai (1998) estimates a value of US$8 200/ km^2/yr based on US$5.67 per tonne of carbon and a primary productivity for mangroves in Thailand's Kanjanadit district of 1 510 t of carbon/ km^2/yr. Using this value as a benefit transfer, the 55 km^2 of mangroves in Portland Bight have an annual value of US$45 million. It is assumed that the net area of mangroves remains stable in the PBPA, but that it would decline by 1 per cent annually in the absence of good management.

Coastal protection: Mangroves and other wetlands as well as coral reefs contribute to coastal protection, as such ecosystems are able to dissipate wave energy. In recent years, mangrove destruction has resulted in damage to the coastal

[7] Data are scarce given the illegality of this activity (see Cesar et al. 2000).

[8] This is a very different picture from areas along Jamaica's northern coast. For example, Gustavson (1998) calculated tourism values for Montego Bay had a net present value associated with the hundreds of thousands of tourists ranging from US$210 million to US$630 million.

[9] Costanza et al. (1997) give an annual value for coastal ecosystems of US$0.82/km^2 and for forests of US$0.66/km^2. This would give a weighted average of roughly US$0.75/km^2 for the relevant parts of the PBPA.

road going into the Portland Ridge. For the Portland Bight, Cesar et al. (2000) estimated that the total coastal protection value was around US$3.55 million in NPV terms or nearly US$400 000 per year (with 10 per cent discount rate). It is assumed, following Pet-Soede et al. (1999), that a 1 per cent loss in coastal ecosystems leads to a 1 per cent loss in the coastal protection function, and this in turn leads to a loss of 1 per cent of the value of the coastline. With a 1 per cent decline in mangrove stands in the absence of park management (but no decline with park management), the benefits of the PBPA in terms of coastal protection are US$4 000 per year.

Biodiversity: To estimate biodiversity in a developing country, Ruitenbeek (1992) suggests taking the value of foreign support likely to be available to protect the biodiverse resource through NGOs, through the Global Environment Fund and other means. A recent study for Indonesia has shown that two marine parks were able to capitalize on their global value of biological diversity, by obtaining an average of US$10 000/km^2/year (Cesar et al. 2000). In the PBPA, the areas of most interest in terms of biodiversity are the Hellshire Hills, the Portland Ridge, the wetlands, and the rest of the strip along the coast. These areas, totalling about 200 km^2, could be eligible for global grant funding of around US$10 000/km^2/year, or a total annual cash revenue of US$ 2 million.

Total benefits of PBPA: The values of the ecosystems' services can be combined to calculate the total benefits of the PBPA (Pendleton 1995). To do so, the difference in value between a "with PBPA" scenario and a "without PBPA" scenario needs to be calculated. However, as discussed, the aggregation of economic values would still need to take into account the compatibility of the different functions for a specific use (Spurgeon 1992; Barton 1994). Of all the services discussed above, the only one not compatible with sustainable use is charcoal. Therefore, in the "with PBPA" scenario, charcoal production will stop. It is assumed that the changes are complete in 25 years, so that fisheries will be back at its maximum sustainable yield in 2025.

Comparison of costs and benefits: Table 6 pulls together all the values of the ecosystem. The total (incremental) benefits of the PBPA are estimated at US$52.6 million in present value terms (at a 10 per cent discount rate) in the optimistic tourism scenario and US$40.8 million in the pessimistic tourism case. Hence, the US$19.2 million costs over the next 25 years (see above) are well justified on economic grounds.

Case study two: Costs and benefits of coral mining in Lombok, Indonesia[10]

Introduction

One of the key threats to coral reefs is the extraction of corals for lime production and construction materials. This is carried out in many areas around the world, including East Africa (Dulvy et al. 1995; Andersson and Ngazy 1995), South Asia (Brown and Dunne 1988; Rajasuriya et al. 1995; Berg et al. 1998), Southeast Asia (Cesar et al. 1997) and in the Pacific (Salvat 1987). Extraction of corals has a detrimental effect on the reef ecosystem. For instance, a study carried out by Dulvy et al. (1995) in Tanzania showed that live coral cover in mined areas was one third of that in the unmined sites. In addition

Table 6. Values for ecosystem services in the Portland Bight (US$'000)

	"Without PBPA"		"With PBPA"		Accumulated difference 2000-2025[11] (in NPV)
Year	***2000***	***2025***	***2000***	***2025***	
Fisheries	0	0	0	6 780	18 928
Forestry	100	100	0	0	-916
Tourism (high)	0	470	0	4 700	11 809
Tourism (low)	0	470	0	470	0
Carbon fixation*	0	0	450	450	4 122
Coastal protection*	0	0	40	40	366
Biodiversity	0	0	2 000	2 000	18 322
Total (high tourism)	100	570	2 490	13 970	52 631
Total (low tourism)	100	570	2 490	9 740	40 822

*These are calculated in net terms. This means that the "with" scenario gives the net gains relative to the "without" scenario.

[10] This section is based on Cesar (1996) and Ohman and Cesar (2000).
[11] Note that the numbers in this column are not equal to the difference in the numbers of the previous two columns; they are the net present value of the accumulated difference over the 25-year period.

to these direct effects, loss of land and increased sedimentation have also been reported (e.g. Salvat 1987; Dulvy et al. 1995). If corals are collected from a reef, recovery appears to be slow. Dulvy et al. (1995) stated that recovery of the reefs to the pre-disturbance live coral cover could take up to 50 years.

Although coral extraction is destructive, it is a source of income and subsistence for many people in the developing world. Yet, by adversely affecting the foundation of the reef, coral mining is likely to result in longer term costs to society. In this case study we analyze the cost and benefits of coral mining in Lombok, Indonesia. In a financial analysis we describe the mining business and estimate its net profits. In the economic analysis, we also consider the societal costs of coral mining in terms of associated losses to reef functions, specifically fishery, tourism and coastal protection functions. The case study shows that the societal costs far outweigh the private gains accruing to a handful of individuals, even though these individuals themselves have a clear interest to continue, partly because of a lack of other income-generating activities in the area.

Financial analysis: The coral mining business

Lombok is an island situated in the south central Indonesian archipelago between Bali and Sumbawa. Its population of 2.4 million people depends to a large extent on the island's coastal resources. Tourism is an important industry that is growing rapidly. Other activities include fishing and mangrove forestry (Subani and Wahyono 1987; Cesar 1996). Coral mining for lime production is a small-scale, but widespread, industry around the island, with recently 500 to 1 000 families involved in the business. A case study by Cesar (1996) described a small area in West Lombok where 60 families have practised mining on a 2 km long stretch of reef over a 10-year period. The corals were collected, burnt and sold as lime.

A crucial input for the mining process is locally harvested fuel wood. The study found that each family used roughly 20 m^3 of fuel wood taken from a secondary forest. Another interesting expense in the production of lime for each family was the side-payments for "protection", as coral mining is illegal in Indonesia. This is important to consider in the financial analysis as it is a real cost to the business. Finally, there were no labor costs, as coral mining in Lombok is a family business; fathers and sons do the mining and the women break up the corals and are involved in the burning and sieving processes.

Economic analysis: Societal costs of coral mining

Extraction of corals for lime production affects many essential reef functions. Here, three such functions are discussed: fisheries, tourism and coastal protection. These three were selected as they were considered to be quite important and relatively easy to quantify. The sum of the quantifiable damage can be interpreted as a lower-boundary of the total mining losses. As a result of mining activities the functions of coral reefs will decrease gradually. Figure 2 gives the assumed paths over time, as elaborated in Cesar (1996). Fringing coral reefs act as natural wave breakers and protect against coastal erosion. In the Lombok study it was assumed that coastal protection would start breaking down after five years of mining. Tourism on the other hand, would be affected immediately. As divers are sensitive to the aesthetic appearance, other diving destinations would become relatively more popular. Therefore, it was assumed that after two years, tourism would have vanished. It was further suggested that no substantial recovery of the corals would take place within the time frame of the analysis. For fisheries, it was assumed that reef fisheries would disappear and be replaced by a less valuable pelagic fishery.

For the economic valuation of the losses of these functions, the case study presents two scenarios, one in which there is limited tourism potential and little coastal construction (the "low" scenario) and one in which there is high tourism potential and considerable coastal infrastructure (the "high" scenario). All costs are calculated in NPV terms for a 30-year time horizon. The NPV expresses the discounted sum of annual costs over the 30 years. The net loss of the fishery function was valued at US$74 900 in both scenarios. For the "low" scenario, the loss of the tourism function was estimated at US$2 900 and that of the coastal protection function at US$12 000. In the "high" scenario, loss of tourism is estimated at US$481 900 and erosion costs are estimated at US$260 000 (see Figure 3 and Table 7).

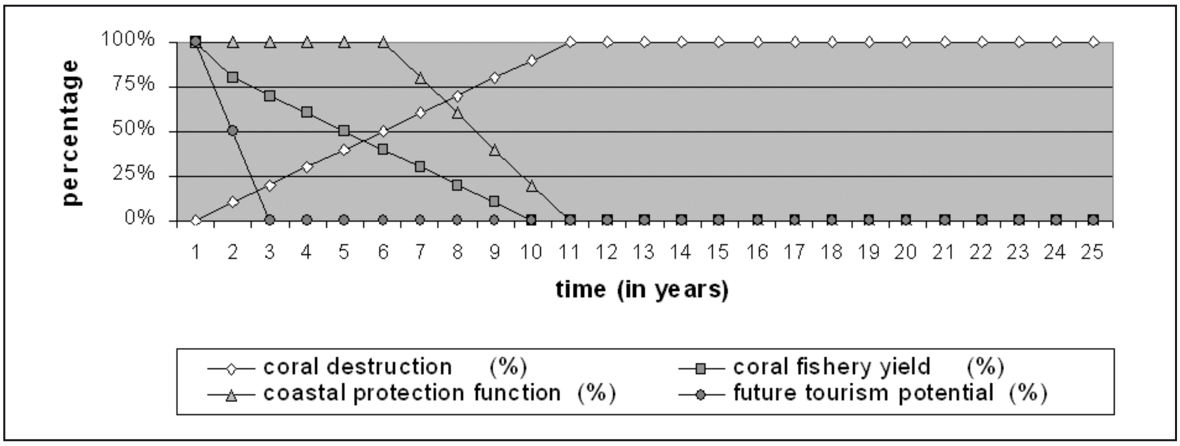


Figure 2. Destruction of coral reefs over time in the Lombok case study

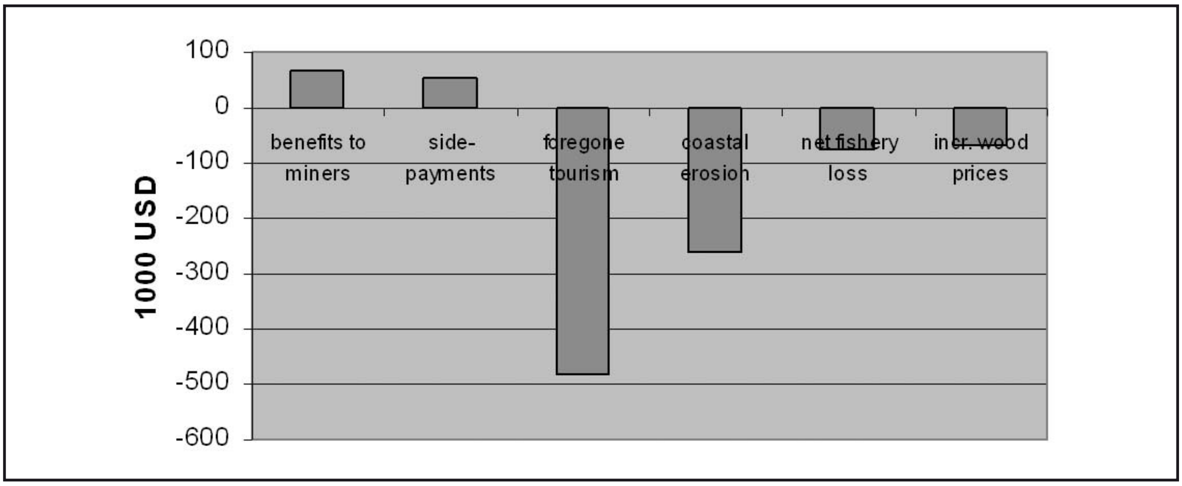


Figure 3. Costs and benefits of coral mining in a "high" scenario case

Table 7. Costs and benefits of coral mining per square kilometer in NPV terms

"Low" scenario (US$'000)				"High" scenario (US$'000)			
Costs Direct costs		Benefits Direct benefits		Costs Direct costs		Benefits Direct benefits	
Labor	0	Sales of lime	302	Labor	0	Sales of lime	302
Wood	67			Wood	67		
Side-payments	54			Side-payments	54		
Other costs	13			Other costs	13		
		Side-payments	54			Side-payments	54
Indirect costs		Indirect benefits		Indirect costs		Indirect benefits	
Coastal erosion	12			Coastal erosion	260		
Increase in wood prices	67			Increase in wood prices	67		
Other functions	n/a			Other functions	n/a		
Opportunity costs				Opportunity costs			
Foregone tourism	3			Foregone tourism	482		
Net fishery loss	75			Net fishery loss	75		
Labor costs	101			Labor costs	101		
Total costs	392	Total benefits	356	Total costs	1 119	Total benefits	356
Costs to miners	235	Benefits to miners	302	Costs to miners	235	Benefits to miners	302
Net present value (economic)			-33	Net present value (economic)			-762
Net present value (financial)			67	Net present value (financial)			67

Table 7 also shows that there are three additional items in the economic analysis. First, when calculating mining profits in the financial analysis, labor costs were set to zero because only family labor was involved. For the economic analysis, however, these costs need to be imputed in some way, as the mining family could have been employed elsewhere ("opportunity costs"). These costs were estimated at US$101 000 in NPV terms. Secondly, the true costs of fuelwood were assumed to be larger than the price paid by the families, because of the unsustainable way in which the logging was carried out. The economic costs were assumed to be double the price paid. Thirdly, the side payment paid by the mining family for protection is a true cost to that family. However, from an economic point of view, it is merely a transfer of resources from one group in society (the miner) to another (the protector), so these costs were not incorporated.

Combining the net profits from mining with the societal costs, Table 7 shows that the economic cost imposed on society by mining is US$36 000/ km^2 for a "low" value scenario (costs are US$392 000 in NPV terms and benefits are US$356 000). For the "high" scenario, the contrast between costs and benefits is even more pronounced: US$1 119 million versus US$0.356 million. This means that the NPV of mining is US$-763 000 in the "high" scenario. For both scenarios, therefore, coral mining constitutes a significant, long-term loss to society.

Case study three: The economic cost of coral bleaching in the Indian Ocean

Introduction

The 1998 massive worldwide episode of coral bleaching and subsequent damage to coral reefs is likely to result in serious socioeconomic impacts. With 135 persons per km^2, the Indian Ocean region is the most densely populated coastal region in the world (WRI 1998). The majority of the population is poor and the dependence on fisheries for income and animal protein intake is high. Over-fishing is already a major threat and coral bleaching could worsen this. In other areas, coastal tourism and diving are the main income-generating activities; in the Maldives 45 per cent of the GNP stems directly or indirectly from tourism revenues. Furthermore, the land area around the Indian Ocean is prone to seasonal cyclones; coral reefs form natural barriers to protect the coastline from erosion. In Sri Lanka, severe coastline erosion has already occurred in areas where the reef substrate has been heavily mined. Countermeasures to prevent further erosion are already costing the Sri Lankan government around US$30 million (Berg et al. 1998).

This case study aims to provide a plausible range of expected damage estimates in monetary terms. It is based on studies carried out under the "Coral Reef Degradation in the Indian Ocean" program (CORDIO). Specifically, this case study summarizes the tourism and fisheries studies carried out in 1999-2000 under this umbrella program in the Maldives, Sri Lanka, Tanzania and Kenya. The data are generalized to arrive at an overall estimate for the Indian Ocean. Monetary values do not express the true losses to coastal populations dependent on reefs and to others enjoying these ecosystems. Yet, these values can hint at the extent of the problem. And this can assist in raising awareness of the bleaching problem.

Uncertainty and scenarios

The uncertainty surrounding many of the relationships between coral bleaching and coral mortality on the one hand and ecosystem services on the other is enormous. In addition to that, the recovery rate of reef areas after widespread mortality is difficult to predict. In order to consider possible future outcomes, two scenarios are explored. In the first, damage to the reef is not too bad and recovery is relatively quick; in the second, damage is great and there is very slow or no recovery, with the result that long-term impacts are severe. These two scenarios were postulated in Wilkinson et al. (1999) and further specified as described below.

The optimistic first scenario

- A slight decrease in tourism-generated income and employment, as some divers stay home or go elsewhere, and few tourists alter their behavior.
- Some change in the fish species composition. (Initially, fish productivity increases with larger numbers of herbivores; catch reductions for ornamental fish, etc.).
- No major change in the coastal protection function, as bio-erosion of dead reefs and coral growth of new recruits even each other out.

The pessimistic second scenario

- Major direct losses in tourism income and employment, especially when charismatic marine fauna disappear as a result of bleaching and resulting mortality.
- Fish productivity drops considerably as the reef structure disintegrates, resulting in less protein in the diet, particularly for coastal communities.
- The reef ceases to function as a protective barrier, resulting in increased coastal erosion.

Valuation of economic damage

Given the mainly long-term impacts of coral bleaching and the only limited time that has elapsed since the bleaching episode of 1998, it is very difficult to translate the current results from the CORDIO socioeconomic studies into a long-term valuation estimate. With this caveat, estimates of the cost of coral bleaching on tourism, fisheries and other reef services are presented.

Tourism: Financial and economic costs for the Maldives and Sri Lanka in 1998-99 are shown in Table 8. Financial costs are actual costs to the economy from tourism losses. The economic costs express the welfare loss to all concerned individuals transpose in the world due to coral bleaching in a specific country. This expresses a global value but not a figure from which a national government can directly benefit. The description for these two countries and the costs for 1998-99 closely matches those derived in the "optimistic scenario". Although the long-term impacts are uncertain, it is assumed that they will follow the optimistic scenario. It is assumed that, after the second year, tourism growth rates return to normal, and hence the losses are the accumulated losses over time due to a two-year dip in growth rates. Estimates of total coastal tourism around the Indian Ocean could not be obtained, but, based on general data in Westmacott et al. (2000c) and on guesstimates by the author, it is assumed that relevant affected tourism in the Indian Ocean is approximately three times the losses in the Maldives plus ten times the losses in Sri Lanka. This gives a total tourism loss of US$389 million for the whole Indian Ocean in present value terms over a 20-year time horizon and with a 10 per cent discount rate.

For the pessimistic scenario, if we assume long-lasting impacts, the data from Kenya and Tanzania seem to be relatively close to the scenario description. These estimates come from a hypothetical willingness-to-pay (WTP) study, where tourists were surveyed in relation to a severe bleaching and associated mortality event. The *financial* cost of coral bleaching in Zanzibar in 1998-99 was estimated at a mid-point of US$3.8 million. In Mombasa, this was calculated at a mid-point of US$16.7 million. The total *economic* cost[12] of the coral bleaching in Zanzibar was estimated at a mid-point of US$6.2 million and for Mombasa US$29.2 million. To arrive at an estimate for the rest of the Indian Ocean, the Zanzibar and Mombasa estimates were extra-polated based on available information.

Fisheries: The fisheries losses are even more uncertain than those of tourism. In a recent case study by McClanahan and Pet-Soede (see Westmacott et al. 2000a), no significant impacts of coral bleaching in Kenya were found. This follows quite closely the optimistic scenario described above. If we assume that in the future this observation will remain, there are zero financial losses in fisheries. The case of a pessimistic scenario is problematic as no hard fishery data are available on which to estimate the losses. On this issue, we follow Wilkinson et al. (1999) by assuming that the bleaching and

Table 8. Optimistic scenario: Financial and economic costs for the Maldives, Sri Lanka, and the rest of the Indian Ocean for 1998-99 and net present value (NPV) over 20 years

	Financial costs (US$M)		Economic costs (US$M)	
	1998-99	*NPV*	*1998-99*	*NPV*
Maldives	3.0	14.8	19.0	93.6
Sri Lanka	0.2	1.0	2.2	10.8
Rest of the Indian Ocean	11.0	54.4	79.0	389.0

Table 9. Pessimistic scenario: Financial and economic costs for Zanzibar, Mombasa and the rest of the Indian Ocean for 1998 and net present value (NPV) over 20 years

	Financial costs (US$M)		Economic costs (US$M)	
	1998-99	*NPV*	*1998-99*	*NPV*
Zanzibar	3.8	32.6	6.2	52.6
Mombasa	16.7	1 41.9	29.2	248.6
Rest of the Indian Ocean	205.0	1 744.9	354.0	3 011.4

[12] Here, we take total economic costs as the sum of the financial and economic costs as presented in Westmacott et al. 2000b.

mortality witnessed in the Indian Ocean leads to a loss of 25 per cent of reef-related fisheries from year 5 until year 20. In the first five years, this percentage grows linearly from 0 per cent to 25 per cent. Following Costanza et al. (1997), the value of fishery production is assumed to be US$220/ha/yr.

Other reef services: Other services provided by reefs include coastal protection, research, etc. For coastal protection, we assume a value of US$174/ha/yr (Wilkinson et al. 1999). Other reef services are valued at US$97/ha/yr, based on Costanza et al. (1997). The calculations for coastal protection were based on the assumption that, in the Indian Ocean, around 25 per cent of reef areas protect medium to high value infrastructure and 75 per cent protect low value infrastructure. It was also assumed that around 50 per cent of the reef areas have high tourism potential and 50 per cent have low tourism potential. For this calculation, the present value data of Cesar (1996) were annualized. In the pessimistic scenario, bleaching in the Indian Ocean is assumed to lead to a decline in reef services of 50 per cent, starting from year 5, with a lineal growth from 0 per cent to 50 per cent in the first 5 years. These percentage losses in services are multiplied by the annual value of the services, and summed across the services to give total annual losses per hectare per year. This number is multiplied by the 36 100 km^2 of reefs in the Indian Ocean. Finally, the net present value over a 20-year period is taken, using a 10 per cent discount rate.

Summary: Table 10 summarizes the information above. In the pessimistic scenario, total damages over a 20-year time period are valued at over US$8 billion, and arise primarily from coastal erosion (US$2.2 billion), tourism loss (US$3.3 billion), and fishery loss (US$1.4 billion). In the optimistic scenario described above, the losses are still considerable, but are of the order of magnitude less than the damage in the pessimistic scenario, and stem mainly from a US$0.5 billion loss of tourism revenue.

Table 10. Estimates of the overall economic valuation of the socioeconomic impacts of the 1998 coral bleaching event in the Indian Ocean ***(Net present value in US$M over a 20-year time horizon with a 10% discount rate)***

Scenarios Coral reef ecosystem services	Optimistic scenario	Pessimistic scenario
Food production (e.g. fisheries)	0	1 361
Tourism and recreation	494	3 313
Disturbance regulation (coastal protection)	0	2 152
Other services	114	1 200
Total	608	8 026

Discussion

Why do economists want to value something as invaluable as coral reefs? The answer could well be, "because coral reefs are so beautiful that we want to make sure that our grandchildren can enjoy them as well."

Yet, there are many coastal populations who are unaware of the goods and services that coral reef ecosystems provide and who do not appreciate the complex linkages of the natural world. Creation or transformation of markets for environmental goods might help overcome these problems. Markets could also assist in cases where people use coral reefs unsustainably and even destructively, and where politicians with short-term views fail to provide funds for coral reef management, even though the long-term costs of inaction are typically much higher than the funds needed initially.

One important challenge in economic valuation studies is to identify to whom the benefits (real or virtual) accrue. In TC studies, some of the costs are paid and accrue to local or foreign business operators. Most costs are, however, virtual. They describe, for example, a potential willingness-to-pay for a specific improvement in reef quality in a national park. In the case of CVM, all values are virtual in the sense that there are no actual cash transactions involved.

A second important challenge is the fact that valuing all the benefits of coral reefs is often frustrating, and sometimes nearly impossible. The good news is, however, that not all benefits have to be valued. Assume it can be shown that net benefits to blast fishers is lower than societal losses from the loss of sustainable fishing income and tourism revenues combined. In that case, no complicated techniques are needed and no major data collection on the value of bio-prospecting, biotic services and physical structure services are required; two services that can be measured in monetary terms suffice to show the costs of inaction.

When valuing reef-destructive activities such as coral mining, the type of valuation presented above provides information that is useful for designing reef management plans. Comparing mining profits with the associated societal costs can significantly raise awareness of the long-term detrimental impacts of coral mining. Furthermore, an understanding of the financial returns to coral miners will increase the appreciation of the driving forces behind each miner's behavior and so improve the design of management plans.

As has been shown in this paper, economic valuation can be used to raise the awareness of all those involved in the use and management of coral reefs, with the result that the beauty of the coral reefs may be enjoyed forever.

References

Ahmed, M., G.M. Umali, C.K. Chong, M.F. Rull and M.C. Garcia. 2005. Valuing recreational and conservation benefits of coral reefs in Bolinao, Philippines. *In* these Proceedings.

Alcala, A.C. and G.R. Russ. 1990. A direct test of the effects of protective management on abundance and yield of tropical marine resources. J. Cons. Int. Explor. Mer. 46:40-47.

Andersson, J. and Z. Ngazy. 1998. Coastal communities' production choices, risk diversification, and subsistence behaviour: Responses in periods of transition. Ambio 27:686-693.

Ayob, A.M., S.B. Rawi, A. Arzemi and S.A. Ahmad. 2001. Pulau Payar Marine Park: Non-use value. Paper presented at the Second Conference for Resource and Environmental

Economists, Malaysia, organized by the Malaysian Association for Resource and Environmental Economics (MAREE), 11 August 2001.

Barton, D.N. 1994. Economic factors and valuation of tropical coastal resources. SMR-Report 14/94, Bergen, Norway, 128 p.

Belli, P., J. Andersson, H. Barnum, J. Dixon and J. Tan. 2001. Economic analysis of investment operations: Analytical tools and practical applications. World Bank Institute, Washington D.C.

Berg, H., M.C. Öhman, S. Troëng and O. Lindén. 1998. Environmental economics of coral reef destruction in Sri Lanka. Ambio 27:627-634.

Brown, B.E. and R.P. Dunne. 1988. The environmental impact of coral mining on coral reefs in the Maldives. Environmental Conservation 15(2):159-166.

Caribbean Coastal Area Management (CCAM) Foundation. 1999. Management plan for the "Portland Bight Sustainable Development Area" 1998-2003. Prepared for the Natural Resources Conservation Authority, Kingston, Jamaica.

Carson, R.T., R.C. Mitchell, W.M. Hanemann, R.J. Kopp, S. Presser and P.A. Rudd. 1992. A contingent valuation study of lost passive use values resulting from the Exxon Valdez oil spill. Report to the Attorney General of the State of Alaska.

Cesar, H.S.J., M.C. Öhman, P. Espeut and M. Honkanen. 2000. An economic valuation of Portland Bight, Jamaica: An integrated terrestrial and marine protected area, Working Paper, Institute for Environmental Studies, Free University, Amsterdam.

Cesar, H. 1996, Economic analysis of Indonesian coral reefs. The World Bank, Washington, D.C.

Cesar, H., C. Lundin, S. Bettencourt and J. Dixon. 1997. Indonesian coral reefs: An economic analysis of a precious but threatened resource. Ambio 26(6):345-350.

Cesar, H. 2000. Coral reefs: Their functions, threats and economic value. *In* H. Cesar (ed.) Collected essays on the economics of coral reefs. CORDIO, Kalmar University, Kalmar, Sweden.

Cesar, H. and E. Hempel. 2000. Opportunities and constraints of grouper aquaculture in Asia. The World Bank, Washington, DC.

Costanza, R., R. d'Arge, R. de Groot, S. Farber, M. Grasso, B. Hannon, K. Limburg, S. Naeem, R.V.O. O'Neill, J. Paruelo, R.G. Raskin, P. Sutton and M. van den Belt. 1997. The value of the world's ecosystem services and natural capital. Nature 387:253-260.

De Groot, R.S. 1992. Functions of nature: Evaluation of nature in environmental planning, management and decision-making. Wolters-Noordhoff.

Dixon, J.A., L. Fallon Scura and T. van't Hof. 1993. Meeting ecological and economic goals: Marine parks in the Caribbean. Ambio 22:117-125.

Driml, S.M. 1994. Protection from profit: Economic and financial values of the Great Barrier Reef World Heritage Area and other protected areas. Research Publication 34, Great Barrier Reef Marine Park Authority, Townsville, Australia.

Driml, S.M. 1997 Bringing ecological economics out of the wilderness. Ecological Economics 23:145-153.

Driml, S.M. 1999. Dollar values and trends of major direct uses of the Great Barrier Reef Marine Park. Research Publication 56. Great Barrier Reef Marine Park Authority, Townsville, Australia, 12 p.

Driml, S.M., T.J. Hundloe and R.K. Blamey. 1997. Understanding Great Barrier Reef economics. Proceedings 1: The Great Barrier Reef, Science, Use and Management, A National Conference. James Cook University, Townsville, Australia.

Dulvy, N.K., D. Stanwell-Smith, W.R.T. Darwall and C.J. Horill. 1995. Coral mining at Mafia Island, Tanzania: A management dilemma. Ambio 24:358-365.

Edwards, S.F. 1991. The demand for Galapagos vacations: Estimation and application to wilderness preservation. Coastal management 19:155-169.

Espeut, P. and S. Grant. 1990. An economic and social analysis of small-scale fisheries in Jamaica. Paper prepared for the Food and Agriculture Organisation (FAO) of the United Nations.

Gustavson, K. 1998. Values associated with the local use of the Montego Bay Marine Park. Report Prepared for the Environmentally and Socially Sustainable Development Sector Department, Latin America and the Caribbean Region (LCSES) of the World Bank, Washington, D.C.

Halcrow. 1998. South coast sustainable development study. Technical Report 8 (Tourism), Kingston, Jamaica.

Haughton, M. 1988. An analysis of statistical data from the Jamaican inshore fisheries. *In* S. Venema, J.

Moller-Christensen and D. Pauly (eds.) Contribution to tropical fisheries biology. FAO Fisheries Rep. 389: 443-454.

Hausman, J. G. Leonard and D. McFadden. 1992. A Utility-Theoretic Combined Discrete Choice Model and Count Data Model: Assessing Recreational Use Losses Due to Natural Resource Damage, discussion paper, Massachusetts Institute of Technology (MIT).

Hodgson, G. and J.A. Dixon. 1988. Logging versus fisheries and tourism in Palawan: An environmental and economic analysis. Occasional Paper No. 7, East-West Environment Institute. King, O.H. 1995. Estimating the value of marine resources: a marine recreation case. Ocean and Coastal Management 27(1-2):129-141.

Hundloe, T., F. Vancly and M. Carter. 1987. Economic and socioeconomic impacts of the crown of thorns starfish on the Great Barrier Reef. Report to the Great Barrier Reef Marine Park Authority, Townsville, Australia.

Leeworthy, V.R. 1991. Recreational use value for John Pennekamp Coral Reef State Park and

Key Largo National Marine Sanctuary. Strategic Assessment Branch. Ocean Assessments Division. National Oceanic and Atmospheric Administration (NOAA). Rockville, Maryland, USA.

Marcondes, M. 1981. Adaptation de una metodologia de evaluation economica, aplicada al Parque Nacional Cahuita, Costa Rica Centro Agronomico Tropical de Investigacion y Ensenanza (CATIE), Serie Tecnica No. 9.

Mattson, J. S. and J. A. De Foor. 1985. Natural resource damages: Restitution as a mechanism to slow destruction of Florida's natural resources. Journal of Land Use and Environmental Law 1(3):295-319.

McAllister, D.E. 1988. Environmental, economic and social costs of coral reef destruction in the Philippines. Galaxea 7:161-178.

McAllister, D.E., 1991. What is a coral reef worth? Sea Wind 5(1):21-24.

McClanahan, T.R. 1999. Perspective: Is there a future for coral reef parks in poor tropical countries? Coral Reefs 18(4):321-325.

Moberg, F. and C. Folke. 1999. Ecological goods and services of coral reef ecosystems. Ecological economics 29:215-233.

Ngazy, Z., N. Jiddawi and H. Cesar. 2003. Coral bleaching and the demand for coral reefs: A marine recreation case in Zanzibar. *In* this vol. In these proceedings.

Öhman, M. and H. Cesar. 2000. Costs and benefits of coral mining. *In* H. Cesar (ed.) Collected essays on the economics of coral reefs. CORDIO, Kalmar University, Kalmar, Sweden.

Pearce, D.W. and D. Moran. 1994. The economic value of biodiversity. IUCN/Earthscan, London, U.K.

Pearce, D.W. and K.R. Turner. 1990. Economics of natural resource and the environment, 1st ed. Harvester Wheatsheaf, London, U.K.

Pendleton, L.H. 1995. Valuing coral reef protection. Ocean and coastal management 26(2):119-131.

Pet-Soede, C., H.S.J. Cesar and J.S. Pet. 1999. An economic analysis of blast fishing on Indonesian coral reefs. Environmental Conservation 26(2):83-93.

Pham, K.N. and V.H.S. Tran. 2003. Analysis of the recreational value of the coral-surrounded Hon Mun Islands in Vietnam. *In* these proceedings.

Posner, B. et al. 1981. Economic Impact Analysis for the Virgin Island Resources Foundation' St Thomas, US Virgin Islands. *(as cited in Pearce & Moran 1994)*.

Rajasuriya A., M.W.R.N. DeSilva and M.C. Öhman. 1995. Coral reefs of Sri Lanka: Human disturbance and management issues. Ambio 24:428-437.

Riopelle, J.M. 1995. The economic valuation of coral reefs: A case study of west Lombok, Indonesia. Dalhousie University, Halifax, Canada. Thesis.

Ruitenbeek, H.J. 1992. Mangrove management: An economic analysis of management options with a focus on Bintuni Bay, IJ. EMDI Environmental Report No. 8, Halifax and Jakarta.

Ruitenbeek, H.J. and C.M. Cartier (with contributions from L. Bunce, K. Gustavson, D. Putterman, C.L. Spash, J.D. van der Werff, S. Westmacott and R. Huber). 1999. Issues in applied coral reef biodiversity valuation: Results for Montego Bay, Jamaica. World Bank Research Committee Project RPO#682-22 Final Report, World Bank, Washington D.C.

Sathirathai, S. 1998. Economic Valuation of Mangroves and the Roles of Local Communities in the Conservation of Natural Resources: Case Study of Surat Thani, South Thailand, EEPSEA Research Report Series, Singapore.

Salvat, B. (ed.) 1987. Human Impacts on Coral Reefs: Facts and Recommendations. Antenne de Tahiti Museum, E.P.H.E.

Sawyer, D.A. 1992. Taka Bone Rate: Management, development and resource valuation of an Indonesian atoll. Dalhousie University, Halifax, Canada. M.A. thesis.

Seenprachawong, U. 2004. An economic analysis of coral reefs in the Andaman Sea of Thailand. *In* these proceedings.

Spash, C.L., J.D. van der Werff, S. Westmacott and H.J. Ruitenbeek. 1998. Lexicographic preferences and the contingent valuation of coral reef biodiversity in Curaçao and Jamaica. Study prepared for the World Bank. World Bank, Washington D.C.

Spurgeon, J.P.G. 1992. The economic valuation of coral reefs. Marine Pollution Bulletin 24:529-536.

Subani, W. and M.M. Wahyono. 1987. Study on destruction of coastal ecosystem and its impact on the fishery resources on the south coast of Bali, west and east coast of Lombok, and Jakarta Bay. Journal of Marine Fisheries Research 42:53-70.

Westmacott, S., H. Cesar and L. Pet-Soede. 2000a. Socioeconomic assessment of the impacts of the 1998 coral reef bleaching in the Indian ocean. *In* D. Souter, D. Obura and O. Linden (eds.) Coral reef degradation in the Indian Ocean: Status Report 2000. CORDIO, Sweden.

Westmacott, S., I. Ngugi and J, Andersson. 2000b. Assessing the impacts of the 1998 coral bleaching on tourism in Tanzania and Kenya. *In* S. Westmacott, H. Cesar and L. Pet-Soede (eds). Assessment of the socioeconomic impacts of the 1998 coral reef bleaching in the Indian Ocean. CORDIO, Sweden.

Westmacott, S., H. Cesar, L. Pet-Soede and O. Linden.

2000c. Coral bleaching in the Indian Ocean: Socioeconomic assessment of effects. *In* H. Cesar. 2000. Collected essays on the economics of coral reefs. CORDIO, Sweden.
Wilkinson, C.R., O. Linden, H. Cesar, G. Hodgson, J. Rubens and A.E. Strong. 1999. Ecological and socioeconomic impacts of 1998 coral mortality in the Indian Ocean: An ENSO impact and a warning of future change? Ambio 28(2):196-199.
World Resources Institute (WRI). 1998. World resources 1998-1999. UNEP, UNDP and the World Bank, Oxford University Press, Oxford, U.K.
Wright, M.G. 1994. An Economic Analysis of Coral Reef Protection in Negril, Jamaica. Williams College, Williamstown, Massachusetts. Thesis.
Yeo, B.H. 2004. The recreational benefits of coral reefs: A case study of Pulau Payar Marine Park, Kedah, Malaysia. *In* these proceedings.

Annex I: Economic values for marine systems – a compilation from the literature[13]

Summary table

Study	Direct Use	Indirect use	Non-use	Total economic value	Benefit/ opportunity cost ratio
1 Cahuita National Park, Costa Rica; *Marcondes (1981)*	√				√
2 Virgin Islands National Park, St. Johns; *Posner et al. (1981)*	√				√
3 Great Barrier Reef; *Carter et al. (1987)*	√				
4 Great Barrier Reef 'Region'; *Hundloe et al. (1987)*	√		√		
5 Bacuit Bay, Philippines; *Hodgson and Dixon (1988)*	√				
6 Philippines; *McAllister (1988)*	√				
7 Galapagos National Park, Ecuador; *Edwards (1991)*	√				
8 Philippines Coral Reefs; *McAllister (1991)*		√			
9 Galapagos National Park; *de Groot (1992)*	√	√	√	√	√
10 John Pennekamp/Key Largo; *Leeworthy (1991)*				√	
11 Panama Coral Reefs; *Spurgeon (1992)*	√				
12 Valdez Oil Spill, Alaska; *Hausman et al. (1992)*	√				
13 Valdez Oil Spill; *Carson et al. (1992)*			√		
14 Bonaire Marine Park; *Dixon et al. (1993)*				√	
15 Taka Bone Rate Coral Reef Atoll, Indonesia; *Sawyer (1992)*	√				
16 Bonaire Marine Park; *Pendleton (1995)*				√	
17 Coral Reefs at Negril, Jamaica; *Wright (1994)*				√	
18 Indonesia Coral Reefs; *Cesar (1996)*	√	√			
19 Montego Bay Coral Reefs; *Spash et al. (1998)*			√		
20 Montego Bay Coral Reefs; *Gustavson (1998)*	√	√			
21 Great Barrier Reef; *Driml (1999)*	√				
22 Montego Bay Coral Reefs; *Ruitenbeek and Cartier (1999)*		√			
23. Eastbourne, English Channel; *King (1995)*	√				
24 John Pennekamp Coral Reef State Park & adjoining Key Largo National Marine Sanctuary; *Mattson and DeFoor (1985)*	√				
25. Pulau Payar Marine Park, Malaysia: Non-Use Value; *Ayob et al. (2001)*			√		
26. Recreational coral bleaching and the demand for coral reefs: A case study; *Ngazy et al. (2004)*	√			√	
27. An economic analysis of coral reefs in the Andaman Sea of Thailand; *Seenprachawong (2004)*	√			√	
28. Valuation of recreational benefits: An application of the travel cost model to the Bolinao coral reefs in the Philippines; *Ahmed, et al. (2004)*	√				
29. Analysis of the recreational value of the coral-surrounded Hon Mun Islands in Vietnam; *Pham and Tran (2004)*	√				
30. Recreational benefits of coral reefs: A case study of Pulau Payar Marine Park, Kedah, Malaysia; *Yeo (2004)*	√				

[13] Reproduced from Cesar (2000), Pearce and Moran (1994), Cartier and Ruitenbeek (1999) and other articles.

1 Cahuita National Park, Costa Rica; *Marcondes* (1981)

Direct use:
A form of TC appraisal of the recreational value of the Cahuita National Park, Costa Rica. Consumer surplus estimates were derived from observed wage equivalent travel time net of transport costs multiplied by visitor population. The resulting benefit-cost ratio demonstrated that the park is economically beneficial.

Benefit/opportunity cost ratio:
Cahuita National Park ratio 9.54. (A conventionally assessed ratio rather than one based on opportunity cost.)

2 Virgin Islands National Park, St. Johns; *Posner et al.* (1981)

Direct use:
Conventional benefit-cost analysis of the Virgin Islands National Park, St. Johns, identified significant direct and indirect benefits associated with the park, particularly tourist expenditure and the positive effect on land values in proximity to the designated area. Little information is available on the environmental effects of alternative land uses or the extent of visitors' consumer surplus. Total benefit (1980) approximated US$8 295/ha over about 2 820 ha of National Park on St Johns.

Benefit/opportunity cost ratio:
Ratio of total (direct and indirect) benefits to total cost 11.5 (A conventionally assessed ratio rather than one based on opportunity cost.)

3 Great Barrier Reef; *Carter et al* (1987)

Direct use:
Estimating the socioeconomic effect of the Crown of Thorns starfish on the Great Barrier Reef. This TC study provided estimates of consumer surplus of AU$117.5 million/year for Australian visitors and AU$26.7 million/year for international visitors. The study showed that tourism to the reef is valued (in NPV terms) over and above current expenditure levels by more than AU$1billion.

4 Great Barrier Reef 'Region'; *Hundloe et al.* (1987)

Direct use:
A TC study of the Great Barrier Reef estimated AU$144 million/year consumer surplus for domestic tourists and international tourists, based on travel cost expenditure by visitors to the 'Reef Region'.

The same study estimated consumer surplus from visits to coral sites and the 'Reef Region' of the Great Barrier Reef at AU$106 million/year, based on TC to coral sites by domestic and international tourists, and includes all attributes of the 'Reef Region'.

A CVM study on the Great Barrier Reef also provides an estimate of AU$6 million/year consumer surplus, or over AU$8/adult visitor WTP to see coral sites in their present (1986-87) condition; based on a survey of visitors to reef sites only, thereby excluding all other attributes of the Great Barrier Reef 'Reef Region'.

Non-use:
Based on a 1986 mail survey of Australian citizens older than 15 years, the CVM study estimated AU$45 million/year consumer surplus or AU$4/visit WTP to ensure that Great Barrier Reef is maintained in its current state. Estimate excludes respondents who had visited the Reef.

5 Bacuit Bay, Philippines; *Hodgson and Dixon* (1988)

Direct use:
Using (EoP) productive change method, the study at Bacuit Bay, Philippines, concluded that the PV gross revenue for recreation and tourism of the location is US$6 280 with logging, versus US$13 334 with logging ban. Computation was based on mean hotel capacity, occupancy, and daily rates; and an assumed 10 per cent annual decline in tourism revenue due to degradation of seawater quality from sedimentation.

The study also estimated the PV gross revenue for fisheries to be US$9 108 with logging versus US$17 248 with logging ban, based on assumed constant returns to scale of natural systems; and on regression analysis of sediment loading, coral cover and species, and fish biomass relationships.

CBA study evaluates management options: (i) continuation of logging as usual; (ii) logging ban in Bacuit Bay drainage basin.

6 Philippines; *McAllister* (1988)

Direct use:
Using productivity change, the study estimated US$80 million/year of loss in fish production in Philippines caused by dynamiting, muro-ami, and poisoning of coral reefs; based on estimates of current and potential production. Production levels were calculated for varying levels of reef quality.

Productivity Change was also used to estimate the aquarium trade in the Philippines. Global aquarium trade attributable to the Philippine Coral Reefs (US$10 million in 1988) could be increased by 50 per cent with sustainable production practices. The price of Philippine aquarium species is discounted internationally due to method of capture.

7 Galapagos National Park, Ecuador; *Edwards* (1991)

Direct use:
Using Hedonic Demand Analysis, based on a non-linear regression using cost, duration, and itinerary data from travel brochures, as well as cost and duration survey data, this study estimated vacation value of Galapagos National Park, Ecuador at US$312/day/person in 1986.

8 Philippines Coral Reefs; *McAllister* (1991)

Indirect use:
A Replacement Cost study of coastal protection afforded by the Philippines coral reefs. The study estimated US$22 billion, based on construction costs of concrete tetrapod breakwaters to replace 22 000 km^2 of reef protection. As reported by Spurgeon (1992).

9 Galapagos National Park; *de Groot* (1992)

Direct use:
Using productivity change method on Galapagos National Park, de Groot estimated US$0.40/ha/yr (permitted) ornamental product sales; US$0.70/ha/yr local fish and crustacean harvest; and US$5.20 /ha/yr construction materials as having productive use value within the "production function" category of environmental functions.

The study also estimated US$45/ha/yr for recreational value for the total protected area, based on maximum carrying capacity of 40 000 visitors/year, and average expenditure per visit of US$1 300.

US$2.73/ha/yr was estimated for education and research of marine areas, based on research expenditures, and expenditures on field courses, fellowships, training courses, education facilities and materials.

Indirect use:
A Replacement Cost study for organic waste treatment at Galapagos National Park estimated US$58/ha/yr based on the costs of artificial purification technology (applies to marine area only).

Shadow Price was used to estimate the cost for biodiversity maintenance. Estimate of US$4.9/ha/yr, equal to 10 per cent of the market value of any activity reliant on biodiversity maintenance. Classified as a conservation value of the Galapagos National Park, in the category of 'regulation functions'.

The same study also estimated US$0.55/ha/year for nature protection; based on the park budget and the idea that money invested in conservation management should be seen as productive capital because of the environmental functions and socioeconomic benefits provided by conservation of Galapagos National Park.

Non-use:
Based on sales of books and films, de Groot estimates US$0.20/ha/yr for cultural/artistic inspirational use; based on donation, de Groot estimates US$0.52/ha/yr for spiritual use for Galapagos National Park.

An option value of US$120/ha/yr was also estimated, which is equal to the total value of all the park's conservation and productive use values combined. Conservation values include *inter alia* habitat/refugia value and recreation, while productive uses include food, construction materials, etc.

Total economic value:
Total annual monetary returns from direct and indirect use of Galapagos National Park approximate US$120/ha/yr. In present value terms this represents US$2 400/ha (at 5 per cent discount rate) or almost US$2.8 billion for the entire study area.

Benefit/opportunity cost ratio:
Benefit Transfer was used by de Groot on Galapagos National Park: US$7/ha/yr was estimated based on the similarities of the Dutch Wadden Sea and Galapagos estuarine areas. It was assumed that 10 per cent of fishery in Galapagos depends on the nursery function provided by inlets and mangrove lagoons.

10 John Pennekamp/Key Largo; *Leeworthy* (1991)

Total economic value:
TCM estimates a consumer surplus for recreation and tourism of US$285 to US$426/person/day, based on a survey of some 350 park users in 1990 at John Pennekamp/Key Largo, Florida. Nine models were estimated, final range was taken from the two models which best fitted the data. The inclusion of an 'opportunity cost of time' variable was found to increase significantly consumer surplus estimates.

11 Panama Coral Reefs; *Spurgeon* (1992)

Direct use:
Based on a percentage of the Smithsonian Research Institute's budget for work in Panama, the education and research value of Panama coral reefs is estimated at US$2.5 million in 1991. One-sixth of the 1991 US$15 million budget is considered attributable to coral reefs in Panama.

On the other hand, the education and research value of the Belize coral reefs value was estimated at US$150 000/year, based on annual expenditures by UK Coral Cay Conservation to maintain 25 researchers on reefs in Belize.

12 Valdez Oil Spill, Alaska; *Hausman et al.* (1992)

Direct use:
A Recreation Demand study estimated the value of recreation use losses caused by the Valdez oil spill in Alaska at US$3.8 million (1989).

13 Valdez Oil Spill; *Carson et al.* (1992)

Non-use:
A CVM study of oil spill by the *Exxon Valdez* estimated median per household WTP of US$31 as a one-off amount to prevent future oil spills. Aggregating over affected households derives an estimate of US$2.8 billion as the total lost passive-use values as a result of the *Exxon Valdez* oil spill.

14 Bonaire Marine Park; *Dixon et al.* (1993)

Total economic value:
A CVM study on recreation and tourism at the Bonaire Marine Park reports a mean annual WTP estimate of US$27.4 for diving. At visitation rates of 18 700 divers (1992) paying US$10/diver/year fee, estimated consumer surplus is US$325 000.

Using productivity change, gross tourist revenue estimated at US$23.2 million (1991). The study also estimated the revenues and costs of dive tourism, and the carrying capacity of dive sites (4 000–6 000/site/year, for a total of 190 000–200 000).

15 Taka Bone Rate Coral Reef Atoll, Indonesia; *Sawyer* (1992)

Direct use:
A productivity change study on Taka Bone Rate Coral Reef Atoll in Indonesia estimates PV gross revenues (in billion Rp): -2 to 103 without management vs 47 to 777 with management; based on fishing activity surveys; and sensitivity analyses wherein fish catch declines are 0-15 per cent and the discount rates are 5 to 15 per cent. CBA study evaluates management options: (i) no management; (ii) establishment of marine park with regulated fishing.

16 Bonaire Marine Park; *Pendleton* (1995)

Total economic value:
Economic valuation for dive at Bonaire Marine Park, using productivity change method, net tourism revenue estimated to be US$7.9 to 8.8 million (1991); based on ownership and profit data.

TCM study yields consumer surplus of US$19.2 million.

Park NPV study based on 20 year period discounted at 10 per cent estimates local benefits at US$74.21 million and consumer surplus as US$1 79.7 million.

17 Coral Reefs at Negril, Jamaica; *Wright* (1994)

Total economic value:
Based on CVM survey data and 162 000 visitors/year on Negril, Jamaica, the study elicits WTP of US$31/person/year for a consumer surplus of US$5 million/year to maintain coral reef in current condition; and US$49/person/year for a surplus of US$8 million/year to restore reefs to "excellent" condition.

TCM was also used to estimate a demand curve for vacations; the coral reef consumer surplus was netted out of vacation consumer surplus to examine the resultant shift in demand and reduction in tourist volume if reef quality should decline.

18 Indonesia Coral Reefs; *Cesar* (1996)

Direct use:
Using productivity change method on Indonesian coral reefs, NPV of fisheries loss/sq km estimated at: US$40 000 (poison fishing); US$86 000 (blast fishing); US$94 000 (coral mining); US$81 000 (sedimentation); and US$109 000 (over-fishing); based on assumptions about the reef and fishery impacts of these practices. The study uses CBA to compare the private and social net benefits of a sustainably managed reef fishery, with those of a fishery subjected to detrimental fishing practices, coral mining, or sedimentation.

The same method was used to estimate the NPV of tourism loss/km^2 of reef in Indonesia. It was found to be: US$3 000 to US$436 000 (from poison fishing); US$3 000 to US$482 000 (blast fishing and coral mining); and US$192 000 (sedimentation) based on assumptions regarding the rate of reef degradation associated with each practice. CBAs for each activity (inc. reef-destroying activity) estimate the value of tourism loss. For each activity, reef degradation causes a decrease in potential tourism revenue. All rates of change are based on assumptions.

Indirect use:
Using productivity change method, NPV of coastal protection/km^2 of reef was estimated at US$9 000 to US$193 000 (blast fishing); US$12 000 to US$260 000 (coral mining); based on replacement costs, the rate of reef destruction by each activity, and the rate of decline in the reef's ability to protect. CBAs for each reef-destroying activity include the cost of protective function losses. For each activity, reef destruction reduces the protective capability of the reef. The reef's loss of protective capability is linked linearly to its protective value.

19 Montego Bay Coral Reefs; *Spash et al.* (1998)

Non-use:
Using CVM on Montego Bay coral reefs, with survey design specifically targeted to dealing with lexicographic preferences through probing of zero bids and analysis of zero bids using Tobit estimation. Expected WTP for non-use value of tourists ranged from US$1.17 to US$2.98 for 25 per cent coral reef improvement; for locals range was US$1.66 to US$4.26. Upper values were for respondents perceiving strong moral duties and rights; lower were for no such duties/rights. Based on population characteristics, non-use NPV of Montego Bay reefs estimated to be US$19.6 million.

A similar CVM survey with similar design as Montego Bay study was conducted at Curacao coral reefs. Expected WTP for non-use value of tourists ranged from US$0.26 to US$5.82, for locals, range was US$0.19 to US$4.05. Based on population characteristics, non-use NPV of Curacao reefs estimated to be US$4.5 million.

20 Montego Bay Coral Reefs; *Gustavson* (1998)

Direct use:
Using productivity change method, NPV of US$1.31 million was estimated for artisanal fisheries at Montego Bay Coral Reefs (1996); including trap, net, handline and spear-fishing by local fishers. Cost of inputs is deducted from gross values to arrive at net values. Base case assumes shadow price of labour of 75 per cent market rate; 100 per cent market valuation leads to negative NPVs for fishing.

Recreational NPV of coral reefs at Montego Bay was estimated at US$315 million (1996) in the study. Calculation included tourist-related accommodation, food and beverage, entertainment, transportation, retail and miscellaneous services. Cost of service provision is deducted from gross values to arrive at net values.

Indirect use:
Using productivity change method, the NPV of coastal production at Montego Bay coral reefs was estimated at US$65 million (1996); based on

value of land at risk or vulnerable to coastal erosion along foreshore. Author notes this is upper value and is dependent on erosion incidence assumptions in absence of reef, which are highly speculative.

21 Great Barrier Reef; *Driml* (1999)

Direct use:
Using productivity change method, gross revenues of fisheries on Great Barrier Reef is estimated at AU$143 million (1996), based on 1995/6 catch data for major commercial species, and a survey of current fish prices. Study updates Driml (1994), estimates presented in Driml (1997) and Driml et al. (1997).

The study also estimated the gross recreational value for the Great Barrier Reef at AU$769 million (1996) using productivity change method. This includes AU$647 million for commercial tourism and AU$123 million for recreational fishing and boating; based on volume and price data for hotel stays and reef trips, and survey data for private recreational boat use. This study also updates Driml (1994).

22 Montego Bay Coral Reefs; *Ruitenbeek and Cartier* (1999)

Indirect use:
Value of Montego Bay coral reef based on model incorporating drug values, local bio-prospecting costs, institutional costs, discovery success rates for marine extracts, and a hypothetical bio-prospecting program for the area using National Cancer Institute sampling protocols. Model highlights role of revenue-sharing arrangements and ecosystem yield in deriving total benefits and marginal benefits. Average net social value of species in base case is estimated to be US$7 775. Based on base case sampling program, total social NPV of Montego Bay reef area is US$70.09 million. First differential of the benefit function yields US$225 000/% or US$530 000/ha coral abundance.

23. Eastbourne, English Channel; *King* (1995)

Direct use:
Using CVM, based on 179 randomly selected individuals, with 167 responses, the mean WTP for recreational beach use and reduction in the frequency of oil spill were estimated at £1.78 and £1.41 respectively. 80 per cent of the zero WTP were protest votes. The aggregated annual recreational use value of the beach was estimated at £4.5 million. It was estimated as a product of mean WTP and the total number of beach days (2.6 million based on the Eastbourne Tourism Survey conducted in 1990). King considers this as the lower bound of the value as non-use and option values are not included in the calculation.

24 John Pennekamp Coral Reef State Park & adjoining Key Largo National Marine Sanctuary; *Mattson and DeFoor* (1985)

Direct use:
Using TC, the study estimated revenue for the beach use from recreational diving, sightseeing and snorkelling at US$47.6 million for 1984-1985, or US$85 per square metre for John Pennekamp Coral Reef State Park and adjoining Key Largo National Marine Sanctuary.

Number of visitors was estimated from the visitors going through the park gate (644 628 people) and those going into the water (467 370 people) from 1 July 1984 to 30 June 1985. About 64 per cent of the total estimated water visitors go to the reef in dive boats. Travel costs include expenses on transportation, meals, lodging, dive trip costs, air tank fills and a portion of diving gear costs.

25. Pulau Payar Marine Park, Malaysia: Non-Use Value; *Ayob et al.* (2001)

Non-use:
Using CVM (referendum) method, the study aims to elicit the WTP from non-users of Pulau Payar Marine Park for non-use values. The WTP for non-use values computed averaged RM31.02 (US$8.16) and dropped to RM30.14 (US$7.93) with revision. Respondents agreed to contribute to the fund for bequest value (52 per cent), existence value (22 per cent) and option value (17 per cent).

26. Recreational coral bleaching and the demand for coral reefs: A case study; *Ngazy et al.* (2003)

Direct use/Total economic value:
Based on a CVM questionnaire survey with 157 divers, the study elicited an average WTP of US$84.7 extra per person per year to dive in more pristine reef sites. Based on the WTP, the authors estimated the economic loss due to bleaching ranged between US$1.6 and US$4.8 million

depending on whether 25 per cent or 75 per cent of visitors to Zanzibar dived. The financial revenue from diving ranged between US$2.5 and US$7.4 million on the same assumption.

27. An economic analysis of coral reefs in the Andaman Sea of Thailand; *Seenprachawong* (2003)

Direct use:
Using TCM, the study estimated the annual benefit from the recreational services of Phi Phi at US$205.41 million. That is, the value of Phi Phi is about US$6 243 per ha per year.

Total economic value:
CVM was used to estimate utility values associated with coral reef biodiversity at Phi Phi. The mean willingness to pay (WTP) per visit was estimated at US$7.17 for domestic visitors and at US$7.15 for international visitors. The total value of Phi Phi's coral reefs was estimated to be US$147 000 a year for domestic visitors and US$1.24 million a year for international visitors. The CVM study also estimated the total value (use and non-use) of the reefs to be US$497.38 million a year, averaging US$15 118 per ha per year.

28. Valuation of recreational benefits: An application of the travel cost model to the Bolinao coral reefs in the Philippines; *Ahmed, et al. (2005)*

Direct use:
Using TCM, the study estimated an average consumer surplus of US$223 per person, equivalent to US$1.3 million based on the crude estimate of 5 845 visitors to the reef at Bolinao in the peak season during March to May in 2000.

29. Analysis of the recreational value of the coral-surrounded Hon Mun Islands in Vietnam; *Pham and Tran (2003)*

Direct use:
Using the zonal TCM, the study estimated the recreational value of the coral-surrounded Hon Mun Islands to be US$17.9 million a year. The annual recreational value estimated for the islands using the individual TCM was approximately US$8.7 million.

CVM was used to elicit WTP to a MPA trust fund, with total WTP from domestic tourists estimated at US$241 239 and WTP from foreign tourists estimated at US$175 450.

30. Recreational benefits of coral reefs: A case study of Pulau Payar Marine Park, Kedah, Malaysia; *Yeo* (2003)

Direct use:
91 per cent of visitors interviewed were willing to pay an entrance fee to Pulau Payar Marine Park, estimated at an average WTP of slightly more than US$4. Using CVM, the annual recreational value was estimated to be US$390 000.

Estimating the Value of Coral Reef Management Options

Jeff Bennett*

Abstract

Incentives for coral reef resource use have, historically, been skewed toward extractive options that yield private returns, and against protection options that provide predominantly public good benefits. The consequence of this incentive imbalance has been an excessive rate of coral reef resource exploitation and hence an under-supply of protected coral reefs. Numerous policy options, ranging from direct government intervention that sets aside specific reef areas as reserves, through to the encouragement of reef-based industries that are predicated on reef protection (for example, ecotourism), are available to correct the situation. However, before such policies are implemented, it is useful to gain an appreciation of the extent of change that would be in the best interest of society. Put simply, it is important to know where to go before starting off on the journey.

To achieve this understanding, it is necessary to gather information regarding the costs of alternative coral reef management options and the benefits they generate. Problematic in the quest for information on the benefits of coral reef protection is that many of the benefits are not marketed. In order to compare relative costs and benefits across a range of management options, a numeral, or unit of measurement, of value is required. In most societies, value is commonly measured in money terms. A challenge to economists is, therefore, the estimation, in monetary terms, of non-marketed, environmental benefits.

One technique that is useful in the estimation of non-marketed values is choice modeling. In a choice modeling application, people who are likely to be affected by changes in resource management are asked, in the format of a questionnaire, to select their preferred management options from a range of options. The options are described in terms of the characteristics or attributes of their outcomes. For instance, coral reef management options may be described in terms of the number of fish species that are present on the reef and the area of coral in a healthy condition. A statistical analysis of the choice made by the questionnaire respondents allows the development of a model that explains the probability of an option being selected by respondents in terms of the attributes of the option's outcomes and the socioeconomic characteristics of the respondents. So long as one of the attributes used to describe the option's outcomes is monetary – for instance, an additional tax to be used to fund the environmental improvements offered by the option – the model of choice can be used to estimate, in monetary terms, the values people place on different management options.

The journey

Whenever starting off to travel to a new destination, three things are critical. We need to know where we are. We need to know where we want to be. And, with those two pieces of information, we need to work out the best way of getting from one to the other. The same three elements are important for many kinds of decisions we make as individuals and with our

* Professor of Environmental Management, National Centre for Development Studies, Australian National University, Canberra ACT 0200 AUSTRALIA.
E-mail: jeff.bennett@anu.edu.au

families. For instance, if we are contemplating buying a house, its important to start off by thinking about our current situation – what we like and don't like about where we currently live, how much money we have saved, etc. Then we can start looking around to see what housing options are available and make a decision which suits us best. Finally, we go through all those painstaking processes that are involved in selling the old house, arranging finance, buying the new house, moving in, changing our address, etc.

If a decision is made on any of these three elements without adequate information, the chances are that we will end up regretting the choice make. For instance, without knowing much about the housing options that are available to us, we might decide on a house that turns out to be worse than the one we are currently occupying. Or if we don't do our homework on the financial arrangements that will enable the purchase of the new house, we may find that we eventually can't afford the change.

Broader groups in society also make decisions. Local communities, provincial governments and national governments have various decision-making responsibilities for the use of resources that have social, economic and environmental impacts. Information regarding our current situation, the impacts on us from making a change, and the mechanisms required to deliver changes that are considered desirable are likely to help in fulfilling those responsibilities. Just as with decisions we take as individuals, if information on the three key decision elements isn't collected and analyzed, the choices made may make the community worse off.

Decisions made by individuals and broader groups in society regarding the use of the resources found in coral reefs can be considered in this way.

Where are we?

First, where do we currently stand in terms of the way coral reef resources are used?

Coral reefs are used for many different purposes. Some people secure their livelihoods from reefs through the harvesting of products for commercial and subsistence use. Others use reefs as the venue for their recreation – diving and snorkelling to look at the diversity of life found there. In doing this, they may also provide income for the people who facilitate their visit. For coastal communities, reefs can also provide important protection against rough seas during storm events. People don't even have to visit a reef to enjoy it. Some people "use" reef resources to provide them with the knowledge that the ecosystem – with its biodiversity – is maintained in good condition.

An analysis of the current situation reveals an important inconsistency. The people who use the reef for "extractive" purposes – the harvesting of reef products – have a strong personal incentive for their activities. They make themselves better off by either directly consuming or selling their harvest. In many cases, because the reef resource is not owned or policed by anyone or any group, resource extractors enjoy their spoils without having to pay for access to the resource. In this situation, the resource is likely to be over-exploited. In other words, the harvesting of reef resources will expand beyond what is best for society as a whole. Symptoms of this are the catching of undersize and spawning fish, and the excessive removal of non-renewable stocks of coral and sand.

While the "passive" users of reefs similarly act in their own best interest, in the main part their actions do not result in the extraction of resources. The benefits enjoyed are typically "joint" in consumption; that is, the use of the reef by one person does not prevent another from enjoying the same benefit. But there are exceptions to this. For example, a very popular reef may experience congestion to the point where the enjoyment of one diver is reduced by the presence of another.

The use of the reef for extractive purposes can have an effect on the ability of the reef to provide for the passive users. And, without any form of ownership in place, the passive users have no avenue to protect their access to the reef resources through market means. Even if there were ownership and enforcement rules in place, passive users may choose not to pay to secure access, preferring to "free-ride" in the hope that enough other people will pay to ensure that the free-rider's access is assured at no personal cost. The danger inherent in free-riding behavior is that everyone free-rides and, consequently, access rights are lost to the extractive users.

The starting point for the journey is, therefore, a situation in which the balance of incentives is heavily skewed toward the use of reef resources for extractive purposes. Hence, the reef resources are being run down at a rate in excess of what is socially desirable. The passive users of resources are being left behind in the race for resource access. This is not necessarily because the passive uses of the reef resources are not as valuable as the extractive uses, but rather because of the lack of an appropriate mechanism to see that the race between the alternative uses is run on an even track. Currently, the passive uses are being hindered by a host of obstacles.

Keeping in mind this unsatisfactory situation, we need to consider the second element of choice.

Where do we want to be?

The current situation gives every indication of delivering to society an outcome that could be improved by some change toward less extractive uses and more passive uses of reef resources. The question is, how much change? We basically have an idea of the direction in which we should be moving but without much indication of how far or how fast we should travel.

To address this element of the information required for decision-making, we need to establish the criteria to be used to judge if various options for changing reef resource use are "better" or "worse" for society. The approach taken by economists is to consider the net impact on human wellbeing of changing from the current situation (a "business as usual" scenario) to the proposed situation, or change option. The option that yields the greatest net benefit to society is the one for which we should be aiming.

In other words, economists seek to assess the benefits that changes are likely to generate for people, weigh those up against their respective costs and advise as to which option delivers the best net value. Be assured that there will be costs associated with change. For instance, options that involve less extractive use of reef resources will involve those currently benefiting from those extracted resources being made worse off, unless they are paid compensation by those who gain from the greater access to passive uses of the reef that arises from the change.

A major challenge facing economists seeking to provide this type of information to decision-makers is the selection and application of a numeral with which both costs and benefits of change can be estimated. Money is well recognized in most societies as the unit used to assess the value of goods and services, and markets are widely available to provide the necessary data inputs to estimate values. Hence, the values generated through the extraction of reef resources can be predominantly estimated by reference to data from markets in which those products are traded.

However, many of the passive use values arise from goods and services that are not marketed. Some – such as access to a reef for recreational use – are associated with marketed products, such as travel, accommodation and sporting equipment. Others – such as the benefits of biodiversity protection – are unrelated to any market activity. This makes monetary estimation of values a particularly challenging issue for economists and one that will be addressed in later sections of this paper.

How do we get there?

With knowledge of what is a preferred allocation of reef resources, the next step is to devise strategies to deliver the change. Earlier, it was argued that the current situation is not delivering to society the reef outcomes that are most desirable because the incentives for extractive use have an overly powerful impact on the allocation process. It was argued that this was often the result of a breakdown in the rules that govern ownership of the resource, or in the process that sees such rules enforced.

This gives us some clues as to how we might achieve the more desirable outcomes identified in the second phase of information provision. Strengthening the institutions that define ownership and lowering the costs of enforcement of those institutions are measures that can be taken. This would allow decentralized resource allocation processes (such as markets) to work toward the desired change. Where such a decentralized approach will not go far enough to achieve the identified goal, more centralized intervention may be desirable. Such measures as the establishment of fish quotas or more direct restrictions on particular extractive uses come under this category. While, due to cost efficiency and flexibility advantages, decentralized mechanisms are usually preferred over such centralized approaches, there are cases where the costs of establishing and policing ownership rights may simply be too high for decentralized allocation processes to operate.

Nevertheless, intervention can be a dangerous strategy if the vehicle to deliver change is not suited to the task it is required to perform. For instance, it may be decided that change should be effected by national government establishing a series of maritime national parks in which no extraction of reef resources is permitted. However, this strategy may deliver an outcome that actually makes society worse off than it is currently because the extent of the lost extractive values is greater than the passive use values that are protected. Conversely, a strategy for change could deliver insufficient protection for passive use values.

Difficulties associated with estimating the non-monetary, non-marketed values associated with change options can also be a reason for the premature establishment of centralized intervention measures to bring about change.

Because of the importance of estimating the non-market values associated with coral reef resource use options, the remainder of this paper provides an examination of some of the techniques that have been developed by economists to address this task.

Non-market value estimation

Economists rely on two basic approaches to estimate peoples' values for non-market consequences of changes to resource use. The first involves observing peoples' actions in markets that are in some way related to the non-market value under investigation. Such methods are known as "revealed preference techniques". The second involves directly or indirectly asking people to state how much they value the outcomes being considered. These are the "stated preference techniques".

Revealed preference techniques are generally regarded as being reliable and robust. They include the "travel cost" method and the hedonic pricing technique. The former uses the relationship between frequency of visits to a recreation area and the cost of a visit in order to infer the value of the recreational experience enjoyed. The latter allows the estimation of values for non-market factors through their impacts on the prices paid for marketed goods such as real estate.

However, revealed preference techniques are restricted in that they can only be used to estimate a limited array of the non-market values provided by coral reef management options. Other non-market values – including the values generated by biodiversity protection – are isolated from markets completely. This is a characteristic of the non-market values where direct contact with the resource itself is not a prerequisite. In addition, revealed preference techniques are limited by their *ex post* nature. They rely on data relating to events that have already happened. Where reef management options are innovative, no reference data may be available.

These limitations encouraged economists to develop the stated preference techniques. The first of these to be applied was the contingent valuation method (CVM).[1] In its earliest form, the CVM involved respondents to a questionnaire simply being asked to state the maximum amount of money they would be willing to pay for an improved set of non-market outcomes. The technique was heavily criticized,[2] primarily because of the potential for respondents to behave strategically by misrepresenting the value they receive. Economists have responded to this criticism in two ways. First they have refined the CVM into a form that involves respondents being asked if they are willing to pay a pre-assigned sum for a specific improvement in the provision of the non-market good being valued. This "dichotomous choice" form of the CVM was shown to be "incentive compatible". However, the technique was limited by being able to produce only one non-market value estimate per application (questionnaire). Its use was, therefore, limited because of the expense involved. It also involved problems associated with the use of an inappropriate questioning frame. Where the scenario depicted in the CVM questionnaire is inconsistent with the context of the real decision-making circumstance, the value estimates so obtained are likely to be biased. For instance, if the respondent is not made aware of potential substitute and complementary goods and services, their reported willingness to pay may be either over- or under-stated.

In part to address the criticisms of CVM, economists have developed other stated preference techniques. Most notable of these has

---

[1] See Mitchell and Carson (1989).

[2] See Portney (1994).

been choice modeling – also referred to as choice experiments.

Choice modeling

Choice modeling (CM) has its origins in psychology, market research and transport economics. Its primary applications have been in the prediction of market shares for newly developed products. For instance, a firm considering the introduction of a new breakfast cereal could use CM to predict its likely performance as a competitor against established products. In the transport field, the technique is used to forecast the sharing of current traffic on a particular route between alternative transport modes if a new service were introduced.

The method adopts a perspective of goods as "bundles" of attributes and characteristics. Each individual product is pictured as a bundle of these attributes supplied at particular levels. For example, milk is considered as a bundle of attributes including volume, price, fat content and packaging type. A specific product may, therefore, be a one liter plastic container of low fat milk retailing for US$2.

In a marketing application of CM, milk consumers would be presented with a sequence of questions in which they are asked to select their preferred milk product from a range of alternatives. The questions in the sequence differ in that the milk products offered are altered. Whilst all the differing products are described using the same product attributes (e.g. packaging, fat content), the levels (e.g. plastic or cardboard container; full cream or low fat) of the attributes are varied so that a good cross-section of all the possible combinations of attribute levels is set before respondents.[3]

By analyzing the choices people make (in terms of the levels of the attributes and the socioeconomic characteristics of the respondents), the market researcher can understand the importance of each attribute as a component of demand. This, in turn, enables the prediction of market shares for established and new products. Furthermore, by comparing the way respondents are willing to give up one product attribute in order to achieve more of another, it is possible to estimate the relative values of the attributes. If one of the attributes involved in the trade-off process is product price, a monetary value for the individual attributes can be estimated. Finally, by comparing different products, it is possible to use the model to estimate how much more (or less) respondents would be willing to pay for one product over another.

The capacity for CM to be used to investigate the prospects of products that have yet to be released in the market makes it of interest to economists seeking to estimate non-market values. Thus, CM can be used as a technique for non-market environmental valuation.[4]

Environmental CM applications involve respondents being asked to select their preferred alternative from a range of potential resource management policies. Each policy outcome is described in terms of a set of attributes. The alternatives differ, according to an experimental design, in terms of the levels of the attributes in each. For instance, a CM application centered on the estimation of values associated with the protection of an endangered species may include policy options characterized by:

- number of the species remaining
- health rating for the species
- levy on income tax (as a payment to secure the alternative)

The levels for the health attribute may be:

- excellent
- good
- poor

Other attributes may be depicted using numerical levels.

A typical "choice set" presented to respondents in a CM questionnaire would take the form set out schematically in Figure 1. A CM questionnaire would feature a number of such choice sets. Hence, each respondent makes a sequence of choices between options. The choice sets feature a number of options that involve change, but in all choice sets, one option remains the same – the no change or status quo option – and it is available at no additional cost to the respondent. The no

[3] This is done using an experimental design involving the selection of an orthogonal fraction of the full factorial of combinations.
[4] See Bennett and Blamey (2001) for a more complete discussion of environmental choice modeling.

change option provides a base for the respondent across all the choice sets.

Question x: Which of the following species management options would you prefer?

	Number of species remaining	Health rating of species	Levy on your income tax in 2002
Option A: Status Quo	15	Poor	$0
Option B: Changed management	20	Excellent	$50
Option C: Changed management	25	Good	$100

1. I would choose Option A ……………☐
2. I would choose Option B ……………☐
3. I would choose Option C ……………☐

Figure 1. A choice modeling application choice set

The choices made by respondents in an environmental CM questionnaire allow an analysis of the trade-offs they are willing to make between attributes. Enough systematic variation across options is provided in the choice sets so that it is possible to detect the impact of variations in attribute levels on the probability of an option being chosen. Similarly, with a random sample of individuals being selected to take part in the CM survey, its possible to detect the influence of peoples' socioeconomic characteristics on their choices.

Hence, the choice data collected from a CM survey can be analyzed to show the impact of each attribute and respondents' socioeconomic characteristics on choice. This analysis can then be used to develop the same type of valuation outputs as produced by their market research counterparts. "Market shares" can be estimated. In the environmental application, these are the percentages of public support that could be expected to generate particular policy options. The values of individual attributes can be estimated. When estimated using the monetary attribute these are known as "implicit prices". They show the amount respondents are willing to pay to achieve an increase in the level of an environmental attribute, given that all other factors remain unchanged. Finally, if the choices presented to respondents are structured appropriately, monetary estimates of the change in welfare experienced by respondents as a result of a change in resource use away from a base case can be determined. These estimates are compatible with the value estimates obtained with reference to market data, and can thus be used in the process of weighing up the benefits and costs of change.

Applications of CM as a means of valuing non-monetary goods cover a range of issues. In Australia, studies have been undertaken to estimate the value of improved wetland conditions in the Macquarie Marshes and Gwydir Wetlands in NSW (Morrison, Bennett and Blamey 1999). Remnant vegetation protection in Queensland, NSW and Victoria has been the focus of work by Blamey, Rolfe, Bennett and Morrison (2000) and Lockwood and Carberry (1998). Whitten and Bennett (2001) have used CM to quantify the trade-offs between different land use management strategies in the upper south east of South Australia and the Murrumbidgee River floodplain in New South Wales. As a component of the National Land and Water Resources Audit, van Bueren and Bennett (2000) undertook a nationwide survey that used CM as a method for estimating the values held by Australians for land and water degradation. Bennett and Morrison (2001) have used CM to estimate the environmental values of rivers as a component of the water reforms process in NSW, by which water is being allocated between environmental and irrigation uses.

Internationally, the technique has been applied to a diverse array of non-market goods. For example, health and safety issues (Mourato, Foster and Ozdemiroglo 2000), recreational hunting, and forest management alternatives have all been investigated (Louviere, Hensher and Swait 2000). The technique has seen application largely in Europe and North America.

The principle strength of CM is its capacity to generate large quantities of data in a single application. The data collected enable a variety of changes to be valued at essentially the same cost as a CVM application. The data also allow a much greater degree of analysis to be performed, and hence a greater degree of understanding of peoples' values can be developed.

However, a number of other strengths are evident. First, the incentive compatibility of the technique is enhanced by the difficulty respondents have in developing strategies to influence the decision-making outcome in their favor. It has been established that, in the presence of uncertainty of this type, truth-telling is the predominant default strategy.[5] Second, the technique is capable of ensuring that an appropriate frame of reference is embedded directly into the questioning process. For instance, close substitute goods can be incorporated into the choice sets so that respondents are confronted directly with the range of goods that is relevant to the decision. An example of this strategy was used by Rolfe, Bennett and Louviere (forthcoming) in their analysis of the values held by Australians for international rainforest protection initiatives.

This is not to say that the technique's application has been perfected. Challenges remain in terms of the complexity of the questions being asked of respondents. The cognitive skills of most people are stretched when faced with a sequence of choice sets, and much effort is devoted in a successful CM application to ensure that the communications aspects of the questionnaire are satisfactory. For instance, most environmental CM applications are limited to five or six choice sets with less than five attributes in order to ensure that respondents are able to answer the questionnaire without resorting to decision shortcuts or to simply making their selections at random. These efforts pay dividends in that response rates in the most recent mail-out questionnaires have exceeded 40 per cent. This shows that CM surveys are viewed as no more confronting than other social surveys that yield approximately the same response rates. Furthermore, the choice set attributes have consistently been found to have a statistically significant impact on choices made, indicating that random choice is not the predominant choice strategy.

A coral reef CM application?

Given the performance of CM as a non-market valuation technique across a range of alternative issues, it is likely that it will be applied to the management of coral reef resources. The stages of such an application are summarised below.

- Locate a specific case study area, a sequence of case study areas or choose to focus on the issue of reef resource protection from a generic perspective.
- Determine a range of potential alternative management strategies.
- Define the likely outcomes of alternative management strategies.
- Establish who the beneficiaries of a changed management regime are likely to be.
- Discuss with reef scientists and policy-makers the possible biophysical attributes of different reef management outcomes.
- Carry out focus group discussions with potential survey respondents to establish their perceptions of the attributes of different reef management outcomes, including the "payment vehicle" – that is, the monetary attribute (e.g. taxes, levies and fees) to be included in the choice sets.
- Reconcile the two different perspectives on outcome attributes to set the structure of the choice sets.
- Decide how the survey will be delivered and collected.
- Design the questionnaire using an experimental design to construct the choice set options.
- Develop the questionnaire with a focus group.
- Pre-test the questionnaire.
- Draw the survey sample from the population of prospective beneficiaries.
- Implement the survey process.
- Code the data.
- Analyze the data by modeling the choices made by respondents to enable the calculation of implicit prices and of the values of changes away from the status quo.
- Use the choice model to estimate the non-market benefits associated with the array of reef resource management options that are under consideration for the area being investigated.

This process would yield value estimates that could then be used in the process of weighing up the respective costs and benefits of the management options under consideration – the second element of information in the decision-making process.

If an area-specific case study were carried out, the values estimated may then be used in a process known as benefit transfer to inform decision-making in other geographic areas. Under this process, the values estimated in the case study are used as surrogate values for other areas where reef resource management is an issue. One advantage of using CM-derived value estimates in this way is that differences in the scale of change in the attributes between the original case study and the "target" site can be taken into account. Furthermore, differences in the socioeconomic characteristics of the beneficiary group can also be integrated into the benefit transfer protocol. These advantages arise because the CM technique provides a relationship between values and attribute levels as well as socioeconomic

[5] See Bohm (1972).

characteristics. This is in contrast with most other valuation techniques that deliver only point estimates of value.

However, even with CM-derived values, the issue of framing must be taken into account. Each value estimation exercise is predicated on the particular set of circumstances in which the application was undertaken. The circumstances include the specifics of the questionnaire (for instance, the inclusion of substitute goods) as well as exogenous factors (including the weather, political events, media coverage of the issue, etc.). The issue of substitute goods is of critical importance. For instance, if a single case study of reef management were carried out, the scenario presented to respondents might be that the specific reef was suffering from environmental decline and that their payment was required to ensure that this was reversed. The values so estimated would be relevant to the case of the single reef requiring attention. If that value estimate were then used to inform decision-making over multiple reef sites, there would be a danger that the estimate would be too high for the purpose. That is because the value estimate for the single reef did not have the appropriate frame for the multiple reef application. To deal with this issue, additional CM applications to estimate values across multiple sites may be useful. The data from those studies can be used to track the effect on value estimates of more "substitute" sites being added to the questioning frame.

Furthermore, a study considering coral reef protection from a more generic or macro perspective would give a contrasting estimate of value in which all reef substitutes were included in the questioning frame. Such a study would also give an appreciation of the magnitude of benefits that could be generated from a comprehensive resource protection program.

Conclusions

Information on three elements of choice is likely to be useful in decision-making regarding the use of coral reef resources. Those elements relate to the questions:

- What is the current situation?
- What are the relative benefits and costs of alternative situations?
- What policy initiatives would be required to achieve the most desirable alternative?

The second element of information is particularly challenging because many of the benefits accruing from changing to other reef management strategies are non-monetary in nature. Without recourse to market data to estimate such values, economists have developed a number of non-market valuation techniques.

One particular stated preference technique, choice modeling, offers considerable flexibility and cost-effectiveness in the task of estimating non-monetary environmental values. Its performance in applications across a number of different types of issues has demonstrated its capacity to provide robust and accurate estimates.

The application of the CM technique to the provision of information regarding the non-market benefits of coral reef protection is prospective. However, the application would require careful attention to be paid to communication issues and to the relevance of the framing effect.

Of particular importance in any application is the recognition of cultural factors in the design of the research strategy and the questionnaire. The majority of CM applications so far performed have been in developed countries. Many of the coral reefs of the world are located in developing countries. Simply transferring the technology developed in countries such as Australia and the United States may not be appropriate to, for instance, the Philippines or Thailand. This is not simply because of differing income levels. Other cultural factors, such as household organization, religious beliefs and traditions regarding natural resource use, would need to be recognized and incorporated. For instance, the selection of the payment vehicle may be particularly sensitive to cultural norms. Thorough preliminary research, including extensive focus group testing of concepts and presentations, is a critical ingredient in the recognition of cultural factors.

References

Bennett J. and R. Blamey. 2001. The choice modeling approach to environmental valuation. Edward Elgar, Cheltenham U.K.

Bennett, J. and M. Morrison. 2001. Estimating the environmental values of New South Wales rivers. *In* I. Rutherford, F. Sheldon, G. Brierley and C. Kenyon (eds) The value of healthy streams: Proceedings of the Third Australian Stream Management Conference. CRC for Catchment Hydrology. Brisbane, Australia.

Blamey, R., J. Rolfe, J. Bennett and M. Morrison. 2000. Valuing remnant vegetation in central Queensland using choice modelling. Australian Journal of Agricultural and Resource Economics 44(3):439-456.
Bohm, P. 1972. Estimating demand for public goods: An experiment. European Economic Review 3:111-130.
Lockwood, M. and D. Carberry. 1998. Stated preference surveys of remnant native vegetation conservation. Johnston Centre Report No. 104. Charles Sturt University, Albury, NSW, Australia.
Louviere, J., D. Hensher and J. Swait. 2000. Stated choice methods. Cambridge University Press, Cambridge, U.K.
Mitchell, R. and R. Carson. 1989. Using surveys to value public goods: The contingent valuation method. Resources for the Future, Washington, D.C., USA.
Morrison, M., J. Bennett and R. Blamey. 1999. Valuing improved wetland quality using choice modelling. Water Resources Research 35(9):2805-2814.
Mourato, S., V. Foster and E. Ozdemiroglo. 2000. Evaluating health and environmental impacts of pesticide use. Environmental Science and Technology 34(8):1456-1461.
Portney, P. 1994. The contingent valuation debate: Why economists should care. Journal of Economic Perspectives 8 (4):3-18.
Rolfe, J., J. Bennett and J. Louviere (forthcoming). Estimating the value of tropical forest protection. Ecological Economics.
van Bueren, M. and J. Bennett. 2000. Estimating community values for land and water degradation impacts. A draft report prepared for the National Land and Water Resources Audit Project. Unisearch Pty Ltd., Canberra, Australia.
Whitten, S. and J. Bennett. 2001. Valuing alternative wetland management strategies using choice modeling. Paper presented at the 45th Annual Conference of the Australian Agricultural and Resource Economics Society. Adelaide, Australia.

Valuation of Coral Reefs: The Next 10 Years

James Spurgeon

Abstract

This paper outlines the role economic valuation could play in the conservation and sustainable use of coral reefs over the next 10 years. It also highlights some key issues that must be dealt with in the valuation of coral reefs. In addressing these points, the paper (i) recognizes the need to tackle the root causes of coral degradation; (ii) considers shifts in natural resource management techniques towards integrating economic and social aspects, and, in the future, encompassing financial, legal, and ethical considerations; (iii) acknowledges the increasing role of tools such as sustainability and performance indicators; and (iv) draws upon some recent projects involving applied environmental valuation. Key roles for environmental valuation include option appraisal, natural resource damage assessments, assisting in the application of market-based instruments (MBIs) and developing sustainable financing opportunities. Issues that need resolving relate to integration of socioeconomic aspects, understanding of cause-and-effect linkages, the assessment and aggregation of non-use values, use of benefit transfers, dealing with distributional effects, and appropriation of environmental values.

Introduction

Decision-makers around the world are at last slowly beginning to understand and acknowledge the considerable economic value afforded by healthy coral reefs. It was 10 years ago that the concept of total economic value (TEV) was first applied to coral reefs (Spurgeon 1992). The concept highlighted the significant economic values that can accrue from the wide range of direct, indirect and "non-use" values associated with coral reefs. At that time few published references existed on the economic value of corals. Notable exceptions included publications referring to the establishment of the recreational value of coral reefs in Florida (Mattson and DeFoor 1985); a cost benefit analysis (CBA) comparing the economic benefits from coral reef based tourism and fisheries with those from logging forests in Palawan (Hodgson and Dixon 1988); an outline of the environmental, economic and social costs of coral reef destruction in the Philippines (McAllister 1988); and an estimate of the non-use value of the Great Barrier Reef (Hundloe 1990).

Since then, the number of papers written and published on the valuation of coral reefs has grown substantially. Coral reef valuations have now been undertaken for entire countries, such as Indonesia (Cesar 1996). Furthermore, a collection of papers on coral reef valuation has been published as a book (Cesar 2000) and seminars have been organized on the subject (ICLARM 2001).

However, whilst there is increased awareness of their value, globally the status of coral reefs is in serious decline (Wilkinson 2000). Approximately 11 per cent of the world's corals were destroyed prior to 1998 but 16 per cent were destroyed in 1998 alone, mostly as a result of the mass-bleaching event linked to the El Nino and global warming. It is predicted that a further 14 per cent may be destroyed within the next 2 to 10 years, and 18 per cent within the next 10 to 30 years, reaching a total loss of coral reefs of almost 60 per cent. The causes of coral mortality are related to a multitude of natural and anthropocentric factors, in particular global climate change (Wilkinson 2000).

Is there a role for environmental valuation to help protect and manage the world's remaining coral reefs? In answering this question, this paper explores some relevant trends in environmental management and highlights various recent applications of environmental valuation in natural resource management. The paper concludes by identifying key issues in coral reef valuation that need greater attention over the next 10 years.

Trends in environmental management

To determine what place environmental valuation may have in coral reef management over the next 10 years requires an understanding of current and future trends within the overall context of environmental management. Below, four such trends are briefly considered.

Tackling the root causes of environmental degradation

It is essential for the long-term success of environmental conservation that the "root causes" of environmental damage be fully understood and appropriately addressed. All too often, the "solutions" implemented are short-term superficial "fixes" rather than fundamental changes that harness natural forces and tendencies and result in win/win situations.

Figure 1 highlights a few examples of root causes of coral degradation, their circular relationship, and their impacts, symptoms and consequences. One significant root cause is the failure of current market forces to take into account the wider economic and financial implications of social and environmental impacts that result from new developments. This means that many impacts on corals are often not accounted for in decision-making processes. In such cases the impacts are known as "externalities", because they are external to the conventional economic and financial values often considered in decision-making, particularly by the private sector. For example, the decision to allow deforestation of land can lead to sedimentation and loss of coral reefs many miles away from the logging activity. Furthermore, many of the coral reef values affected will have no obvious financial or economic market values, rendering an accountable loss even less likely. Effectively, such losses simply become someone else's problem.

In order to overcome this market failure, it is necessary to change the way that decision-making is undertaken, so that wider development implications are taken into account. This can be achieved by valuing environmental and social impacts that have no obvious market values, using environmental valuation techniques, and incorporating them within economic CBA.

In addition, greater use of MBIs should be adopted. Examples of these are natural resource damage assessments, and user fees that help capture (i.e. appropriate) externalities within the market place (Pearce et al. 1989; Pearce and Barbier 2000). Accurate environmental valuation is integral to the development of appropriate pricing and charging policies for such market-based instruments.

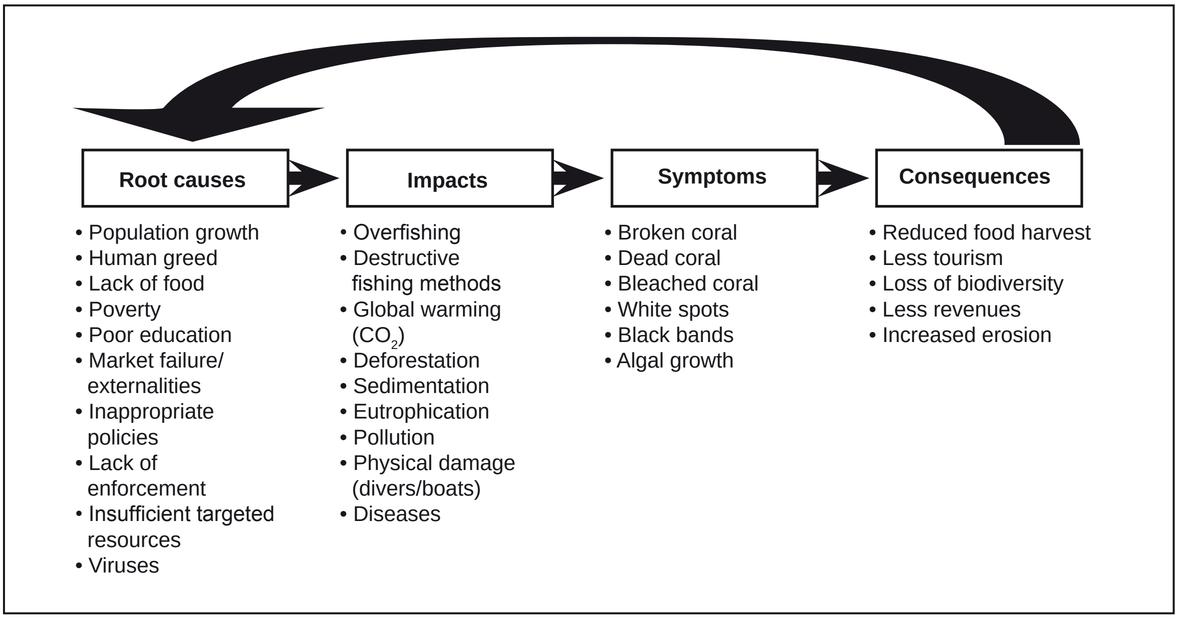


Figure 1. The cycle of coral degradation

It is only by fully understanding and appreciating wider environmental and social values, and by identifying ways of accounting for, and capturing such values, that the long-term economic benefits of tackling the root causes of environmental degradation become apparent.

Focus of international funding agencies

Poverty is one key root cause of environmental degradation that international funding agencies such as the World Bank and the UK's Department for International Development (DfID) are now actively trying to tackle. Accordingly, a much larger proportion of development projects and associated funding will be targeted at poverty alleviation. In particular, the links between different values of coral and the opportunities for alternative and sustainable livelihoods need to be fully explored. Associated with this is the need to pay greater attention to the socioeconomic benefits provided by corals, such as employment and nutrition.

Since the Rio Earth Summit in 1992 there has been considerable global emphasis on climate change and biodiversity conservation. These are two other areas where environmental valuation of coral reefs is now increasingly being used. Likewise, outcomes from Rio + 10 will influence the focus of future coral reef valuation efforts.

Changing approaches to natural resource management

In the past, natural resource and protected area management was generally focused on understanding and managing ecosystems from a biological perspective. This approach was supported by limited stakeholder consultation and use of ecological models to identify population dynamics.

Current management strategies are beginning to incorporate wider, social and economic factors. Stakeholder consultation has evolved into stakeholder participation, and capacity building and institutional strengthening are now seen as vital, particularly in developing countries. The feasibility and design of new development projects are often assessed using CBA and environmental impact assessment (EIA); occasionally bio-economic models are used to support decision-making.

However, in the future, financial, business, legal and ethical disciplines and factors will also be playing a pivotal role in natural resource management. Stakeholders will become actively engaged in the management process. The private sector will become heavily involved, often through private/public partnerships. Some marine protected areas will become privatized, commercial operators and co-operatives will manage others, and corporate/business sponsorship may become commonplace. The success of protected areas will, however, continue to depend upon obtaining public and local support.

New market-based instruments will be adopted to complement appropriate policies and regulations. CBA and strategic environmental assessment (SEA) will be increasingly undertaken at a policy level as well as the project level. And finally, fully integrated management models will be developed, often based on remote sensing images and GIS databases. Understanding the full current and potential values of coral reefs will become critical to a successful outcome in this radical transformation of management approaches.

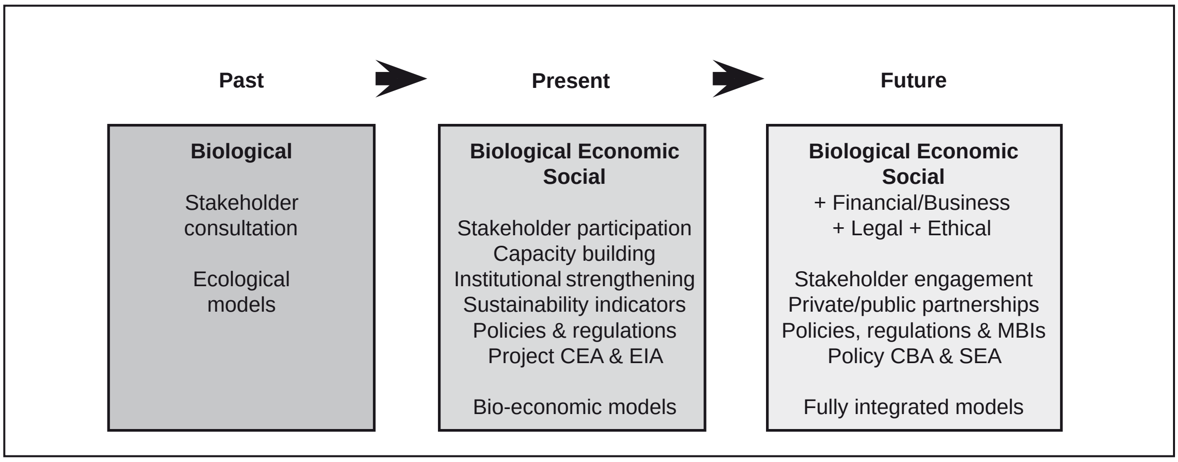


Figure 2. Changing approaches to natural resource management

Diversification of measuring tools

Governments and organizations are moving towards use of a range of indicators to support their approach to environmental monitoring and management (World Bank 1997). Many indicators are being developed by different organizations. They include, for example, sustainability indicators, key performance indicators, and quality of life indicators (DETR 1999).

Environmental values, based on the theory of economic welfare, are just one type of indicator. They need to be used in conjunction with other indicators and evaluation approaches, such as multi-criteria analysis. These approaches, however, also have their own advantages and disadvantages (Pearce and Barbier 2000).

The role of environmental valuation and economics

Resource management decisions

Environmental valuation has begun to play a major role in option appraisal for resource management decision-making. This generally involves undertaking CBAs to compare the economic viability of different options. Examples relating to coral reefs include demonstrating the economic viability of implementing marine protected area management (White et al. 2000), assessing the economic viability and enhancing the effectiveness of coral restoration (Spurgeon 2001), demonstrating the economic losses from blast fishing (Pet-Soede et al. 2000) and from coral mining (Ohman and Cesar 2000), and selecting a preferred coastal zone management approach (Gustavson and Huber 2000). By incorporating environmental costs and benefits within CBA, the most efficient sustainable option can be selected. Furthermore, such an approach can be a powerful means of justifying additional expenditure on environmental management.

However, there is an increasing need to assess options in a broader sense, reflecting wider social benefits. For example, in the UK, the Environment Agency (known as the Agency) has a statutory duty to consider the wider economic and social costs and benefits of its environmental management actions. In accordance with this duty, a study was undertaken to help the Agency select a preferred salmon fishery management option for the River Lune in northwest England (GIBB Ltd[1] 1999). Salmon numbers in the river had been in decline for around 10 years; this had led to a growing conflict between anglers and fishers. On the one hand, the many anglers caught relatively few salmon through fly-fishing, but injected large sums of money into the local economy through tourism and so, indirectly, supported local jobs. On the other hand, a small number of local fishers caught many salmon using nets, contributing relatively little to the local economy, but earning a direct living. Issues relating to the overall distribution of benefits were of great importance.

The study involved several low-cost socioeconomic questionnaire surveys that incorporated a contingent valuation method (CVM) component (i.e. asking individuals their "willingness to pay" (WTP) for certain options). An economic model was developed that incorporated a fishery model predicting future salmon numbers under various management scenarios. The overall implications of various net fishers and angling restrictions (e.g. numbers of licenses, catch limits and seasons) were then assessed in terms of three key indicators. These indicators were: (i) the net economic benefit to the nation (i.e. welfare benefit); (ii) the gross financial expenditure/revenues injected into the local economy; and, (iii) the number of jobs supported. The results were used to help select and justify the combination of fishing restrictions eventually imposed by the Agency.

A major impediment to widespread use of environmental valuation is the expense of carrying out original valuations of public preferences using techniques such as contingent valuation. Robust values often require a carefully constructed and rigorously tested questionnaire, a large sample size (e.g. 500), and a lengthy face-to-face interview process (e.g. 30 minutes). It is, therefore, often not economically justifiable to do such a study for every valuation required. A solution to this cost problem that is rapidly gaining popularity involves benefit transfers. This means taking environmental values from one situation where an in-depth valuation study has been applied, and using the values (often adjusted or as a function) to value environmental changes in similar situations elsewhere.

[1] Now known as JacobsGIBB Ltd, an international firm of consultants (also formerly known as Sir Alexander GIBB).

In order to facilitate the Agency's decision-making process through use of benefit transfers, several major valuation studies have been undertaken on their behalf. The aim has been to estimate standard values for specific environmental changes and develop a model whereby the standard values are adjusted for different situations to reflect variation in key explanatory variables.

Two such studies[2] involved conducting national CVM surveys covering all eight Agency regions around the UK to assess use and non-use values associated with fish stocks in inland water bodies (Spurgeon et al. 2001). One was a telephone CVM survey aimed at anglers and designed to determine standard values for angler consumer surplus and expenditure. The other was a face-to-face CVM survey, targeted at the general public and designed to assess their recreational use values and non-use values for inland fish stocks. In each case, overall national standard WTP values were determined. These could be multiplied by different adjustment factors to reflect differences between regions, types of water body, types of fish and the extent to which fish stocks are improved. It is worth noting that variations in regional adjustment factors give rise to potential distributional impacts, an increasingly sensitive issue in CBA. The study highlighted the considerable importance and value to the public of non-use values.

Another ongoing Agency study involves the development of a robust benefit transfer model relating to recreational use values and public non-use values associated with improving water levels and flows in rivers in the UK (JacobsGIBB 2002). The need for the study arose from the fact that a large number of rivers in the UK suffer from low flows, often caused by excessive water abstraction. The Agency is keen to return the rivers to their natural state wherever it is economically justifiable to do so. However, a previous attempt by the Agency to reduce a licensed abstraction rate on the basis of arguments using non-use benefit transfers was dealt a major blow in court (Moran 2000). Various criticisms of the benefit transfer process were noted, a major one being the lack of empirical evidence as to the relevant population over which to aggregate household non-use WTP values. Although small on a per person basis, overall non-use values for natural resources can often be the largest component of benefit. Hence their correct valuation and acceptance can be highly influential in the decision-making process.

It is not considered economically viable to undertake original non-use valuation studies for every potential river improvement scheme. Consequently, the study has involved an in-depth CVM survey eliciting WTP values for recreational use values and general public non-use values associated with improving water levels on just one river, the Mimram, in Hertfordshire. The survey focused on how recreational use values and non-use values vary with distance from the river. In addition, scoring and rating exercises were included to assess the relative importance of different river characteristics and types of benefit. The results are being used to develop a benefit transfer model using a set of adjustment factors that will facilitate application of the approach to other rivers.[3] Important findings of the study show:

- Users predominantly live within 12 km of the river;
- In addition to their use value, users also hold a large non-use value for the river, around 50 per cent of their overall WTP value; and
- The majority of the public living at least up to 130 km from the river hold non-use values for the river.

A groundbreaking aspect of the Mimram study has been the extent to which stakeholders have been actively engaged in the valuation process. This was achieved initially through a widely advertised "open day", which identified typical stakeholders and benefits associated with healthy flowing rivers. Focus groups were then held to gain a more in-depth understanding of stakeholder perceptions and benefits. A questionnaire survey was subsequently designed that included a combination of ranking, rating (scoring) and WTP elicitation techniques. Further, local resident and general public focus groups/discussions were used to test for understanding and completeness. The stakeholders were also re-consulted to confirm that the results adequately captured their values.

In addition to helping assess project options, environmental valuation can, and is, playing a

---

[2] Undertaken jointly by GIBB Ltd and McAllister Elliott and Partners.

[3] Another stated preference technique known as "choice modeling" is also becoming a powerful means of assessing the value of different characteristics to help in benefit transfers (Bennett 1999).

valuable role in assessing wider policy options in terms of their overall economic, social and environmental efficiency. Indeed, this is now happening for many new environmental policies under consideration within both the UK and European Union.[4]

Enhancing environmental assessments

Not only should environmental valuation come into economic CBA decisions, but it also has a place in environmental impact assessments (EIAs). JacobsGIBB have been incorporating the concept of environmental values for coral reefs and other habitats within EIAs (e.g. EIAs related to port and power developments in Zanzibar and Abu Dhabi), in strategic environmental assessments (SEAs) (e.g., for the Saudi Arabian Tourism Master Plan) and in due diligence studies for international lending banks (e.g. for power plants and marine cables in the Philippines and Thailand). A critical issue that arises in these studies is the need to disentangle scheme impacts from other impacts, and to understand the cause-and-effect linkages.

In such cases, the use of environmental values can be a powerful way to demonstrate the need for suitable mitigation and compensation measures and cost-effective targeted monitoring programs. If carried out appropriately, the approach can potentially save developers and project sponsors considerable latent costs and liabilities. In SEAs, the additional advantage of being able to highlight and promote the benefits of using environmental valuation and market-based approaches for strategic environmental management purposes may arise. For example, this includes the use of environmental charges and damage fees to help raise revenues and minimize environmental damages.

Market-based instruments and funding opportunities

There are excellent opportunities for using MBIs to help manage natural resources more efficiently, although these are also not without their problems (Huber et al. 1998; Pearce and Barbier 2000). Nevertheless, economic instruments can both help generate revenues for environmental protection and directly modify human behavior, thereby protecting natural resources. Such instruments include user fees, damage fees, waste/discharge fees, transferable quotas/licenses and tourist taxes (e.g. accommodation or airport taxes).

In order to further explore the potential benefits of MBIs, a recent study[5] examined in outline a number of ways to maximize opportunities for raising revenues for coral reef management (Spurgeon 2000). It also developed a framework and an eight-stage approach for achieving such a goal, based on the concept of TEV. At the heart of the methodology is the importance of identifying the full range of coral reef stakeholders (both beneficiaries and impactors) at local, regional, national and international levels.

In addition, the study identified a significant role that businesses could play in supporting the management of coral reefs, particularly given the global drive towards corporate social responsibility. Figure 3 highlights an outline framework proposed for identifying coral reef beneficiaries. Each dot in the matrix represents a type of benefit or value for which there will be one or more potential arguments or MBIs to help capture the value and raise revenues for conservation. A similar matrix was developed for those with an impact on coral reefs.

Natural resource damage assessments

There is growing recognition around the world that people or organizations imposing significant damage to valuable natural resources can be brought to justice through environmental liability. Estimates of the value of damages can be made and, depending on the relevant national laws, the polluter can be made to pay.

Natural resource damage assessments are often associated with shipping incidents. Recent studies[5] include assessment of the environmental value of damage to coral reefs from ship-groundings in the Red Sea and the Philippines, and to the wildlife and pristine image of the Galapagos Islands from the Jessica oil spill. Under such circumstances, damage claims and compensation payments of millions of dollars are not uncommon. However, it is interesting to note the considerable scope to adopt a wider charging regime for smaller-scale damages caused by boats, divers and dredging operations.

---

[4] For example, JacobsGIBB are currently determining the full economic costs and benefits associated with 300 "Natura 2000" protected areas in Scotland designated under the EU Birds and Habitats Directives.

[5] Undertaken by JacobsGIBB and part funded by DfID.

Stakeholder Groups:	Use Values												Non-Use	
	Direct Use Values								Indir Use Values		Option Value		Non-Use Value	
	Recr		Fish		Prods		Res/Educ							
Communities/ general public	●	•	●	●	●	●	●	●	●	•	●	●	●	●
	•	•	•	•	●	●	●	●	•	•	●	●	●	●
Fishers	●	•	●	●	•	•	●	●	●	•	●	●	●	•
			•	•	•	•	•	•	•	•	•			
Recreational users	●	●	●	•	•	•	●	●	•	•	●	●	•	•
	●	●	•	●	•	•	●	●	•	•	●	●	•	●
Conservation groups	●	●	•	•	●	●	●	●	•	•	●	●	●	●
	•	•	•	•	●	●	●	●	•	•	●	●	●	●
Schools/ Universities	●	●	•	•	•	•	●	●	•	•	●	●	●	●
	●	●	•	•	•	•	●	●	•	•	●	●	●	●
Government	●	•	●	•	●	●	●	●	●	●	●	●	●	●
	•	•	•	•	●	●	●	●	●	•	●	●	●	●
Businesses	●	•	●	•	●	•	●	●	●	•	●	●	•	•
	•	●	•	●	•	•	●	●	•	•	●	●	•	•

Notes: Location where the effect occurs:

Local	Regional
National	International

• Potentially some impact/link

● Potentially significant impact/link

Figure 3. Framework for identifying revenue opportunities from coral reef beneficiaries

These studies clearly demonstrate the importance of considering the magnitude of non-use values when justifying expensive restoration and other suitable compensatory measures. Again, benefit transfer approaches are commonly used in damage valuation assessments. However, it is important that particular care is taken to use appropriate adjustment factors to account for site-specific differences. Furthermore, a good understanding of cause-and-effect linkages is essential.

Other research (Spurgeon 1999) also suggests that economic valuation that encompasses environmental values could play a valuable role in deciding the most effective means of restoration, and the best use of money obtained in such damage claims. In relation to this, the considerable cost of some coral restoration schemes may be questionable.

Some challenges and issues to overcome

Environmental valuation techniques and their inclusion as part of a suite of decision-making tools have progressed rapidly over the past couple of decades. However, there is scope for improvement. A number of issues still need to be resolved. Some of the current key challenges with respect to coral reef valuation are summarized below.

Understanding and assessment of cause-and-effect linkages, required in virtually all environmental valuation, need improvement. This is essential for both environmental impact linkages (e.g. pollution effects on corals) and environment-economy linkages (e.g. coral cover and economic values).

There is a need to develop an agreed acceptable approach to undertaking benefit transfers for coral reefs. Reliable environmental valuation studies determining public preferences are expensive to conduct. However, cost-effective valuation based on benefit transfers is possible provided there is sufficient understanding of the link between key environmental variables and values. A coordinated global approach is needed to develop sufficient robust valuations for use in benefit transfer models.

A database of values for different coral reef benefits is needed. This should incorporate appropriate details on valuation scenarios and site-specific characteristics affecting the values.

The accuracy and robustness of each valuation must also be clarified.

Problems associated with equity and distributional bias need to be overcome. There is a danger that WTP analysis will be biased towards providing environmental benefits in favor of the wealthy to the detriment of those less well off. A generally accepted approach to handling this issue is needed.

The quality and credibility of environmental valuation studies must be standardized and enhanced. Although beginning to gain credibility with some decision-makers, there is still considerable skepticism about the use of environmental valuation techniques by others. The situation is not helped by poorly designed valuation studies and use of grossly inaccurate assumptions.

The understanding and valuation of non-use values requires much additional research. Several of the studies outlined above have indicated the importance of non-use values. Non-use values relating to coral reefs are likely to be significant and will often considerably outweigh coral reef use values. There is, therefore, a need to accurately assess unit values and determine over what populations the values should be aggregated.

To raise the credibility and importance of non-marketed values, new approaches are required which can help appropriate/capture such values.

Conclusion

In conclusion, environmental valuation can and should play an increasingly important role in coral reef management over the next 10 years. However, valuation will only be one of the suite of tools required to be incorporated into robust and consistent decision-making. It is also apparent that valuation of coral reefs is many years behind valuation of other environmental goods, such as water resources. Based on the trends, studies and issues alluded to above, the following predictions concerning valuation of coral reefs over the next 10 years can be made.

Integration of stakeholder involvement, socioeconomic aspects, alternative livelihoods and poverty alleviation will become more common in developing approaches to environmental valuation, especially in the developing world.

Non-use values will play an increasingly important role, as will methods to appropriate such values.

Benefit transfers will be commonly used to help facilitate the spread of environmental valuation within decision-making.

Environmental values will become one of several key indicators used to help protect and manage coral resources.

MBIs will increasingly be used to assist in coral reef management and in financing conservation. The application of user fees and environmental damages will become more sophisticated with time.

As the potential financial value of coral reefs is recognized, management of coral reefs and marine protected areas will become more business-like, with increased private sector participation. This needs to occur in a socially inclusive and highly ethical manner, in partnership with government bodies, NGOs and local communities.

References

Bennett, J. W. 1999. Some fundamentals of experimental choice modelling. Choice Modelling Research Report 11. University of New South Wales, Sydney, Australia.

Cesar, H. S. J. 1996. Economic analysis of Indonesian coral reefs. Working Paper Series – Work in Progress), 97 p. World Bank, Washington, D.C., USA.

Cesar, H.J.S. 2000. (ed.) Collected essays on the economics of coral reefs. CORDIO – Sweden, 244 p.

DETR. 1999. A better quality of life: A strategy for sustainable development in the UK. HMSO, London, U.K.

GIBB Ltd. 1999. Economic assessment of the River Lune salmon fishery. Final Report to the Environment Agency, North West Region, U.K.

Gustavson, K. and R. M. Huber. 2000. Ecological economic decision support modelling for the integrated coastal zone management of coral reefs. *In* H. S. J. Cesar (ed.) Collected essays on the economics of coral reefs. CORDIO, Sweden, 244 p.

Hodgson, G. and J. A. Dixon. 1988. Logging versus fisheries and tourism in Palawan. Occasional Paper 7, East West Environment and Policy Institute, Honolulu, Hawaii, USA.

Huber, R. M., H. J. Ruitenbeek and R. S. Motta. 1998. Market-based instruments for environmental policy

making in Latin America and the Caribbean. World Bank, Washington, D.C., USA.
Hundloe, T.J. 1990. Measuring the value of the Great Barrier Reef. Australian Parks and Recreation 26(3): 11-15.
ICLARM. 2001. Economic valuation and policy priorities for sustainable management of coral reefs. International Consultative Workshop. ICLARM December 2001, Penang, Malaysia.
JacobsGIBB Ltd. 2002. River Mimram public preferences study. Final draft report to the Environment Agency, January 2002.
Mattson, J. S. and J. A. DeFoor. 1985. Natural resource damages: Restitution as a mechanism to slow destruction of Florida's natural resources, J. Land Use Environ. Law 1(3):295-319.
McAllister, D. C. 1988. Environmental, economic and social costs of coral reef destruction in the Philippines. Galaxea 7:161-178.
Moran, D. 2000. Accounting for non-use value in option appraisal: Environmental benefits transfer and low flow alleviation. *In* P. McMahon and D. Moran (eds) Economic valuation of water resources CIWEM. Terence Dalton Publishers Ltd., U.K.
Ohman, M. C. and H. S. J. Cesar. 2000. Costs and benefits of coral mining. *In* H. S. J. Cesar (ed.) Collected essays on the economics of coral reefs. CORDIO, Sweden, 244 p.
Pearce, D. W., A. Markandya and E. Barbier. 1989. Blueprint for a green economy. Earthscan, London, U.K.
Pearce, D. W. and E. Barbier. 2000. Blueprint for a sustainable economy. Earthscan, London, U.K.
Pet-Soede, L., H. S. J. Cesar and J. S. Pet. 2000. Blasting away: The economics of blast fishing on Indonesian coral reefs. *In* H. S. J. Cesar (ed.) Collected essays on the economics of coral reefs. CORDIO, Sweden, 244 p.
Spurgeon, J. P. G. 1992. The economic valuation of coral reefs. Marine Pollution Bulletin 24(11):529-536. Pergamon Press.
Spurgeon, J. P. G. 1999. Economic valuation of damages to coral reefs. Paper presented to Coral Reefs: Marine Wealth Threatened, Conference organized by National University of Mexico, Cancun, Mexico.
Spurgeon, J. P. G. 2001. Maximising opportunities for sustainable financing of coral reefs based on a total economic valuation approach. Paper presented to the 9th International Coral Reef Symposium, Bali, Indonesia.
Spurgeon J.P.G., G. Colarullo, A. F. Radford and D. Tingley. 2001. Economic evaluation of inland fisheries: Indirect economic values associated with fisheries. Final Report to the UK Environment Agency. R&D Project Record W2-039/PR/2.
Spurgeon, J. P. G. 2001. Improving the economic effectiveness of coral reef restoration. Bulletin of Marine Science 69(2):293-294.
White, A. T., M. Ross and M. Flores. 2000. Benefits and costs of coral reef and wetland management, Olango Island, Philippines. *In* H. S. J. Cesar (ed.) Collected essays on the economics of coral reefs. CORDIO, Sweden, 244 p.
Wilkinson, C. 2000. Status of coral reefs of the world: 2000. Australian Institute of Marine Science, Townsville, Australia.
World Bank.1997. Expanding the measure of wealth: Indicators of environmentally sustainable development. Environmentally Sustainable Development Studies and Monographs Series, Number 17. The World Bank, Washington, D.C., USA, 110 p.

Coral Reef Use and Management – The Need, Role, and Prospects of Economic Valuation in the Pacific

Padma Lal[1]

Abstract

The need for economic valuation of coral reefs and other natural resources to underpin resource allocation decisions has always been recognized by economists, but recently it has been emphasized by others. In practice, however, the usefulness of economic valuation as an input in the management of coral reefs in the small island nations of the Pacific, and elsewhere, is not as clear. This paper argues that its relevance needs to be particularly examined in the context of the great degree of uncertainty in our understanding of the complex and dynamic coral reef ecosystems and the lack of understanding about the functional relationship between human activities and their impact on the goods and services supported by the reefs. It is equally important to examine the need for detailed economic valuation in the light of the increased devolution of use and management decisions down to local communities and the use of the adaptive decision-making process.

Economic valuation can help improve coral reef conservation and management, but the level of detailed valuation required will depend on the use the value estimates will be put to and the management objective addressed. It will also depend on whether a "top-down" centralized decision-making process is appropriate or whether a "bottom-up" community-based decision-making process is to be used. If it is the latter, it is very likely that the local Pacific island communities will be making only minor decisions one at a time, for which detailed net economic valuation-based decision-making may be overdone. In any case the net benefit estimation in these circumstances will be associated with a great degree of uncertainty. Instead, some gross estimation of the expected net economic (financial) benefits may suffice. But more importantly for community-based management, careful considerations of other economic issues may be more useful in designing community-based institutional regimes to suit the local conditions.

Introduction

It is now generally recognized that, unless economic factors are taken into account, efforts to manage natural resources and the environment are not likely to produce the desired outcomes. However, although economists have been arguing for careful considerations of economic costs and benefits in decision-making, not many countries have either fully embraced the importance of economic valuations or used economic valuation estimates to underpin resource use decisions.

Even in developed countries economic valuation of natural resources and cost-benefit analysis (CBA) have not been employed directly in actual resource allocation decisions (McFarquhar 2001). Often a decision is made and CBA is then used to justify it.

This is despite the fact that many international conventions and treaties and government and non-government agencies have encouraged countries to take economic factors into account in environmental conservation decisions. Under the Ramsar Convention, the Ramsar Bureau has encouraged economic valuations of natural resources such as coral reefs and other wetlands. IUCN has recognized the relevance of economic valuation and the need to "ensure that resource users pay the full social costs of the benefits they enjoy" (IUCN-UNEP-WWF 1991). Coral reef related initiatives, such as the International Coral

[1] Graduate Studies in Environmental Management and Development, National Center for Development Studies, Australian National University
padma.lal@anu.edu.au

Reef Networks, have emphasized the importance of economic valuation of coral reefs and the goods and services they support.

In many international and regional initiatives, while economics may not be directly mentioned, it is an underlying principle. The Convention of Biological Diversity, for example, does not mention economic valuation directly, but the theme is picked up in article 11 on "Incentive Measures" (Glowka 1998), which asks each contracting party to adopt "economically and socially sound measures that act as incentives for the conservation and sustainable use of biological diversity". The South Pacific Regional Environment Programme (SPREP) notes the need to promote natural resource economics "to assist environmental officials, national and fiscal planners in taking stock of economic implications for environmental impacts" (SPREP 2000). International non-governmental organizations, external donors and governments have used these international and regional initiatives to guide conservation and development projects in the Pacific.

Economics provides a valuable analytical framework for considering coral reef management issues because it highlights the incentives resource owners and users face, and the trade-offs they make when choosing a particular activity in order to maximize the benefits from the scarce resources. The theoretical relevance of economic valuation in encouraging efficient allocation and use of resources in the context of social welfare based public policy is unquestionable. In practice though, how useful is economic valuation in the management of coral reefs in the small island nations of the Pacific, and elsewhere? This is not clear, particularly in the light of the increased devolution of use and management decisions down to local communities. Its role is also unclear in situations where there is incomplete understanding of the complex and dynamic coral reef ecosystems, the functional relationships between human activities, and their impact on the goods and services supported by the reefs.

In this paper, the total environmental values associated with coral reef systems in the Pacific, as well as management challenges in the region, are outlined. The role that economic valuation of the goods and services supported by coral reefs can ideally play in the management of coral reefs is then discussed. Finally, the relevance of and the role that economic valuation can play in the context of community-based conservation and development in the Pacific are explored.

Total environmental values - importance of coral reefs

Coral reefs are not only amongst the most productive ecosystems on earth, but they are also biologically among the most diverse habitats. They provide a unique set of goods and services directly or indirectly used, and thus valued, by humans (e.g. Cesar 1996; Moberg and Folke 1999; Gustavson 2000).

As elsewhere, coral reefs in the Pacific region have many different direct and indirect use and non-use values (Table 1). However, there are some goods and services provided by coral reefs, including research and education (Spurgeon 1992), that have not, so far, played a significant role in the Pacific. Although indigenous knowledge is extensive, little has been recorded. Information is gradually being compiled, and increased effort is being placed on coral reef research and bio-prospecting (Aalbersberg 2001; South et al. 2001).

While the total economic value of coral reef-based use, non-use and other values in the Pacific is not known, coral reefs are the backbone of many island nations' subsistence and commercial economies, as well as of their culture.

In some cases, particularly those of the small coral atoll islands of Micronesia, they are the only resource that meets the subsistence and development needs of the people (Preston 1997). Eighty per cent of the rural households in the Solomon Islands, Kiribati and the Marshall Islands catch reef and lagoon fish for local consumption. In Kiribati and the Solomon Islands, locals derive 67 per cent and 77 per cent respectively of their animal protein from reef-based seafood (The World Bank 2000 quoted in Dalzell and Schug 2001). Even in countries where there is economic diversity, local dependence on the coral reefs can still be high, with about 80 per cent of the total inshore fisheries catch being used for subsistence; this proportion is higher for smaller and more remote Pacific islands (Dalzell 1996). In many villages away from the main centers, where opportunities for cash and jobs are limited, the coral reef is the main source of food security and an important source of protein (Dalzell and Schug 2001).

Table 1. Goods and services supported by coral reefs and associated habitats in the Pacific

Total Economic Value (TEV)			Ecological Process Values	Cultural Function Values
Use Values		**Non-Use Values**	"Ecological glue" - Primary value of aggregate life support functions, such as photosynthesis, nutrient filtration	Cultural "glue" value – (***vanua, fenua***) Such as, social cohesion, reciprocity
DIRECT USE VALUE Extractive uses • Seafood – fishes, clams, beche de mer, etc. • Aquarium fishes • Hard and soft coral for aquariums • Coral as a source of lime as an ingredient used in betel nut chewing • Carbonate sand for cement making and agricultural lime • Coral used for dental and facial reconstruction • Coral used for bone repairs • Coral as sewerage soakage pits Non-extractive use • Tourism • Diving; snorkeling and swimming	INDIRECT USE VALUES • Nutrient filtering • Flood control • Storm buffer • Shoreline stabilisation • Microclimatic stabilisation • Biodiversity maintenance • Education and research • Bio-prospecting	• Bequest • Existence		

Source: Adapted from Moberg and Folke 1999; Spurgeon 1992

In the Pacific the annual gross value of coral reef-based seafood and non-seafood fisheries alone is in the vicinity of US$260 million, for a total harvest of 108 000 t (Dalzell et al. 1996). On average, this represents a combined fish and non-fish yield of over 30t/yr/km^2 (Dalzell 1996; Pulonin et al. 1996). This represents, in addition to what is exported, local seafood consumption in the region ranging from 23 kg/person in Melanesian to about 60 kg/person in Polynesia (Dalzell et al. 1996). In most countries, in addition to fish and non-fish products harvested for consumption or sale, fish and coral for the aquarium trade, and extraction and sale of coral rubble and coral sand are also important sources of income. Preliminary data suggest that the South Pacific Forum countries[2] export about 200 000 to 250 000 aquarium fish each year, with an approximate export value of US$1 to 1.5 million (Pyle 1993). About 1.3 million pieces of hard, soft and curio corals, valued at US$2.3 million were exported in 1997 (Fiji Fisheries 1998), the majority of which came from Fiji, with very small amounts exported from elsewhere in the Pacific region (Lovell and Timuri 1999). These harvests of fish and corals for aquarium use have increased over time.

While detailed information is unavailable for coral reef-based mineral extraction in the Pacific region as a whole, its importance cannot be disputed. Corals are used as a source of lime in betel nut chewing, an activity of immense value in PNG; as sewerage soakage pits in Fiji (Vuki et al. 2000); as a source of lime for cement making in Fiji; and as a source of rubble and sand for the building industry (Lovell and Tumuri 1999). In Tonga alone the annual construction industry demand of 10 000 to 20 000 t of coral sand valued at about half a million Tongan dollars is met by mining beach sand; beach sand is produced by the wave scouring of fringing reefs and is transported by local currents to the shore (Muller 2000).

All these renewable and non-renewable products – seafood, fish and coral for the aquarium trade and extractive sand and coral rubbles – are direct use values of coral reefs. Other direct use values of importance are non-extractive, particularly tourism, recreational diving and snorkeling and boating. Tourism in the Pacific is one of the fastest-growing industries and most countries see their coral and lagoon-based resources as the prime attraction, with reef diving and snorkeling as one of the main tourist activities. Tourism in

[2] Cook Islands, Federated States of Micronesia, Fiji, Kiribati, Nauru, Niue, Palau, Papua New Guinea, Republic of the Marshall Islands, Samoa, Solomon Islands, Tonga, Tuvalu, Vanuatu (plus Australia and New Zealand).

the region generates over US$723 million a year (Carswell 2001). In some countries, such as the Cook Islands, tourism is the main source of economic gross domestic product, with tourism contributing 42 per cent of the total economy (Cook Islands et al. 1998). In Fiji the tourism industry is the highest foreign exchange earner, generating over US$562 million in 1998 and supporting over 30 000 people in direct employment.

In addition to these use values, for many of the Pacific islanders, coral reefs and lagoons are part of their customary tenure-based *vanua* or *fonua* that form the basis of their emotional, spiritual, ecological and economic wellbeing. *Vanua* in Fiji, for example, defines, amongst other things, the duty of care that people have towards each other, the future generation and the environment (Vuki et al. 2000). Associations with their *vanua* or *fonua* provide the locals with a personal cultural identity (Johannes 1993). It also underpins their cultural capital, that Throsby (1995) defines as "…(a) set of attitudes, practices and beliefs that are fundamental to the functioning of a particular society's values and customs". These provide what Lal and Young (2000), have called "a flow of cultural process values" - sense of cohesiveness, belongingness, customs and obligations about reciprocity. These characteristics have been encapsulated in the term "Pacific Way" (Tupouniua 1980). The Pacific is not unique in having these cultural function values. Similar values have also been noted in Australia (Rose 1996) and elsewhere, such as Southern Kenya, where the traditional management of reefs has primarily been to "appease spirits" (McClanahan et al. 1996 quoted in Moberg and Folke 1999).

Humans also value coral reefs for their ecological services. These include maintenance of biodiversity and provision of a 'genetic library'; regulation of ecosystem processes and functions; maintenance of resilience; and maintenance of ecological processes and functions between ecosystems (supporting other systems through the production and export of organic matter and plankton) (Moberg and Folke 1999). Some of these values, such as primary productivity that keeps the whole system together and produces functions that have secondary value, or the primary values of the ecosystem such as the food chain relationships and nutrient flow, are not included in the total economic value (Perrings 1995). Perrings thus defines the total environmental value as the sum of the total economic value plus the ecological process value (EPV).

Extending the concept of the total environmental value to include the cultural function value, Lal and Young (2000) defined the total environmental value of coral reefs as the sum of the total economic value of market and non-market goods and services plus the ecological process value and cultural function value (Figure 1). That is:

Total environmental value = Total economic value (TEV) + Ecological process value (EPV) + Cultural function value (CFV)

Management issues in the Pacific

Despite the importance of coral reefs throughout the world, they are under serious anthropogenic threats (Cesar 1995; WRI 2000; Moberg and Folke 1999). Among the key threats from human impacts in the Pacific (summarized in Table 2) that mainly affect direct uses, are over-harvesting of fish and non-fish products for food, and over-harvesting of fish and coral for the aquarium trade. Many of these threats are due to rapid population growth, over-fishing (due to increased effort and the use of destructive fishing methods that damage coral reef habitats), and changes in lifestyle that increase the consumption of material goods.

External effects of onshore activities, including tourism related developments; human waste disposal and associated eutrophication; and deforestation and encroaching agriculture resulting in soil erosion and sedimentation, are also major concerns (UNEP 1999; RoundTable 1999). Another issue emerging, albeit in localized areas, is increasing conflict between commercial fishers and tourist operators (South and Skelton 2000; Salvat 2000; Salvat 2001). In countries such as Fiji, tour operators are concerned about the impact commercial fishing for the aquarium trade and seafood has on the species diversity. Change in community structure and degradation of coral reef habitats make dive sites less attractive to recreational divers. While these concerns are localized, Pulonin and Roberts and other authors quoted in Dalzell and Schug (2001) note the

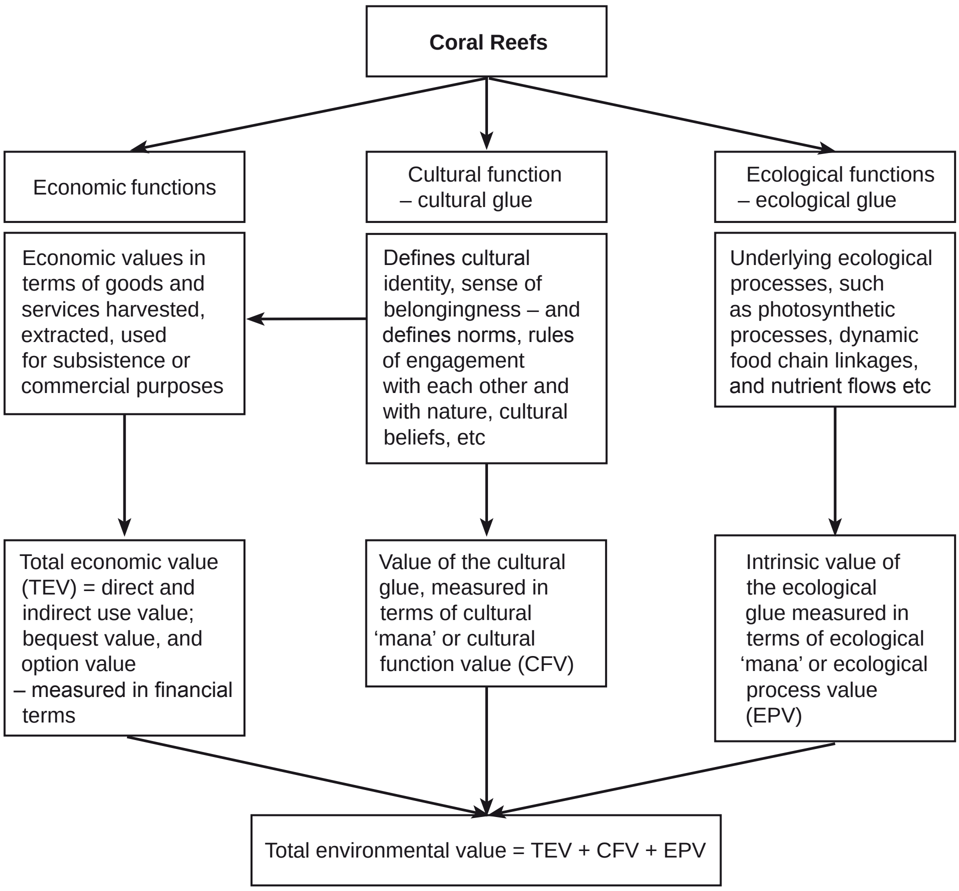


Figure 1. Total environmental values

impact fishing has had on, among other things, the degradation of coral reef habitat, reef community structure, and species composition. However, actual functional relationships between fishing and these effects are unknown.

While such impacts are not widespread in the Pacific, with about 60 per cent of the reefs considered at low risk (World Resource Institute 1998), in each country, reefs close to urban centers are under serious threat. In Fiji, most of the coral reefs are considered to be in a critical state (South and Skelton 2000), with many reefs under more than one threat. These concerns are similar to those found elsewhere in the world (Cesar 1996; Moberg and Folke 1999; WRI 2000). The difference is in the extent and magnitude, with coral reefs in other countries in a more critical state.

In the Pacific, while many of the impacts are localized, new trends are of great concern because of the Pacific Islanders' heavy reliance on their marine resources for their basic livelihood (RoundTable 1999; UNEP 1999; Adams 2001).

In summary, key coral reef management issues found in the Pacific, for which economic valuation information can be useful, include:

- Over-harvesting of marine organisms - coral reef-based fish and non-fish products, fish and live coral for the aquarium trade
- Over-harvesting of coral sand and hard coral
- Degradation of coral reefs due to externality effects of land-based activities
- Competition between tourism and commercial fisheries.

Underlying economic reasons for coral reef degradation

The key underlying reasons for many of these problems can be traced back to market failure associated with the presence of public goods for which there are no markets; the failure of policy or government to provide suitable management; and "livelihood failure". These three issues are discussed below.

Table 2. Comparison of the threats to coral reefs

Southwest Pacific	Fiji	Nauru	New Caledonia	Samoa	Solomon Islands	Tuvalu	Vanuatu	
• Natural disturbance and impacts								
- cyclones	x			x				
- crown-of-thorns	x							
- coral bleaching	x							
• Anthropogenic threats								
- over-fishing and destructive fishing practices	x	x		x	x			
- landuse activities and habitat destruction	x		x	x	x			
- coastal pollution	x				x			
- sedimentation, erosion and nutrient loading	x		x		x			
- tourism and recreational activities	x			x			x	
Southeast and Central Pacific	**Cook Islands**	**French Polynesia**	**Kiribati**	**Niue**	**Tokelau**	**Tonga**	**Wallis**	**Futuna**
• Natural disturbance and impacts								
- volcanic activity					x	x		
- cyclones		x		x				
- crown-of-thorns	x	x	x					
- coral bleaching	x	x				x		
• Anthropogenic threats								
- over-fishing and destructive fishing practices	x	x	x			x	x	x
- extraction and mining		x	x			x		
- sedimentation, erosion and eutrophication	x	x		x		x	x	x
- aquarium trade		x						
- coastal pollution	x	x	x				x	x
- tourism and recreational activities	x	x	x			x		
American Samoa and Micronesia	**American Samoa**	**Northern Marianas**	**FSM**	**Guam**	**Palau**			
• Anthropogenic threats								
- over-fishing and destructive fishing practices	x	x	x	x	x			
- landuse activities and habitat destruction	x	x	x	x				
- coastal pollution	x			x				
- sedimentation, erosion and nutrient loading	x	x		x	x			
- tourism and recreational activities		x		x	x			

Market failures

Coral reefs pose major challenges in defining ownership and use rights. Reefs are non-competitive, non-excludable and non-divisible, and thus individual property rights have not evolved naturally. While rights to terrestrial systems can be easily demarcated, fenced and enforced, rights to coral reefs cannot. As a result, while land is owned by individuals, aquatic resources, including coral reefs, often remain as public goods owned by the state. In the absence of private property rights, people using a natural resource treat it as a public good and market mechanisms cannot be relied on to allocate the resource to its highest valued use. Nor is there any incentive for individuals to restrain their activities and conserve the resource since they will not be assured of capturing the benefits of so doing. As a result, the market fails.

Costs not fully borne by those using the resource are likely to be disregarded, and the resources are generally over-exploited, degraded and abused. Market failure due to a lack of property rights is one of the fundamental causes of inefficient resource use and resource degradation (Wills 1997). Excessive degradation of coral reefs is explained by the absence of appropriate property rights. This is despite the presence of some form of customary "ownership" rights in many Pacific countries and the belief in the Pacific Way (Tupouniua 1980; Halaphua 1997).

Customary ownership rights and market failure

Communally owned, customary tenure in the Pacific usually covers terrestrial and aquatic resources and is held by people related by blood, common ancestry or marriage (Ward 1995). The Cook Islands, Fiji, and Samoa, for example, all have communally owned resource systems. In Fiji, family clans, or *mataqalis*, communally "own" the physical resources and the environment, including the coral reefs, lagoons and mangroves (Batibasaqa et al. 1999). Traditionally, these *mataqalis* manage the resources by using seasonal and area closures and ban the harvesting of certain species to allow the stocks to grow in time for expected pulse fishing for special celebratory events (Fong 1994; Adams 1998). The coastal fisheries are still managed in self-contained feedback loops at the village level (Adams 2001), with the traditional custom and culture guiding the use and management of communally owned resources for the common good (Ruddle 1998; Johannes 1993; Ruddle and Akimichi 1985).

But with the gradual erosion of customary marine tenure, largely because most colonial and post-colonial governments ignored local customary marine tenure and "appropriated" the ownership of the seabed and all aquatic resources, many of the resources are no longer managed properly. Even in Tonga, that was never colonized, marine resource ownership was assumed by the Tongan Crown (Petelo et al. quoted in Adams 2001). In all these countries, the state took the primary responsibility for "managing" the coral reefs and associated resources, and the governments themselves have been responsible for the over-harvesting and degradation of coral reefs.

Where customary rights were recognized and enforced, and where the transaction costs were less than the expected returns, a market for the coastal resources could develop and coral reef "owners" could "negotiate" a payment (resource rent) for the use of their resource. Resource rent is equivalent to the net benefits generated in an activity after all other input costs are paid, including returns to management. Thus, for example, to ensure that those harvesting fish for food or fish and live coral for aquarium trade took into account the cost of using coastal resources, they would be required to pay a resource rent that reflects the value of the public good in that activity. For this to be possible in the absence of an open market for public goods, some institutional mechanism needs to be in place to enforce compensation to the resource owners.

This has been the case in Fiji, where commercial fishers pay access fees to owners of customary fishing rights before obtaining a fishing license from the government. The government issues a commercial license only if the local customary right owners have given their permission. The customary fishing rights owners usually charge an annual "goodwill" or resource rent, which in recent years has ranged from US$1 000 to $5 000. Such a payment system, plus some control by the customary fishing right owners on the number of permits issued, has been applied, particularly to non-indigenous Fijians, who are the main commercial fishers. This has contributed to the fact that fishing pressure on the coral reef- and lagoon-based resources have not increased over time. However, these "goodwill" charges do not reflect the expected resource rent from a particular *mataqali* because rights associated with customary marine tenure are unclear. Until recently, the government declared these traditional rights to be non-compensable, despite having established an arbitration process to determine compensation for loss in fisheries resources due to mangrove reclamation and coral harvesting (Lal 1990).

Over-harvesting of fisheries resources also results from the fact that a resource rent-based payment system was not applied to the members of the customary fishing right owners, who were given exclusive rights to commercially harvest non-finfish species such as beche de mer, trochus and giant clam. These fisheries have all been over-fished – in some cases, such as that of the giant clam, to extinction. Nor is there any control on subsistence fishing.

A lack of clear property rights reflecting the ecological characteristics of the system concerned can also help explain excessive pollution impacts caused by human waste disposal and by soil erosion from deforested lands. Under western notions of property rights, private individuals, as mentioned earlier, often own land, while the aquatic systems belong to the state. In the absence of clear private property rights over the coral reefs and lagoons, people causing the externality effects do not have any incentive to reduce their level of pollution as they do not have to bear the costs incurred on the coastal system. As a result, pollution is excessive. Governments have tended to address pollution problems using command and control methods of licensing and by regulating the level of pollutants permissible. But even where command and control strategies have been used to control pollution, they have been applied to point source pollution. Non-point source pollution from agricultural activities and soil loss from deforestation, the management of which is often problematic, have not been addressed.

Government failures

Over-exploitation of resources also results from government or policy failures. Management has responded by using centralized, conventional strategies (for example, Adams 1998; Dalzell 1996; MRAG 1999; Huber and McGregor 2001). In particular, command and control-based regulatory strategies borrowed from single species temperate fisheries management models have been employed. Common strategies include licensing users, restricting the areas where harvesting of fish and non-fish products is permitted, and fish size limits. These approaches have been generally unsuccessful (Dalzell and Schug 2001), although some regulations have been effective. Poor management could, to some extent, be a result of incomplete information underpinning management design. Weak monitoring and enforcement capabilities, and limited resources available to the appropriate government agencies have also been responsible for the poor state of the resources.

Moreover, the command and control strategies do not generally provide incentives to the fishers to change their behavior in such a way as to achieve sustainable resources. Generally, users respond best to economic instruments, such as resource rent charges. To achieve efficient resource use, those using public goods need to be charged an appropriate level of resource rent. Ideally, resource rent is levied on the basis of the amount of fish and other renewable products extracted, although some of it may be captured in license fees. But even where economic instruments, such as license fees, have been used, they have been too small to have any impact on the level of effort. Only a few countries, such as Papua New Guinea and Fiji, charge fishers resource rent for the harvest of coastal fishes. In Fiji, as seen above, non-customary right inshore fishers pay "good will" for access to coastal resources to harvest finfish for local sale as well as for baitfish used in tuna fishing. These, too, have been too small to have any impact on fishers' effort, and "government failure" continues.

Livelihood failures

More recently, the marine protected area (MPA) management approach to protection has been widely advocated. This approach involves coastal areas being demarcated as protected areas, mainly for ecological reasons, and fishing and other extractive uses being banned. In some cases, tourism and recreational uses may be permitted. However, where "top-down" MPAs have been established, they have met with limited success (Huber and McGregor 2001), largely because local communities often do not have other non-fisheries related sources of income (World Bank 2000). This concern is illustrated by the following quote from Palau in relation to an MPA project supported by the South Pacific Biodiversity Conservation Programme, and listed as one of the International Coral Reef Action Network projects:

"While support and commitment to the objectives of the Ngaremeduu Conservation Area Project is [sic] strong…many people are concerned and feel threatened that the Project will deprive many of a range of preferred development options….[The] perceived loss of other cash-based development opportunities that are inconsistent with the conservation objectives of the [Ngaremeduu Conservation Area Project] is the only area of contention that may undermine community support for the project." (Ngaremeduu CAP Transition Strategy 2001).

Similar disregard for the need of the local community for income is found in many other projects in the Pacific (Lal and Young 2001). Consequently, despite the declaration of MPAs, coral reefs have continued to be degraded, due to what Emerton (2000) calls "livelihood failure".

To address concerns about livelihood and management failures there has been an increased emphasis on the use of traditional customary marine tenure to develop co-management in the Pacific (World Bank 2000; Adams 2001; Huber and McGregor 2001). Locally based MPA systems seem to have more success, but lessons from these MPAs and from fisheries co-management regimes suggest that greater consideration of other economic issues, and not just economic valuation information, is likely to produce greater success (see below; Sesega 2000; Lal and Keen 2001). For effective co-management of fisheries resources, carefully designed institutional arrangements are also necessary (see Huber and McGregor 2001 for more discussion).

The role of economic valuation

Economic valuation can play an important role in helping to address the coral reef management issues raised above. Economic valuation reveals the full cost of resource use, and thereby can provide governments and other decision-makers with reasons for conserving and using natural resources in a sustainable manner. It can help people make more informed choices between different activities, projects or programs by taking into account the full costs (and benefits) of "using" the environment. Developers can be made to consider the economic costs (and benefits) of the environmental impacts of development activities, and to reflect in their pricing the market value for public, non-marketed services provided by an ecosystem (Pearce et al. 1989; Pearce and Barbier 2000). However, the level of detailed economic valuation necessary will depend on its intended use and the local context.

Advocacy

Economic valuation information has commonly been used for advocacy, "prove [ing] to decision-makers in developing countries that improved management and conservation of coral reefs pays off" and helping prioritize options (ICLARM 2001). Throughout the world, the environmental goods and services supported by coral reefs and other natural systems have been "given too little weight in policy decisions" and this neglect "may ultimately compromise the sustainability of humans."

Decision-makers, individuals, communities and governments alike are more readily convinced about the benefits of conserving coral reefs and coastal resources if quantitative measures as well as non-monetary measures of benefits are available to them. It is easier to compare the economic (monetary) value of goods and services supported by the natural systems with monetary estimates of other developments than it is to compare non-monetary measures of the value of coral reefs.

The power of numbers cannot be undervalued, even if only crude estimates are available. This was the experience in Fiji. Crude economic value estimates of mangrove resources was the single most powerful piece of information that convinced the Minister responsible for land development to place a moratorium on the reclamation of large-scale mangroves in 1983. Prior to that, and despite their *in situ* uses for subsistence and commercial fish harvests as well as for firewood and other non-timber products being well recognized, mangrove resources were being reclaimed at a rapid rate. Reclamation was carried out by the government in an effort to "produce new lands" for agricultural or industrial use.

Different levels of information can be used to assist natural resource use decisions. Decisions can be made at the national level when a government is choosing national or regional level policies or projects that may have significant national level impacts because of inter-sectoral linkages. For this, general equilibrium based, national level, economic impact assessment of change in gross domestic product (and national employment) are appropriate economic measures (Perman et al. 1999). For small activities or developments, partial analysis of net economic contribution is generally used, as discussed below.

Choice between different uses

Ideally, society derives maximum welfare by using resources in ways that produce the highest net returns. Economic values are measured in terms of their net contribution to the economic wellbeing of the economy. In the current example, these value estimates reflect consumers' willingness to pay (WTP) for goods and services that are supported by coral reefs and producer surplus. Furthermore, these are defined in terms of marginal changes and are context-specific, reflecting the relative preferences of individuals and the society as a whole. In essence, the economic valuation of a use or non-use reflects the consumer surplus and producer surplus, or net rent, associated with the supply and consumption of the goods and services. Hence, ideally, when estimating the *in situ* economic value of any natural system, including coral reefs, the consumers' WTP (consumer surplus) for each of these goods and services and net producer surplus estimates are aggregated to derive TEV estimates. Where the supply of natural resources does not incur costs (such as wild fishery or coral reefs), producer surplus may be zero and the appropriate valuation will only involve estimating the consumer surplus (Costanza et al. 1998).

To make informed choices between activities, economists would use marginal change in the TEV resulting from the activities and choose that option which has the highest net value, as measured by the net present value, the cost-benefit ratio or the internal rate of return (Sinden and Thampapillai 1995). To make such a comparison, cost-benefit analysis of each option is undertaken to determine the economic benefits, and net costs (producer and consumer surplus). The use that contributes the most to economic welfare would be the option chosen.

Similarly, to choose between a development project that may have a negative impact on the quality of a coral reef system and the conservation of the reef system, one would need the economic value of the change in the total economic values of direct and indirect uses and non-use values of coral reefs with and without the proposed development project. One of the assumptions behind this approach is that for each of the goods and services supported by the coral reef, substitutes are readily available. The developers would compensate those who stand to lose as a result of the development.

Internalizing external costs and efficient resource use

From a social perspective, a resource is said to be efficiently used if all costs are internalized – for example, if external costs are borne fully by those causing the externalities and those using the public goods. Ideally, all types of payments would be based on economic valuation (Panayantou 1995).

In theory, agriculturalists or foresters who cause soil erosion resulting in coral reef degradation, would pay, according to the "polluter pays principle" (PPP), the value of the degradation caused by their activities. Society would thus be better off, with all resources being used in an efficient manner, because those causing the impacts would be encouraged to internalize the external costs. In order to control the level of erosion and other damaging land based activities in this way, information about the economic value of the impacts would be needed, and a "pollution tax" or fee on those causing the impact would be levied. Where customary rights are recognized and negotiation possible, and assuming upstream uses were legal, economic valuation information would help resource owners negotiate appropriate compensation for damage caused by upstream users.

For the use of public goods, such as fisheries, efficiency can be improved by making the fishers pay (resource rent) for the resource instead of treating them as "free goods." Even where customary ownership rights exist, as in Fiji, economic valuation of resources could help resource owners obtain fees that closely reflect the resource rent values, instead of fees being arbitrarily set, as is currently the case. For extractive uses of renewable resources, the appropriate fee is the resource rent charge.

Alternatively, where fisheries exhibit open access characteristics, economic valuation can help identify the level of resource rent that needs to be extracted to ensure efficiency in use. If fishers have to pay for the use of public goods, especially if the charges imposed closely reflect the level of resource rent expected from the fishery, they will be encouraged to use the resources in a sustainable and an optimal manner. It is worth noting that the change in pricing signals for reef use may have implications downstream. Consumers may have to pay higher prices for the products and services; the price of fish in the market may go up. While this may not be an issue for exported products, as the producers may already have high profit margins, domestic consumers may be adversely affected in the short-run. In the long-term this may, however, lead to an adjustment in the demand, consequently leading to efficient resource use.

Where coral reefs are used for recreational purposes, economic valuation can help determine the charge levied on tourists. This fee will reflect the net benefits they derive over and above what they pay to visit a site, that is the consumer surplus (Geen and Lal 1993; Dixon et al. 1993). Where traditional marine tenure exists, the fees could be levied by customary right holders or by the government, and could capture the value of the public goods to the recreational users.

The measure of marginal net benefits used for choosing between options will depend on the choices under consideration, and the aspect of the reef that is involved or may be affected. Moreover, the economic benefit estimates required to make choices between options differ from the measures that would be needed to improve efficiency in the use of renewable resources (such as fish, non-fish and live coral), or of non-renewable mineral resources. These measures differ again from the economy-wide level choices that central governments will make when deciding on broad sector-level policy decisions.

Funds raised through resource rent charges and charges levied to make users internalize their external costs could be highly valuable in cash-strapped countries such as those in the Pacific. To be effective, the user charges collected need to be ploughed back into management.

Economic valuation of coral reefs

Ideally, the partial valuation estimates used in key economic decision-making would capture people's WTP for environmental goods and services, regardless of whether or not the services supported by the ecosystem actually contribute to the money economy (Costanza et al. 1998). Usually, of the total environmental value, only the TEV has been estimated. Globally, the TEV of coral reefs has been estimated to be US$375 billion (Costanza et al.1998).

Economic valuation of a coral reef-based system would require estimating the total economic value (sum of consumer and producer surplus) derived from direct and indirect use and non-use values listed in Table 1. Different valuation methods have been used to estimate these values (Table 3). For each valuation method, economists have identified some inherent methodological issues (Freeman 1999). These, together with many uncertainties and incomplete information about the dynamics of coral reef ecosystems, cast some doubt on the usefulness of detailed economic valuation in many situations in the Pacific.

Table 3. Methods of valuing the goods and services provided by coral reefs

Goods and services		Measurements	Methods
Direct use values – extractive	Fisheries – fish and non-finfish harvested for subsistence and commercial and the aquarium trade	Net economic value of fisheries output "with and without" coral reefs	Production method
	Live coral for the aquarium trade	The net value of the products	Production method
	Pharmaceutical and other industrial uses	The net value of the products	Production method
	Construction material	Resource rent	Market value approach
Direct use values – non-extractive	Tourism	• Tourism consumer surplus • Tourism producer surplus	• Contingent valuation method (CVM)/ Travel cost method (TCM) • Hedonic pricing method • Production method approach
	Education	• Financial benefits • Social benefits	• Benefits arising from education program expenditures • CVM
Indirect values	Biological support	Biological functions	• Change in productivity using Production Method • Percentage dependence technique
	Physical protection	Coastal protection	• Change in productivity approach • Percentage dependence technique • Replacement cost technique
	Global life support	Carbon storage function	Benefit transfer approach
Non-use values	Existence values	Satisfaction for future generations	CVM; choice modeling
	Option values	Expected values for future uses	CVM; choice modeling
	Ecological process values	???	??
	Cultural function values	???	?? (perhaps CVM and opportunity cost approach – see Lal and Young (2000))

Adapted from Spurgeon 1992; Huber and Ruitenbeek 1997.

Economic valuation of coral reefs in the Pacific is almost non-existent. Globally, most coral reef valuations cover only aspects of the total economic valuation. Ecological values and cultural functional values (Figure 1) are usually not valued.

Many TEV studies have focused on direct or indirect use values only. Frequently, they have concentrated on harvested product values and recreational and tourism use values (e.g. Gustavson 2000; Driml 1999; Cesar 1996; Pendleton 1995; McAllister 1991; Hundloe 1990; Hodgson and Dixon 1988). Only a few studies report on the indirect values associated with some of the ecological functions, such as coastal protection (Gustavson 2000; Huber and Ruitenbeek 1997; Cesar 1996; McAllister 1991). In one coral reef valuation study in the Pacific islands identified, Mohd-Shawahid (2001) estimates the economic value of fisheries products harvested in Samoa.

Extractive uses

Generally, the production valuation method has been used to determine the economic value of direct extractive uses of fisheries and other flora and fauna harvested. The production valuation method involves subtracting all the costs (opportunity costs) of all inputs from the total revenue in order to estimate the net benefit. Where demand and supply functions are known, this method will provide an estimate of the consumer and producer surplus.

Generally speaking, there are several drawbacks in some of these studies. Some production method-based studies used gross revenue as a basis of the estimation (Hodgson and Dixon 1998; Driml 1999), while others have estimated net economic values explicitly using revenue and cost data (e.g. Cesar 1996). On the other hand, Mohd-Shawahid (2001) estimated the net returns using an assumed percentage of gross returns. By using gross values and ignoring the opportunity cost of capital and labor in fishing effort, the economic values of extractive uses are over-estimated.

In some studies, the functional link between the presence of coral reef and the flow of fish and non-fish products was not taken into account (Driml 1999; Mohd-Shawahid 2001). It is possible that, even if coral reefs were totally degraded, the coastal zone/lagoon would continue to support some of the species and sustain extractive uses, albeit at lower levels. In such circumstances, the total value of fisheries output could not be attributed to the coral reef system.

Coral reef ecosystems are complex, and their dynamics not well understood. Determining the potential optimal fisheries yield for complex reef environments involving many species of fish and non-fish fauna is fraught with difficulties (Johannes 1998). The food web linkages are poorly recognized and the dynamics of each species is insufficiently understood to determine optimal yield. Determining the optimal yield is even more difficult for countries in the Pacific, where no, or only limited, scientific information is available, and where local technical capacity is almost non-existent (Huber and McGregor 2001). In the Pacific, this problem is magnified by the lack of resources available for scientific research (South 2001). Analysts have, thus, had to make many assumptions. When estimating economic values, the base (or current) harvest level is often assumed to be the socially optimal one.

It is also difficult to "determine causal relationships between human actions and ecosystem functions and processes" (Bingham et al. 1995). When estimating the net economic value of the impacts of human activities, various assumptions are made, making it impossible to aggregate values of various direct and indirect uses (Spurgeon 1992). Cesar (1996), for example, estimates the value of separate coral reefs by looking at the loss in fisheries output due to detrimental fishing practices, coral mining and sedimentation, but refrains from aggregating the total effect of these practices. On the other hand, McAllister (1988) used the current harvest level of aquarium fish in the Philippines to determine the potential economic value of the Philippines adopting sustainable production practices.

It is possible that reported values of coral reef fisheries, estimated using production methods, are overestimated or underestimated. Care needs to be exercised in interpreting reported values, although Huber and Ruitenbeek (1997) note that the production method of a small number of local direct and indirect uses can provide a "useful benchmark for other valuation."

Recreational and other values

Recreational values associated with coral reefs have generally been estimated using the travel cost method (TCM) and contingent valuation (e.g. for GBRMP, Hundloe (1990) uses both CM and TCM). Some have used gross travel related expenditures on hotels, taxes, travel costs, etc. For example, Hodgson and Dixon (1988) used this approach to determine the recreational value for Bacuit Bay in the Philippines; Cesar (1996) for Indonesia; Driml (1997) for the Great Barrier Reef Marine Park; and Gustavson (2000) for Montego Bay Marine Bay. In these cases, tourism and recreation values of coral reefs are probably under-estimated (Cartier and Ruitenbeek 2000). On the other hand, others, such as Dixon et al. (1993), used gross expenditures on divers fees, hotels, etc., to justify the establishment of the Bonaire Marine Park. The direct expenditure method was also used to evaluate coastal whale watching in Tonga (Orum 1999).

The contingent valuation method has also been used to determine recreational values (Hundloe 1990; Spash et al 2000). CVM was used to estimate tourist visit value to coral reef sites in Nigril, Jamaica (Wright quoted in Cartier and Ruitenbeek 2000). CVM has also been used to estimate bequest and existence values (e.g. Huber and Ruitenbeek 1997). While TCM and CVM can provide insights into non-use and other values, care needs to be taken in designing surveys to accommodate lexicographic preferences (Huber and Ruitenbeek 1997).

For estimating indirect use values associated with coral reefs, different methods have been used. Gustavson (2000), for example, estimates the value of coastal protection by determining the prices of land that would have been eroded, thus attributing the "protection of the coastal property" from erosion to the presence of the coral reefs. To estimate the economic value of shore protection provided by coral reefs, Cesar (1996) also used the net economic value of agricultural land that could be eroded if coral reefs were lost due to reef blasting or mining.

McAllister, on the other hand, uses the replacement cost method to determine the coastal protection offered by coral reefs in the Philippines, thus treating the costs as the economic value of the shore protection provided by coral reefs. Cesar (1996) also used costs of building shoreline protection infrastructure, such as groynes and seawalls, to determine the economic value of the shoreline protection offered by coral reefs.

Valuation issues

In practice, it is possible to overestimate, and in some cases underestimate, the actual economic value of the services provided by coral reefs (Cartier and Ruitenbeek 2000). Many of the valuations of extractive uses of coral reefs using the production valuation method, and direct tourism values derived using the travel cost method, may capture the value of resources protected rather than the actual value of the services provided by coral reefs. Standard CBA tells us that, in order to determine the economic contribution of a project resource or an activity, or the economic costs due to a project, it is necessary to do a "with and without" assessment. However, the challenge is to estimate the shifts in the supply curve (in the case of fish and non-fish production), or the demand curve (in the case of tourism and recreational uses) (Spurgeon 1992). Thus, for example, sedimentation that causes coral reef degradation and that results in a decrease in species diversity would shift the recreational diving demand curve downwards. This would result in a lower WTP for each recreational dive, consequently reducing the consumer surplus associated with recreational use of the coral reefs. Similar shifts in the supply of coral reef fish would occur with a decrease in reefs as habitat, reducing the expected resource rent or producer surplus.

The WTP for coral reef resources may be underestimated when subsistence use is the main activity. This is likely to be particularly problematic when the loss in subsistence values from a development activity is considered to be less than the expected net benefits derived from the development activity that produces goods and services sold in mature markets.

Replacement cost methods and the value of coastal land as a proxy for the shore protection value of coral reefs may also overestimate the value of shore protection services provided by coral reefs. Coastal land may not be totally lost if coral reefs were lost. Similarly, replacement cost represents the gross, not the net, value of the reefs.

In general, TEV studies of coral reefs may not generally capture the value of all the goods and services provided by them, even if appropriate net values (consumer surplus and producer surplus) are captured for each of the goods and services. Furthermore, in most coral reef valuation studies, partial or total economic value estimates relate to the total reef area and not to increments thereof (Cartier and Ruitenbeek 2000). Such valuation estimates may suffice if they are to be used for advocacy purposes. The TEV estimates of the total reef area, even if only some of the direct and indirect use values are fully captured, may serve such a purpose. But if the estimates are to be used in CBA-based decision-making, than valuation estimates need to reflect the net economic contribution, that is, the sum of the consumer surplus and the producer surplus.

Economic valuation of coral reefs and resource allocation decisions in the Pacific

As discussed above, society's welfare is maximized if a resource is used in that activity in which it produces the highest net economic benefits.

For large projects or broad national policies, estimates of the impacts of coral use on gross domestic product, including any flow-on effects throughout the economy, is the key focus. Such economy-wide impacts are measured using a variety of models, including input-output models and computable general equilibrium models (Perman et al. 1999). Such models not only require excellent data, but they also need a very good quantitative understanding of the linkages between different sectors of the economy and of interactions between the economy and the environment. Moreover, they are based on, among other assumptions, assumptions that markets for all goods and services are in equilibrium, that all markets are connected, and that all "firms" are profit maximizers. Very few countries in the Pacific region have such economy-wide models; even where they do exist, they are insufficiently disaggregated to measure coral reef-based activities. For advocacy purposes, a crude estimation of the total economic benefits derived using multiplier factors may suffice in those situations where large activities are involved.

At the micro level, the appropriate valuation measure is the change in TEV. This value is estimated as the sum of the consumer surplus and the producer surplus generated in each use and non-use, with this sum then used in a CBA-based decision-making framework. However, even if the economic valuation estimate concludes that a particular coral reef area should, say, be put aside as a marine protected area, that conclusion may not be socially desirable. For example, a "no take" zone will not be acceptable to local communities' that are dependent on the reef for their livelihood, especially where there is no alternative source of income.

In extreme cases, where coral reefs are a scarce resource and the local communities have very few substitutes, as is often the case in the Pacific, people's WTP (demand curve) for coral reefs is likely to approach infinity as less and less coral reefs remain. The consumer surplus, and thus the total economic value of the coral reefs, may approach infinity (Costanza et al. 1998) as the supply of coral reefs reaches a threshold.

In many developing countries it is also often not just a case of choosing between different activities based on maximizing economic welfare, but one of equitable distribution of income, an issue which economic welfare-based CBA ignores (Sinden and Thampapillai 1995).

It is also very likely that governments and local communities will be interested in maintaining a diversity of income sources, to ensure resilience in the face of external shocks, such as cyclones, to which the Pacific islands are regularly exposed. Thus, decisions made solely within the economic framework may not provide socially optimal outcomes. For the Pacific islands, ecological process values and cultural capital values are also likely to be crucial for the sustainability of livelihoods. It is for these reasons that Pacific island nations have promoted, and in some case implemented, community-based conservation and development projects. Examples of these are fisheries co-management in Samoa (King and Fa'asili 1999) and the South Pacific Biodiversity Conservation Program and the International Waters Programme (SPREP 2001).

Under such circumstances, economic valuation could play a useful role but, as discussed below, in a limited capacity.

Resource use decisions and CBA

In general CBA, let alone economic valuation estimates, have not been employed to make real choices when it comes to natural resource use, including coral reef use. Leaving aside the standard arguments for not using CBA – ethical debates about measuring natural resources in monetary terms, difficulties in choosing appropriate discount rates and shadow values for traded and non-traded goods affected by policy distortions, and problems in estimating WTP for non-marketed goods and services – few coral reef valuation studies focus on the CBA of alternative use and management strategies. Hodgson and Dixon (1998) evaluated a possible impact on coastal fisheries of continued logging and consequent sedimentation of the coastal reefs in the Philippines. They compare the net benefits between continued logging and a logging ban. Cesar (1996) examines the net benefits of a sustainably managed reef fishery and compares it with the net benefits of a fishery subjected to detrimental fishing practices, coral mining or sedimentation.

Operationally, too, CBA has not often been used, even in countries such as the United Kingdom (McFarquhar 2001). It seems CBA has been largely advocated and employed by multilateral development banks, such as the World Bank and the ADB, and by some United Nations agencies. Many of these projects are "top-down" state (or donor) driven investment processes, and often projects are chosen first and figures manipulated to justify decisions already made. In an Australian-funded mangrove reclamation project in Fiji, initial CBA of the proposed drainage and irrigation project showed a negative NPV. Because of the lower than desirable estimated economic returns, various input values and the value of social discount rates were changed until an acceptable NPV was derived. This observation is also supported by McFarquhar (2001, p. 9), who notes that CBA in general and social pricing in particular "take on an Alice in Wonderland quality….[with] figures become [ing] what one wants them to mean. Projects are chosen first and figures are manipulated to support the decision". The formal CBA is used as a "kind of window dressing" (Kenney and Raiffa 1976, p. 9).

This does not mean that economic valuation information cannot, or should not, be used to make informed decisions about trade-offs. What it suggests is that estimating economic values associated with coral reefs alone cannot guarantee an informed decision. There needs to be a level of rigor applied when estimating economic values. Countries should have the capacity to critically assess the valuation estimates provided by researchers. Institutional decision-making mechanisms that require explicit consideration of economic valuation have to be in place. In most developing countries, and the Pacific island nations are no exception, personnel trained in resource and environmental economics and in CBA are limited. In such situations, an economic valuation based on a centralized decision-making process could be nothing more than a first step towards encouraging consideration of economic costs and benefits of different actions. Where information is limited and where there is limited understanding about coral reef system dynamics and the relationship between human activities and reef health, institutional capacity that allows key decision-makers to integrate ecological, economic and social information is needed.

Economic valuation and "bottom-up" decision-making

As a reaction to poor results achieved through the "top-down" centralized decision-making process of the past (e.g. Pretty 1995), there is a general push for decentralized decision-making and an increased devolution of responsibilities to local levels. Recent experiences in the Pacific region clearly favor local, community-based management and conservation of marine resources (Huber and McGregor 2001). The Pacific island governments have also formally endorsed the use of "bottom-up" community-based management in the action strategy for nature conservation in the Pacific Islands region (RoundTable 1999). Participatory approaches have gained favor internationally; within the Pacific the "bottom-up" approach is becoming a norm because of the belief that it can empower local communities to articulate their own agenda (Lal and Keen 2001).

In community-based management processes, everyone is actively involved in the decision-making. This includes identifying the issues, deciding on what actions need to be taken, designing the projects, implementing and monitoring, and ensuring that the project remains responsive to changing circumstances (Bond and Hulme 1999). Communities in this "process approach" learn from experience; and this, along with flexibility in scope, scale and methods, is an integral component. This adaptive decision-making process (ADMP) also recognizes uncertainty and risks, adopts a precautionary approach to management, and involves making decisions based on the best available information while having feedback loops so that stakeholders learn from their own experiments and build on experience (Lal et al. forthcoming).

In such a "bottom-up" decision-making environment, it is unlikely that appropriate resources will be available at the local level for detailed economic valuation studies for every small use and management decision that local communities are likely to make. In any case, one of the foundations of "bottom-up" process is the possibility of individuals negotiating a solution and thus obviating the need for detailed economic valuation. Moreover, given incomplete understanding of the complex and interactive ecosystems and/or the dearth of detailed economic and biological baseline information, valuation of small areas may be difficult. They may also be highly costly, so the level of accuracy needs to be weighed against the costs and benefits of information collection. Gross over-simplification may be required about, amongst other things, the relationship between activities and their impacts. Economic valuations may thus provide nothing more than information about the orders of magnitude and the relative values of goods and services supported by coral reefs. Such incomplete and uncertain values could not be of much use in the actual CBA-based decision-making process unless other information is also considered.

Where decision-making is devolved to the local level, and that perspective is given importance in a more "bottom-up" approach, social welfare criteria and detailed economic valuation may be somewhat "irrelevant" (McFarquhar 2001, p.10). Local communities may choose between activities from their own particular perspectives. Needs and aspirations of the local communities and local level issues are likely to be given greater weight than are benefits to the society as whole, especially in the presence of uncertainties and risks. This is not to say that some idea of economic valuation of different uses and CBA cannot be used to guide decisions. But economic valuation information will only be one of the inputs in the decision-making process. Financial and economic information will be of use at the second tier level (Lal 1990; Norton et al. 1998; Tacconi 2000). The CBA framework can be used to systematically and explicitly identify all the costs and benefits associated with alternative activities, and, where possible, economic valuation information can be used to modify a project. Stakeholders could agree on the desired development and conservation goals and use cost effectiveness criteria to choose between alternative projects (Rijsberman and Westmacott 2000). In this approach, economic valuation of the expected coral reef improvements resulting from certain management decisions is not necessary.

Therefore, whether a "bottom-up" or "top-down" approach is used, economic valuation of coral reefs may not be the only piece of information that is used to determine "optimal" use. Moreover, where activities are minimal and islands are scattered across a vast span of water, the cost of carrying out non-market valuations is likely to be large in comparison with the expected improvement in decisions. A CBA-based decision, derived using market- and non-market-based valuation may not be the most cost effective. Instead, careful considerations of key economic issues and institutional decision-making processes may be more suitable. Lal and Keen (2001) have identified many economic issues, other than just economic valuation estimates. Careful consideration of factors such as incentives to which community members respond; individual needs, aspirations and goals; potential for rent seeking behavior, and: equitable sharing of benefits in proportion to individual effort, are some of the suggestions that Lal and Keen highlighted.

Economic valuation, internalizing external costs and efficient resource use

As discussed earlier, pollution effects can be minimized if those causing the impacts are made to pay for them. Thus, government can get "impactors" to pay for the marginal cost of degradation caused by sedimentation and eutrophication. In most countries, licensing of point source pollutants has been the common "management" strategy. However, rarely do activity license fees reflect the marginal environmental costs (O'Connor 1999). Even in developed countries, where pollution taxes have been levied, fees are often set too low to have any effect (Cansier and Krumm 1997; Panayantou 1995). They are at best aimed at cost recovery of management fees only.

Where transaction costs of identifying the non-point polluters are high, economic valuation of impacts may not help improve economic efficiency. Nonetheless, economic valuation can help identify the optimal magnitude of fees to be set in the long-run, even if, in order to gain acceptance of the charging principle, initial fees are set at a low rate (Panayantou 1995; O'Connor 1999).

Conclusion

Economic valuation of coral reefs and their goods and services can contribute to improved management and conservation in the Pacific. However, economic valuation *per se* cannot have much of an impact unless it is clear what information is needed, what type of decision should be made, and what level of detail is appropriate and necessary.

For general advocacy purposes, making a valuation based on gross returns (or losses if reefs were not conserved) available to appropriate decision-makers could suffice. But if the information is needed to make informed choices between alternative uses of coral reefs, detailed marginal net economic benefits as well as the consumer surplus and producer surplus associated with each use option would ideally be required. If the detailed marginal total economic values are not available, then a decision based on partial valuation may be adequate. In the order of preference, valuations in the past have been based on the sum of consumer surplus and producer surplus, the net rent (producer surplus), and price times quantity (as a proxy for the economic value assuming an inelastic supply and a non-linear demand for goods and services) have been used (Costanza et al. 1998). Various assumptions have been made to try and capture the net economic values. However, it is important to note that it is the marginal net economic benefits associated with the activities not total economic values of coral reefs that need to be considered when choosing between options.

Similarly, if valuation information is required to identify "pollution fees" designed to minimize, or reverse, the impacts of land-based activities, then the net economic value of the expected impacts needs to be determined. To do this, basic information about the functional relationship between human activities and their impacts on the goods and services supported by coral reefs is critical. Where such information is unavailable, or the understanding of the complex coral reef ecosystem is incomplete, economic valuation estimates may only be as good as the functional relationships assumed. Some measure of valuations would be useful, provided the cost of obtaining such information does not outweigh the expected difference that information may make on the final outcome.

For economic valuation estimates to have any impact, the presence of an appropriate decision-making framework and centralized or local community-based decision-making processes are needed. In-country capacity to critically assess the robustness of the estimates provided is as important as the capacity to use the information in the appropriate manner. For governments to adequately use valuation information, an appropriate CBA-based decision-making process is important. At the very least, an institutional process ought to be in place by which economic valuation information can be explicitly considered as one, if not the only, criterion for making the appropriate choice.

In countries such as those in the Pacific, choices made using only economic net benefit values may not be sufficient, because of the assumptions that underpin CBA-based decision criteria. In many island nations, the resource base is limited and substitute income sources are almost non-existent. As a result, for local communities, a choice between options may not always be appropriate. Some compromised (combined) set of activities may be necessary in order to maintain economic resilience. Local communities may thus need to identify, *a priori*, in a "bottom-up" development and conservation process, their needs and aspirations and decide on the diversity of activities to meet their objective, given the available natural and human resources.

Economic valuation could provide some assistance in choosing this set of activities. Some relatively crude estimates, together with some assessment of realizing such benefits given the existing infrastructure, may suffice (Lal and Keen 2001). It is at the second tier level that detailed economic valuation could be used to fine tune decisions. As a minimum, a cost effectiveness analysis is important, because the economic value of the improvements in the coral reef environment needs to be estimated.

In conclusion, economic valuation can help improve coral reef conservation and management, but the level of detailed valuation required depends on the use the value estimates will be put to and on the management objective addressed. It will also depend on whether a "top-down" centralized decision-making process is appropriate or a "bottom-up" community-based decision-making process is to be used. If it is the latter, it is very likely that local Pacific island communities will be making only minor decisions at a time, for which detailed net economic valuation-based decision-making may be overdone. In any case, the net benefit estimation in these circumstances will be associated with a great degree of uncertainty. Instead, some gross estimation of the expected net economic (financial) benefits may suffice, together with some assessment of realizing such benefits. But, importantly for community-based management, careful considerations of other economic issues may be more useful in designing a community-based institutional regime to suit local conditions.

References

Aalbersberg, B. 2001. Marine bioprospecting: the pathway from organism to product and the implication for indigenous resource owners, p. 267-273. *In* R. South, G. Cleave and P.A. Skelton (eds). Oceans in the new millennium: Challenges and opportunities for the islands. International Ocean Institute, Romania.

Adams, T. 2001. The interface between traditional and modern fishery management in the Pacific islands. Secretariat to the Pacific Community, www.spc.org.nc/coastafish/Reports/ICFMA/ocm1.htm (15 May 2001).

Adams, T.J. 1998. The interface between traditional and modern methods of fishery management in the Pacific islands. Oceans and Coastal Management 40(2-3):127-42.

Batibasaqa, K., J. Overton and P. Horsley. 1999. Vanua: Land, people and culture in Fiji, p. 100-108. *In* J. Overton and R. Scheyvens (eds). Strategies for sustainable development: Experiences from the Pacific, University of New South Wales Press, Sydney, Australia.

Bingham, G., R. Bishop, M. Brody, D. Bromley, E.T. Clark, W. Cooper, R. Constanza, T. Hale, G. Hayden, S. Kellert, R. Norgaard, B. Norton, J. Payne, C. Russell and G. Suter. 1995. Issues in ecosystem valuation: improving information for decision-making. Ecological Economics 14(2):73-90.

Bond, R. and D. Hulme. 1999. Process approaches to development: Theory and Sri Lankan practice. World Development 27(8):1339-58.

Cansier, D. and R. Krumm. 1997. Air Pollution taxation: An empirical survey. Ecological Economics 23(1):59-70.

Carswell, C. 2001. Tourism and culture and sustainable uses of marine resources, p. 139-146. *In* R. South, G. Cleave and P.A. Skelton (eds). Oceans in the new millennium: Challenges and opportunities for the islands. International Ocean Institute, Malta.

Cartier, C. and J. Ruitenbeek. 2000. Review of empirical biodiversity literature, p. 207-240. *In* K. Gustavson, R.M. Huber and J. Rutienbeek (eds). Integrated coastal zone management of coral reefs: Decision support modeling. The World Bank, Washington, D.C., USA.

Cesar, H. 1996. Economic Analysis of Indonesian Coral Reefs. World Bank Environmental Development, Washington D. C., USA.

Cook Islands, Fiji, Kiribati, Marshall Islands, Nauru, Nuie, Papaua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu and Vanuatu. 1998. Strategic action programme for international waters of the Pacific islands region. South Pacific Regional Environment Programme, Apia, Samoa.

Costanza, R., R. d'Arge, R. de Groot, S. Farber, M. Grasso, B. Hannon, K. Limburg, S. Naeem, R.V. O'Neill, J. Paruelo, R. Raskin, P. Sutton and M. van den Belt. 1998. The value of the world's ecosystem services and natural capital. Ecological Economics 25(1):3-15. Also printed in Nature 387(15 May 1998):253-260.

Dalzell, P. 1996. Selectivity and yields of reef fishing. *In* N. Polonin and C. Roberts (eds). Reef Fisheries. Chapman and Hall, London, U.K.

Dalzell, P., T. Adams and N. Pulonin. 1996. Coastal fisheries in the Pacific islands. Oceanography and marine biology: An annual review 34:395-531.

Dalzell, P. and D. Schug. 2001. Synopsis of information relating to sustainable coastal fisheries. SPREP - Strategic action programme for international waters of the Pacific islands region. South Pacific Regional Environment Programme, Apia, Samoa.

Dixon, J., L. Fallon Scura and T. van Hof. 1993. Ecology and microeconomics as "joint products": The Bonaire Marine Park in the Caribbean. LATEN Dissemination Note No. 6. Latin America Technical Department (LATEN), World Bank, Washington D.C., USA.

Driml, S. 1999. Dollar values and trends of major direct uses of the Great Barrier Reef World Heritage Area and other protected areas. Research Publication 34, Great Barrier Reef Marine Park Authority (GBRMPA), Townsville, Australia.

Driml, S. 1997. Bring ecological economics out of the wilderness. Ecological Economics 23:145-153.

Emerton, L. 2000. Using economic incentives for biodiversity conservation. IUCN - The World Conservation Union, http://www.economics.iucn.org (19 October 2001).

Fong, G. 1994. Case study of a traditional marine management system: Sasa village, Macuata Province, Fiji. FAO. Rome, Italy.

Freeman, A.M.I. 1999. The measurement of environmental and resource values: Theory and methods. Resources for the Future, Washington D.C., USA.

Geen, G. and P. Lal. 1993. Charging users of the Great Barrier Reef Marine Park, Australian Bureau of Agricultural and Resource Economics (ABARE). Canberra, Australia.

Glowka, L. 1998. A guide to undertaking biodiversity legal and institutional profiles. IUCN, Gland, Switzerland, Cambridge, U.K., and Bonn, Germany.

Gustavson, K. 2000. Values associated with the local use of the Motengo Bay Marine Park, p. 83-96. *In* K. Gustavson, R.M. Huber and J. Rutienbeek (eds). Integrated Coastal Zone Management of Coral Reefs: decision support modeling. The International Bank for Reconstruction and Development, The World Bank, Washington D.C., USA.

Halaphua, S. 1997. Harmonising resources for sustainable

economic development in the Pacific Islands context, p. 22-29. *In* B. Burt and C. Clerk (eds). Environment and development in the Pacific islands. National Center for Development Studies. Canberra, Australia.
Hodgson, G. and A. Dixon. 1988. Logging versus fisheries and tourism in Palawan: An environmental and economic analysis. Occasional Paper No. 7. East-West Center Environment and Policy Institute. Honolulu, Hawaii, USA.
Huber, M.E. and K. R. McGregor. 2001. A synopsis of information relating to marine protected areas in the Pacific islands. South Pacific Regional Environment Programmes. Apia, Samoa.
Huber, R.M. and J. Ruitenbeek. 1997. Marine system valuation: An application to coral reef systems in developing tropics. Interim Report to the World Bank Research Committee Project #RPO 681-05. The World Bank. Washington, D.C., USA.
Hundloe, T. 1990. Measuring the value of Great Barrier Reef. Journal of the Royal Australian Institute of Parks and Recreation 26(3):11-15.
ICLARM-WorldFish Center. 2001. Preliminary announcement - International Consultative Workshop on Economic Valuation and Policy Priorities for Sustainable Management of Coral Reefs. ICLARM-WorldFish Center, Penang, Malaysia.
IUCN-UNEP-WWF. 1991. Caring for the earth: A strategy for sustainable living. IUCN -The World Conservation Union, UNEP- United Nations Environment Programme and WWF-World Wide Fund for Nature, Gland, Switzerland.
Johannes, R.E. 1993. The value today of traditional management and knowledge of coastal marine resources in Oceania. Workshop on People, Society and Pacific Islands Fisheries Development and Management: Selected Papers. South Pacific Commission. Noumea, New Caledonia.
Johannes, R.E. 1998. The case for data-less marine resource management: Examples from tropical nearshore finfisheries. Trends in Ecology and Evolution 13(6):243-6.
Kenney, R. and H. Raiffa. 1976. Decisions with multiple objectives. Wiley. New York, New York, USA.
King, M. and U. Fa'asili. 1999. Community-based management of subsistence fisheries in Samoa. Fisheries Ecology and Management 6:133-144.
Lal, P. and M. Keen. 2001. Economic considerations in community based project planning and implementation. South Pacific Regional Environment Programme. Apia, Samoa.
Lal, P., H. Lim-Applegate and M. Scoccimarro. INRM or Adaptive decision-making process (ADM Process) - a case of focus, attitudes and approach. Conservation Biology (forthcoming).
Lal, P. and E. Young. 2000. The role and relevance of indigenous cultural capital in environment management in Australia and the Pacific. *In* E.H. Commission (ed.). Heritage economics: Challenges for heritage conservation and sustainable development in the 21st century. Environmental Heritage Commission. Canberra, Australia.
Lal, P. 1990. Conservation or conversion of mangroves in Fiji - an ecological economic analysis. Environment and Policy Institute. East West Center, Honolulu, Hawaii, USA.
Lovell, E.R. and M. Tumuri. 1999. Provisional environmental impact assessment for the extraction of coral reef products for the marine aquarium and curio trade in Fiji. Fisheries Division, Government of Fiji. Suva, Fiji.
McAllister, D.E. 1991. What is a coral reef worth? Sea Wind 5(1):21-24.
McFarquhar, A. 2001. Environmental valuation, project appraisal and political consensus in the third world. Planning and Markets 4(1):1-27. Downloaded from http://www-pam.usc.edu/ (17 August 2001).
Moberg, F. and C. Folke. 1999. Ecological goods and services of coral reef ecosystems. Ecological Economics 29:215-33.
Mohd-Shawahid, H. 2001. Economic valuation of the terrestrial and marine resources of Samoa. Division of Environment and Conservation, Department of Lands, Survey and Environment. Apia, Samoa.
MRAG. 1999. The performance of customary marine tenure in the management of community fishery resources in Melanesia. U.K. Department for International Development (DFID) Fisheries Management Science Programme (FMSP), London, U.K.
Muller, L.T. 2000. Contingent valuation and beach sand mining in Tongatapu, Kingdom of Tonga. Environmental Management and Development Program, National Center for Development Studies, Australian National University, Canberra, Australia. M.S. Thesis.
Ngaremeduu, S.C.T. 2001. Ngaremeduu Conservation Area Project Transition Strategy 2000-2002. South Pacific Biodiversity Conservation Programme. Apia, Samoa (draft).
Norton, B., R. Costanza and R. Bishop. 1998. The evolution of preferences - Why "sovereign" preferences may not lead to sustainable policies and what to do about it. Ecological Economics 24(2-3):193-211.
O'Connor, D. 1999. Applying economic instruments in developing countries: from theory to implementation. Environment and Development Economics 4(1):91-110.
Orum, M.B. 1999. The economic benefits of whale watching in Vava'u, the Kingdom of Tonga. Centre for Tourism Research, Massey University at Albany, North Shore, New Zealand.
Panayantou, T. 1995. Economic instruments for environmental management and sustainable development. Harvard University, Cambridge, Massachusetts, USA.
Pearce, D. and E. Barbier. 2000. Blueprint for sustainable economy. Earthscan, London, U.K.
Pearce, D., E. Barbier and A. Markandya. 1989. Blueprint for green economy. Earthscan, London, U.K.
Pendleton, L.H. 1995. Valuing coral reef protection. Ocean and Coastal Management, 26(2):119-131.
Perman, R., Y. Ma, J. McGilvray and M. Common. 1999. Natural resource and environmental economics. Pearson Publishing Ltd. New York, New York, USA.
Perrings, C. 1995. The economic value of biodiversity, p. 823-914. *In* V.H. Heywood and R.T. Watson

(eds). Global biodiversity assessment. Cambridge University Press and UNEP, Cambridge, U.K.
Preston, G.L. 1997. Review of fishery management issues and regimes in the Pacific islands region. Gillett, Preston and Associates Inc. Noumea, New Caledonia.
Pretty, J. 1995. Regenerating agriculture: Politics and practice for sustainability and self-reliance. Earthscan. London, U.K.
Pulonin, N., C. M. Roberts and D. Pauly. 1996. Developments in tropical reef fisheries science and management. *In* N. Polunin and C.M. Roberts (eds). Reef fisheries. Chapman and Hall. London, U.K.
Pyle, R.L. 1993. Marine aquarium fish, p. 135-176. *In* A. Wright and L. Hill (eds.) Nearshore marine resources of the South Pacific. Forum Fisheries Agency and Institute of Pacific Studies, University of the South Pacific. Suva and Honiara.
Rijsberman, F. and S. Westmacott. 2000. Cost-effectiveness analysis of coral reef management and protection: A case study of Curacao, p. 49-66. *In* K. Gustavson, R.M. Huber and J. Ruitenbeek (eds). Integrated coastal zone management of coral reefs: Decision support modeling. The International Bank for Reconstruction and Development, The World Bank, Washington D.C., USA.
Rose, D.B. 1996. Nourishing terrains: Australian Aboriginal views of landscape and wilderness. Australian Heritage Commission, Canberra, Australia.
RoundTable. 1999. 1999-2002 Action strategy for nature conservation in the Pacific Islands Region: Monitoring the conservation action. South Pacific Regional Environment Programme. RoundTable, Apia, Samoa.
Ruddle, K. 1998. The context of policy design for existing communitybased fisheries management systems in the Pacific Islands. Ocean and Coastal Management, 40(2):105-26.
Ruddle, K. and T. Akimichi. 1985. Traditional knowledge and management of coastal systems in Asia and the Pacific. UNESCO/ROSTSEA. Jakarta, Indonesia.
Salvat, B. 2000. Status of coral reefs in the Southeast and Central Pacific coral reefs "Polynesia Mana Node": Cook Islands, French Polynesia, Kiribati, Niue, Tokelau, Tonga, Wallis and Futuna, p. 181-198. *In* C. Wilkinson (ed.). Status of coral reefs of the world: 2000. Australian Institute of Marine Science, Cape Ferguson, Queensland and Dampier, Western Australia.
Salvat, B. (ed.). 2001. Status of coral reefs 2000 in Southeast and Central Pacific "Polynesia Mana" network. Foundation Naturalia Polynesia. Papeete, Tahiti.
Sesega, S. 2000. 'Necessary and sufficient conditions for sustaining community-based conservation area projects: Experiences from the South Pacific conservation programme. 19th Annual Pacific Islands Conference: Success stories, continuing challenges and realistic solutions. SPREP, American Samoa.
Sinden, J.A. and D. J. Thampapillai. 1995. Introduction to benefit-cost analysis. Longman Australia Pty Ltd. Sydney, Australia.
South, R., G. Cleave and P. A. Skelton (eds). 2001. Oceans in the new millennium: Challenges and opportunities for the Islands. International Ocean Institute. Romania.
South, R. and P. Skelton. 2000. Status of coral reefs in the Southwest Pacific: Fiji, Nauru, New Caledonia, Samoa, Solomon Islands, Tuvalu and Vanuatu, p. 159-217. *In* C. Wilkinson (ed.). Status of coral reefs of the world: 2000. Australian Institute of Marine Science, Cape Ferguson, Queensland and Dampier, Western Australia.
South Pacific Regional Environment Programme (SPREP). 2000. Action plan for managing the environment of the Pacific Islands Region 2001-2004. (SPREP), Apia, Samoa.
South Pacific Regional Environment Programme (SPREP). 1999. 1999-2002 Action strategy for nature conservation in the Pacific Islands region: Monitoring the conservation action. South Pacific Regional Environment Programme. RoundTable, and Apia.
Spash, C.L., J.D. van der Werff ten Bosch, S. Westmacott and J. Ruitebeek. 2000. Lexicographic preferences and contingent valuation of coral reef biodiversity in Curacao and Jamaica, p. 97-117. *In* K. Gustavson, R.M. Huber and J. Rutienbeek (eds). Integrated coastal zone management of coral reefs: Decision support modeling. The International Bank for Reconstruction and Development, The World Bank, Washington D.C., USA.
Spurgeon, J.P.G. 1992. The Economic valuation of coral reefs. Marine Pollution Bulletin 24(11):529-36.
Taconni, L. 2000. Biodiversity and ecological economics: Participation, values and resource management. Earthscan, London, U.K.
Throsby, D. 1995. Culture, economics and sustainability. Journal of Cultural Economics 19:199-206.
Tupouniua, S. (ed.) 1980. The Pacific way. South Pacific Social Sciences Association, Suva, Fiji.
UNEP. 1999. Pacific Islands environment outlook, UNEP, London.
Vuki, V., M. Naqasima and R. Vave. 2000. Status of Fiji's coral reefs. South Pacific Commission Coral Reef Initiative, Noumea, New Caledonia.
Ward, G.E. 1995. Land, law and custom: Diverging realities in Fiji, p. 198-249. *In* G.E.Ward and E. Kingdon (eds). Land, custom and practice in the South Pacific. Cambridge University Press, Melbourne, Australia.
Wills, I. 1997. Economics and the environment: A signaling and incentives approach. Allen & Unwin, Sydney, Australia.
World Bank. 2000. Voices from the village: A comparative study of coastal resource management in the Pacific Islands. Pacific Islands Discussion Paper Series No. 9. East Asia and Pacific Region, Papua New Guinea and Pacific Islands Country Management Unit, World Bank, Washington, D.C., USA.
World Resources Institute (WRI). 2000. Threats to coral reef. http://www.igc.org/wri/indictrs/rrthreat.htm (Downloaded 31 October 2001).

An Economic Analysis of Coral Reefs in the Andaman Sea of Thailand

Udomsak Seenprachawong[1]

Abstract

The focus of this study is the valuation of coral reefs and how the information derived from the valuation can be used to improve coral reef management in Thailand. The study focuses specifically on the Phi Phi islands, off the west coast of southern Thailand, in the Andaman Sea. The Phi Phi are rich in reefs that are seen by government planners as an ecotourism destination. The annual benefit from the recreational services of Phi Phi estimated using a travel cost method was 8 216.4 million baht (US$205.41 million), or about US$6 243 per hectare per year. Assuming the real value of this recreational value remains the same over 30 years, and using a real interest rate of 5 per cent, the present value of recreation of Phi Phi is US$3 157 million. A contingent valuation method (CVM) was used to estimate utility values associated with coral reef biodiversity at Phi Phi. The mean willingness to pay (WTP) per visit was estimated at US$7.17 for domestic visitors and at US$7.15 for international visitors. From this, the total value of Phi Phi's coral reefs was estimated to be US$0.147 million a year for domestic visitors and US$1.24 million a year for international visitors. Using CVM the study also calculated the mean WTP of domestic vicarious users at US$15.85. From this, the total value (use and non-use) of the reefs was estimated to be US$497.38 million a year, or US$15 118 per hectare per year. It is recommended that an instrument that captures the tourists' consumer surpluses, a user fee, be introduced. Determining that fee for Phi Phi is quite straightforward, as the value that people obtain from visiting the Phi Phi reef site is US$7.15 to 7.17 per visit. Based on these numbers, this study suggests a basic entrance fee of US$1 per person per visit, and a user charge for additional services from the variety of recreational sites being offered at Phi Phi.

Introduction

Powerful economic forces are driving the observed destructive use of coral reefs, often delivering short-term, and sometimes very large, economic profits to selected individuals. However, coral reef protection is usually presumed to conflict with economic development, and to require the sacrifice of economic growth. Meanwhile, some of the most important values of coral reefs, such as their value to future generations and intrinsic values, cannot be quantified. The omission of these benefits in conventional economic analysis means that coral reefs are undervalued, and this can result in their unsustainable use. This is of particular concern for coral reefs in areas such as the Southern Seaboard Development Project (SSDP) area, a proposed new economic area intended to alleviate the urban concentration around Bangkok and to create a more equitable spatial balance in the country. Unfortunately, this option could result in the destruction of pristine coral reefs. Because local communities in the Andaman Sea are totally dependent on the coral reefs, and because the rapid rate of coral reef destruction is evident throughout Thailand, sustainable coral reef management options urgently need to be identified for the area. The research discussed in this paper aims to value the benefits of coral reefs on the west coast of the project development area in the Andaman Sea. It is hoped that the results of this research will prove useful to policy-makers and other relevant parties involved in planning the use of coastal areas in the provinces.

[1] School of Development Economics National Institute of Development Administration Bangkapi, Bangkok 10240, Thailand.
Email: udomsak.s@nida.nida.ac.th or sudomsak@yahoo.com

The SSDP area is endowed with a variety of existing and potential tourism resources, including beaches that co-exist with good urban amenities in Phuket. One of the nature-based islands with high potential for ecotourism development is Phi Phi. The island has high use values (e.g. recreational and tourism, educational and scientific research) and high non-use values (e.g. genetic resources, and both known and unknown future uses of ecological functions). In fact, Phi Phi is being used as an important reference site for conducting coral reef valuation. The results from Phi Phi may be transferred to other coral reef sites, such as coral reefs in the Gulf of Thailand, and specifically to those adjacent to the coastal town of Ban Hin Krood in Prachuab Kirikun province where it is proposed that a thermal power plant be built.

Methods

Analysis of the economic values of coral reefs can be based on their many functions, each of which has an economic value. Following the environmental economics literature (Dixon 1995), we can distinguish extractive direct use values, non-extractive direct use values, indirect use values, and non-use values. In this study, no attempt is made to calculate the total economic value. Total economic value is made up of use value and non-use value of the coral reefs. Values are calculated for two non-extractive direct uses – recreation and tourism.

There are two major difficulties in recreation and tourism valuation (Cartier and Ruitenbeek 1999). Firstly, the recreation and tourism direct use value attributable to a coral reef is usually estimated by accounting for tourism revenue generated by a particular coral reef holiday destination. From a utility perspective, this value ignores the consumer surplus generated by the recreational experience and hence underestimates the values. Secondly, there are problems relating to the bundling of a vacation destination's attributes. When a coral reef is just one attribute of the bundle, tourism revenue cannot be attributed solely to the reef.

Most studies focusing on coral reef recreation/tourism values estimate consumer surplus using a travel cost method (TCM) or a contingent valuation method (CVM) (see, for example, Driml 1999; Hundloe et al. 1987). The current study employed both TCM and CVM to generate estimates of reef values at Phi Phi. Initially, TCM was used to estimate the consumer surplus for domestic and international visitors to Phi Phi. However, the estimated value from TCM may include all the attributes of Phi Phi valued by tourists who have come to view coral as part of their vacation package. The CVM study was used to isolate the consumer surplus associated with visits to the coral sites. It focused only on tourists visiting the reef sites.

Travel cost method

TCM is based on the idea that, although the actual value of the recreational experience does not have a price tag, the costs incurred by individuals in travelling to the site are an indication of their WTP for the experience, and so can be used as surrogate prices. From these and other data, it is possible to estimate an area's consumer surplus – its value to users as a recreational resource. The survey approach collected information about visitors' trips, as well as their age, income, sex and other socioeconomic factors. Of the 850 questionnaires distributed, 630 domestic visitors and 128 international visitors returned completed forms, an 89 per cent response rate. This study employed the individual travel cost method (ITCM). The demand curve in this model relates an individual's annual visits to the costs of those visits. A functional form relating the dependent variable (visits per year) and independent variables (travel cost and socio-economic variables) has to be identified to obtain a more accurate demand curve. The choice is between two functional forms: linear and double log. This study used the double log demand function:

$$V_i = e^{\alpha_0 + \sum_{c=1}^{l} \alpha_c D_{ci} + \varepsilon_i} \bullet \prod^{k} X_{ji}^{\beta_j} \bullet P_i^{\beta_p} \qquad (1)$$

V_i = number of visits of individual i
D_{ci} = dummy variables referring to individual i
X_{ji} = socioeconomic features of individual i and other variables referring to i
P_i = price paid by individual i (integration variable)
i = 1,…,n index of observations
c = 1,…,l index of additive dummy variables
j = 1,…,k index of socioeconomic variables
α_o = constant
α_c = coefficients of the additive dummy variables
β_j = coefficients of socioeconomic variables
β_p = coefficient of the price variable
ε_i = error term

Once estimated, the model is expressed in the following form:

$$V = e^{\alpha_0 + \sum_{c=1}^{l} \alpha_c D_c} \bullet \prod_{j=1}^{k} X_j^{\beta_j} \bullet P^b \quad (2)$$

For each single individual, the consumer surplus (CS) is the integral of the demand function V with respect to the price P between the lower bound p_{li} and the "choke price" or the upper bound p_{ui}. The choke price is the price that leads to a demand equal to zero. The indefinite integral of the demand function is:

$$\int v dp = e^{\alpha_0 + \sum_{c=1}^{l} \alpha_c D_c} \bullet \prod_{j=1}^{k} X_j^{\beta_j} \bullet \frac{p^{b+1}}{b+1} \quad (3)$$

The integral between p_l and p_u is:

$$CS = \frac{e^{\alpha_0 + \sum_{c=1}^{l} \alpha_c D_c}}{b+1} \bullet \prod_{j=1}^{k} X_j^{\beta_j} \bullet (p_u^{b+1} - p_l^{b+1}) \quad (4)$$

The consumer surplus for each individual is computed by plugging into the above formula the values for each individual dummy variable D_{ci}, the travel cost p_{li}, the choke price p_{ui}, and the value of the explanatory variables X_{ji}:

$$CS_i = \frac{e^{\alpha_0 + \sum_{c=1}^{l} \alpha_c D_{ci}}}{b+1} \bullet \prod_{j=1}^{k} X_j^{\beta_j} \bullet (p_{ui}^{b+1} - p_{li}^{b+1}) \quad (5)$$

The annual consumer surplus per individual can be computed by summing up the consumer surplus estimates from all observed consumers (N) and dividing this by N:

CS per individual = $\frac{1}{N}\sum_{i=1}^{N} CS_i$ (6)

The annual consumer surplus per visit is calculated by dividing the annual consumer surplus per individual by the annual sample average number of visits:

CS per visit =
CS per individual/Sample average visits per year (7)

The CS per visit is then multiplied by the total number of visitors to Phi Phi during the year to obtain the annual total benefit of Phi Phi. Thus:

Total benefit (TB) = CS per visit x Total visitors (8)

Loss of a site usually means loss of all future recreational opportunities, not just the current annual value. The entire future stream of annual recreational values must therefore be included. Because they happen in the future, economic theory dictates this stream of benefits be discounted to make them comparable with the present. Assuming that the annual value of recreation is constant over time, the present value of the stream of future benefits can be calculated using the following formula:

$$PV = \sum_{t=1}^{T} \frac{TB}{(1+r)^t} \quad (9)$$

Contingent valuation method

CVM is a technique that allows the value of environmental goods and services to be estimated by asking people directly, usually by means of a survey questionnaire, about their WTP for a change in the availability of such environmental goods and services. The individual maximum WTP for an environmental change is assumed to be the value the individual attaches to such a change. The major advantage of this approach compared with revealed preference methods is that CVM can elicit both use and non-use values. Another attraction of CVM is that it may be applied at varying levels of complexity according to the time and financial resources available for the research.

CVM was used to see how much people would be willing to pay for the conservation of Phi Phi's coral reefs. A total of 400 domestic visitors and 128 international visitors were interviewed. The people questioned were given information about the current conservation situation in Phi Phi. They were told that the reef at Phi Phi is about 25 per cent degraded, and that if nothing is done scientists estimate that it will become 40 per cent degraded in about 20 years. Respondents were asked whether or not they would be willing to pay a pre-determined amount to a trust fund to restore the coral reefs at Phi Phi totally. The amount ranged from US$1 to US$50 a year. The amount suggested was varied randomly among respondents to reduce the possibility of answers being biased by the question itself.

Hanemann (1984) shows that, if there exists a representative consumer who has an indirect utility function V(P,M,Q,S), the level of utility accruing to the consumer depends on price (P), income (M), socio-characteristics (S) and the quality (Q). The respondent is asked if he or she would pay to help restore the coral reefs around

Phi Phi at the given price, P. The respondent will say yes if:

$$V(M-P,Q^1,S) > V(M-0,Q^0,S) \quad (10)$$

Equation (10) shows that the respondent will answer yes if his or her utility deriving from improved reef quality (Q^1) and paying the price (P) is higher than not having improved reef quality (Q^0) and not paying the price (P=0). If is the observable component of the utility, the probability of the respondent saying yes is:

Prob(yes)=

$$\text{Prob}[V(M-P,Q^1,S)+\varepsilon_1 > V(M-0,Q^0,S)+\varepsilon_0] \quad (11)$$

where ε_i is an unobservable component of the utility. Assuming that the random variable follows a logistic probability distribution:

$$\text{Prob(yes)} = \frac{1}{1+e^{-\Delta V}} \quad (12)$$

where $-\Delta V = V(M-P,Q^1,S) > V(M-0,Q^0,S)$

The recreational benefit of the hypothetical market (to improve the coral reefs around Phi Phi) is measured as WTP and is defined as:

$$V(M-WTP,Q^1,S) > V(M-0,Q^0,S) \quad (13)$$

Hanemann shows that if is linearly specified, the probability of the respondent saying yes is:

$$\text{Log}[\frac{\text{Prob(yes)}}{1-\text{Prob(yes)}}] = \alpha_0 - \beta_1 P + \beta_2 Q + \sum \beta_i S_i \quad (14)$$

Parameters α_0 , β_1, β_2, and β_i will be estimated parametrically. The mean maximum WTP for coral reef restoration can be calculated using formula (15).

$$\text{Mean maximum WTP} = \frac{1}{\beta_1}[\ln(1+e^{\alpha_0+\beta_2 Q+\sum \beta_i S_i})] \quad (15)$$

Results

Using TCM, the survey found that the total benefits of the recreational services offered by Phi Phi were about US$1.75 million a year for domestic visitors and US$203.66 million a year for international visitors. Adding these two numbers gives a figure of US$205.41 million a year (or US$6 243 per hectare per year) for the total recreational benefit that Phi Phi provides. Assuming this remains the same over 30 years,and using a real interest rate of 5 per cent, the present value of recreation of Phi Phi is US$3 157 million (or US$95 957 per hectare).

Table 1. Coral reef benefits based on the travel cost method

Sample size	Consumer surplus per visit	Number of visitors (1998)	Total benefits
Domestic (n=630)	US$85	20 540	US$1.75 million
International (n=128)	US$1 494	136 277	US$203.66 million

Table 2. Coral reef benefits based on the contingent valuation method

	Users			Non-users
	Domestic (n=400)	International (n=128)		Domestic (n=200)
WTP per visit	US$7.17	US$7.15	WTP per person	US$15.85
Number of visitors (1998)	20 540	136 277	Number in labor force (1998)	31.3 million
Total benefits	US$0.147 million	US$1.24 million	Total benefits	US$496 million

Using CVM, the mean maximum WTP was found to be US$7.17 per year for domestic visitors and US$7.15 for international visitors. From this it was calculated that the total value of Phi Phi's coral reefs was US$0.147 million a year for domestic visitors and US$1.24 million a year for international visitors. This study, using CVM, also calculated the mean WTP of domestic vicarious users as US$15.85. From this, the total use and non-use value (excluding international non use value) of the reefs was estimated to be US$497.38 million a year, or an average of US$15 118 per hectare per year.

Discussion

Phi Phi is representative of many coastal areas in Thailand with potentially rich coral reefs in need of improved management so that economic and other benefits can be restored and enhanced. It is apparent from this analysis that, because the reefs generate a large consumer surplus, local and national governments in Thailand can justify greater expenditure on improving coastal resource management. One way to capture the net benefit values of Phi Phi (and so raise the money needed to improve management) would be to directly charge consumers.

Tourists could be charged a fee to participate in activities that physically use the environment, such as water sports (specifically including snorkeling boats, and dive operations), swimming and beach activities.

This study used CVM to estimate utility values associated with coral reef biodiversity at Phi Phi. WTP was estimated at US$7.15 to US$7.17 per visit. Based on this number, this study suggests a basic entrance fee of US$1 per person per visit to Phi Phi. Given that Phi Phi provides numerous recreational experiences for the visitors, additional user charges for some special and fragile recreational sites could be imposed. For example, an extra fee of US$3.75 could be charged to visitors choosing to visit the coral reef at Maya Bay. This user charge would help raise additional revenue for the park by targeting high-income consumers while leaving low-income visitors unaffected. At the same time, charging an additional fee at the reef site would help reduce the number of visitors and hence decrease the negative pressure on the fragile marine environment. This additional fee could also be higher during times when the marine environment is more sensitive to disturbance, and so provide an incentive for tourists to visit at other times.

Critical issues remain to be further explored before the optimal policy for benefit value capture can be determined. These include policy procedures and processes for implementation, including information sharing and consultation, and the administrative arrangements for implementation and enforcement. This would best be conducted through the responsible management authority, the Phi Phi Management Committee.

Acknowledgements The author wishes to acknowledge a research grant from the Economy and Environment Program for Southeast Asia (EEPSEA) and valuable comments provided by H. Jack Ruitenbeek.

References

Cartier, C.M. and H.J. Ruitenbeek. 1999. Review of the biodiversity valuation literature. *In* H.J. Ruitenbeek and C.M. Cartier (eds). Issues in applied coral reef biodiversity valuation: Results for Montego Bay, Jamaica. World Bank Research Committee Project RPO#682-22 Final Report, World Bank, Washington D.C., USA.

Dixon, J. A. 1995. Ecology and microeconomics as joint products: the Bonaire Marine Park in the Caribbean, p. 127-145. *In* C.A. Perrings , K.G. Maler, C. Folke, C.S. Holling and B.O. Jansson (eds). Biodiversity conservation: problems and policies. Kluwer Academic Publishers.

Driml, S. M. 1999. Dollar values and trends of major direct uses of the Great Barrier Reef Marine Park. Research Publication 56. Great Barrier Reef Marine Park Authority, Townsville, Australia, p. 1-12.

Hanemann, M. 1984. Welfare evaluations in contingent valuation experiments with discrete responses. Am. J. Agric. Econ. 66:332-341.

Hundloe, T., F. Vanclay and M. Carter. 1987. Economic and socio-economic impacts of crown of thorns starfish on the Great Barrier Reef. Report to the Great Barrier Reef Marine Park Authority, Townsville, Australia.

Recreational Value of the Coral Surrounding the Hon Mun Islands in Vietnam: A Travel Cost and Contingent Valuation Study[1]

Pham Khanh Nam and Tran Vo Hung Son

Abstract[2]

Understanding the recreational value of natural resources is fundamental to effective conservation programs. When natural resources are damaged by human activities, their recreational value is greatly reduced along with their potential contribution to conservation programs.

The purpose of this research is to explore the recreational value of the coral surrounding the Hon Mun Islands. The islands contain the richest coral biodiversity in Vietnam, but are only about 6 km from a port that has been earmarked for expansion. This research employs the travel cost method and the contingent valuation method to measure and analyze impacts on the recreational value of the islands. The zonal travel cost model (ZTCM) estimates the annual recreational value of the islands at approximately US$17.9 million, while the individual travel cost model estimates this value at about US$8.7 million. A 20 per cent loss of the (ZTCM) recreational value that could be expected to result from the proposed port expansion is still larger than the expanded port's projected annual revenue of US$3.1 million. Therefore, the port expansion proposal needs to be reconsidered.

Introduction

Coastal areas, which have high total economic value (TEV), including use and non-use values, play an important role in the economic development of Vietnam. The country's coast stretches over 3 000 km and contains diverse ecosystems and landscape. The recreational value of this coastal area holds significant potential economic benefits. However, a report by the Ministry of Science, Technology and Environment on the status of Vietnam's marine environment in 1994 (Tran 1998) indicates increased levels of degradation and pollution in the coastal waters of Vietnam; many important ecosystems in the coastal areas have been over-exploited, and marine biodiversity has decreased dramatically. Public recreational marine areas, such as Ha Long Bay, the Son Tra Peninsula of Danang Province or the Hon Mun Islands of the city of Nha Trang, have contributed significantly to the economy, but have been polluted and over-exploited by various activities. It has been difficult for the Government to stem the loss of marine biodiversity because of the conflict between economic development and environmental protection.

Nha Trang City is situated 450 km from Ho Chi Minh City and 1 280 km from Hanoi (General Statistical Office 1998). Nha Trang, with its attractive marine features, including coral reefs and birds' nests, is one of the most important tourism sites in Vietnam. In addition to boasting an airport and a seaport, Nha Trang is strategically located along both National Route 1 and the railway route linking the North and the South.

The Hon Mun Islands are located to the south of Nha Trang Bay. The islands have a variety of habitats and ecosystems, including fringing coral reefs, mangrove forests and seagrass beds with an adjacent deep-water upwelling, which supports the local fishing industry.

In recent years, with increasing economic development, the marine environment adjacent to Nha Trang City, especially around the Hon

[1] This research was funded by the Economy and Environment Program for Southeast Asia (EEPSEA).

[2] Since this research was completed, including this paper, the port expansion has been improved, but at a reduced scale.

Mun Islands, has faced increased exploitation. Coral reefs have been destroyed by many, mainly human-induced, factors. Shipping, dynamite-fishing, coral harvesting and marine tourism have led to a decrease in marine biodiversity and the loss of precious genetic resources, such as those of the Hawksbill turtle, false killer whales and leatherback turtles, from the South China Sea. Destructive activities obviously diminish the benefits reaped from tourism in the islands. The question is: "How much recreational benefit is lost if these activities are not held in check?" Moreover, there is a plan to expand Nha Trang Port. If this plan becomes reality, the quality of water in the Hon Mun area will deteriorate with the increase in port traffic, affecting marine ecosystems and recreational activities. Policy-makers will have to choose between the port and marine biodiversity/recreational activities. So far, there has been no decision made by the Government. The port expansion proposal is facing opposition, especially from the Department of Science, Technology and Environment (DOSTE).

The ability of local government authorities to effectively manage and protect the marine environment of the islands has been limited by inadequate knowledge of marine management and the need to consider local villagers. In early 1998, the Ministry of Fisheries and the World Conservation Union (IUCN) conducted an initial survey of the four most important environmental sites across Vietnam. The Vietnamese Government then selected the Hon Mun Islands as a pilot for a national system of marine protected areas (MPAs) (Vo 1998). According to the MPA investment project proposal for Hon Mun issued by the Khanh Hoa Department of Science, Technology and Environment in 1996 (DOSTE 1996), the purposes of the MPA are to maintain biodiversity, protect coral reefs, improve fisheries, control pollution, manage tourism, and create new jobs for local people hired to manage the MPA.

In light of the imminent threat posed by the port expansion project, it became necessary to carry out a research project to estimate the recreational value of the islands, so that decision-makers could compare this value with that of the proposed port expansion.

The estimated recreational value is particularly important in view of the fact that the Nha Trang Port is not the only one in the region that is suitable for expansion. There are other suitable ports. For example, Cam Ranh Port, situated 60 km south of Nha Trang City, is considered to be one of the three best ports in the world in terms of its natural characteristics and its strategic location near the point linking the highland area and the rest of the country. Then there is Vung Ro Port, situated 60 km north of Nha Trang City, next to the road to the Central Highlands of Vietnam.

On the other hand, there is no national substitute for the Hon Mun Islands in terms of coral-related tourism and research.

The estimated recreational value of the islands can be used to help assess the economic impact of expansion of the port and devise future recreational development plans for the islands. Policy-makers will obviously need to know the benefit of tourism compared with that of other activities (for example, fishing and bird nest collection) at the islands in order to decide how to allocate resources among competing uses. Also, a willingness to pay (WTP) analysis will provide important supporting information to assess the financial sustainability.[3]

Study method

The overall objective of the research was to analyze the recreational value of the Hon Mun Islands.

Hypotheses and research questions

The research was conducted in the form of a survey that addressed the following questions:

a) How do factors such as travel cost, income, and visitors' socioeconomic characteristics affect the recreational demand for the Hon Mun Islands?
b) What is the annual recreational value of the Hon Mun Islands?
c) What is the composition of the recreational value of the Hon Mun Islands, which includes values gleaned from foreign visitors as well as from Vietnamese visitors?
d) What is the visitors' willingness to pay (WTP) for funding the Marine Protected Area that will be set- up around the Hon Mun Islands, and what factors affect their willingness to pay?

[3] The Hon Mun Islands were declared an MPA in January 2001. When this research project commenced, the proposal for the Hon Mun Islands to be declared an MPA was still being considered. Appendix A highlights the proposed map before the declaration of Hon Mun Islands as an MPA.

e) Is it reasonable to stop the port expansion project?

Valuation method

Hon Mun is a public site, with no admission fee. People who use the site's resources for fishing, aquaculture and recreation do not pay for these privileges, so it is impossible to use market prices to value the site. Therefore, the travel cost method was used to estimate the recreational value of the islands.

The travel cost model (TCM)

Many TCM studies in Asia have valued the recreational benefits of natural resources based on surveys of only domestic tourists. For example, the estimated tourism value of Cuc Phuong National Park (Francisco and Glover 1999) did not include the value from international tourists, even though the authors had interviewed foreigners. The TCM application for Lumpinee Public Park in Thailand (Dixon and Hufschmidt 1986) also omitted this value. The reason for this omission in both cases was that the number of foreign tourists was too low to give a significant result – a problem that often arises in such studies. However, according to figures from the Department of Tourism of Khanh Hoa (So Du Lich Khanh Hoa 1999), foreign tourists to Nha Trang make up one-third of the total number of visitors. Therefore, it would be unacceptable to exclude responses of foreign tourists from the calculation. In this project, values for Vietnamese and foreign visitors are calculated separately and then added to derive the total recreational value of the Hon Mun Islands.

From the various travel cost models, the zonal travel cost model and individual travel cost model were selected.

Individual travel cost model (ITCM)

The ITCM function that relates an individual's annual visits to his/her travel cost is as follows:

$$V_i = f(TC_i, S_i) \quad (1)$$

Where:

Vi is the number of visits made by individual I in a year

TCi is the travel cost of individual I

S_i represents other factors determining the individual's demand for visits to Hon Mun, such as income, substitute costs, age, gender, marital status, and level of education.

The most popular functional forms are linear, quadratic, semi-log and log-log. There is no consensus in the literature reviewed on the preferred form. Because the dependent variable consists mostly of low values (i.e., skewed to the left), this study uses the semi-log form. The logarithm of the dependent variable helps to adjust its skewness to normal distribution.

The general semi-log function for the ITCM is:

$$\text{Ln } V_i = a + bTC_i + cS_i + \varepsilon_i$$

$$\text{(Or) } V_i = e^{a + \Sigma dDi} \times e^{cSi} \times e^{bTCi} \quad (2)$$

where S_i is the socioeconomic variable representing income, gender, age, marital status, level of education, and group size.

Table 1 shows details of the variables expected to affect demand for visits to Hon Mun.

The consumer surplus (CS) for each individual is estimated by the integral calculus of the demand function with respect to the travel cost between the price paid and the "choke price". (The "choke price" is the price at which demand is "choked off", or zero). In other words, the consumer surplus is the area below the demand curve and above the price paid line.

$$CS_i = 1/b \times e^{a + \Sigma dDi} \times e^{cSi} \times (e^{bTCi2} - e^{bTCi1}) \quad (3)$$

The consumer surplus (CS) per visit is calculated as follows:

CS_i per visit = CS_i per visitor/average number of visits of a visitor per year (4)

Zonal travel cost model (ZTCM)

The area around Hon Mun is divided into zones 1 to 10, with each zone being increasingly distant from Hon Mun. The first zone is Nha Trang and the farthest zone is Hanoi. There are some characteristics of zoning. In a zone, the inhabitants have similar preferences. Next, the number of zones used can be quite large. Lastly, each zone is an administrative area or a group of

Table 1. Description of variables

Variables		Description
LnV	Logarithm of number of visits	Logarithm of number of visits
TC	Travel cost	Sum of travel cost (VND)
Y	Income	Monthly income (VND)
Ps	Substitute price	Price of substitute site in VND
GEN	Gender of visitors	Equals 1 if male, 0 if female
AGE	Age	Age in years
MAR	Marital status	Equals 1 if married, 0 otherwise
EDU	Education	Equals 1 if graduate and above, 0 otherwise
GR	Group	Visitor's group size

several administrative areas. Table 2 shows the zoning structure.

As in the Khanh Hoa Tourism Report (So Du Lich Khanh Hoa 1998), foreign visitors are divided into two regions according to their country of origin, namely: (1) Asia and Oceania (Australia and New Zealand), and (2) North America and Europe. Visitation rates were calculated for both these regions. Domestically, zones should be divided on the premise that the further the zone is, the fewer visitors from it will visit the site. But internationally, if zones are divided by country rather than region, this premise does not hold. For example, Cambodia, the Lao PDR and the Philippines are close neighbors of Vietnam, but the Hon Mun Islands have received no visitors from these countries. It is also very difficult to divide zones into individual countries because of the limitation of sample size. Brown and Hendry (1989) used this two-region zoning method to estimate the recreational value of elephant-viewing in Kenya.

Table 2. Zones of origin

Zone	Distance (km)	Administrative district	Population
1	5	Nha Trang	341 000
2	33.3	Dien Khanh, Ninh Hoa, Cam Ranh, Van Ninh	647 700
3	110	Phan Rang, Tuy Hoa	350 200
4	217	Da Lat, Buon Ma Thuot,	786 200
5	250	Phan Thiet, Binh Dinh	545 900
6	441	Ho Chi Minh City	5 155 700
7	497	Long An, Tay Ninh, Vung Tau, Dong Nai	925 600
8	516	Da Nang, Hue	1 112 600
		Quang Nam, Quang Ngai	
9	677	An Giang, Can Tho, Ca Mau, Tien Giang	1 456 000
10	1140	HaNoi, Hai Phong, Nam Dinh, Thanh Hoa, Nghe An	5 050 500

Source: Estimated from General Statistical Office (1999) with a population average growth rate of 1.65 per cent.[4]

The trip-generating function for the zonal model in the current study is:

$$V_i = V(C_i, POP_i, S_i) \quad (5)$$

where

V_i are visits from Zone i to the Hon Mun Islands

POP_i is the population of Zone i

S_i are socioeconomic variables such as the average income for each zone. In this project, the dependent variable is expressed as (V_i/POP_i), or the visitation rate.

The visitation rate per 1 000 population in each zone can be determined by using the following formula:

$$VR = \frac{\left(\frac{Vi}{n}\right) N \times 12 \times 1000}{P} \quad (6)$$

where

VR : visitation rate (visits/1 000/year)
Vi : visitors from zone i
n : sample size
N : total visitors per month
P : population in zone j

The form of the demand function may be linear or semi-log. Given the demand function for visits to the islands, it is possible to estimate consumer surplus and recreational value. Consumer surplus is calculated using the integral formula.

Zonal travel cost model versus individual travel cost model

There are two variants of the simple[5] travel cost model. They are the "individual travel cost model" and the "zonal travel cost model". The former aims to establish an individual's recreational demand curve. The number of visits made by an individual over a period of time is used as a

[4] When this table was prepared, population data were only available for 1999. The data were updated for 2000 using the average growth rate of the population.
[5] The multi-site model or the hedonic travel cost model is only applicable if the effects of the addition or subtraction of a site from a set of sites or a change in the quality of site attributes on visitors' welfare is sought.

function of the travel cost. An individual's recreational value is estimated by the area under his/her demand function. So the total recreational value of the site is calculated by integrating the demand function of each individual. The zonal travel cost model divides the area surrounding the site into zones. So the unit of observation is the zone. The number of visits per capita from each zone is a function of the travel cost.

Georgiou et al. (1997) discussed some characteristics of the applicability of both models. One noted issue of the individual travel cost model is that "…[a] model requires that there is variation in the number of trips individuals make to the recreational site in order to estimate the demand function". So the application of the individual travel cost model would face difficulty when the variation is very small, or when individuals do not make several trips to the recreational site. For example, if every visitor were to visit the site only once a year, it would not be possible to run a regression function.

DeShazo (1997) used the individual travel cost model to re-estimate the recreational value of Khao Yai National Park in Thailand based on data collected in 1994. The mean value of the number of visits per year was 1.88. Although the median value and the standard deviation were not shown, it is clear that 1.88 was too small to expect a large variation in the number of visits. His estimates of three forms of the trip generation function indeed proved this limitation. In DeShazo's study, the R-squared values in the three functions were very small: 0.11, 0.13 and 0.09, reflecting the fact that the variation of the dependent variable (number of visits) was too small to support the estimation. This result coincides with arguments (Georgiou et al. 1997) about the individual travel cost model above.

However, this drawback of the individual travel cost model is not a problem for the zonal travel cost model, which uses the number of trips per capita from each zone as a function of the travel cost. However, the zonal travel cost model has its own limitations. As Georgiou et al. (1997) pointed out, "The zonal model is statistically inefficient, since it aggregates data from a large number of individual observations into a few zonal observations. In addition, the zonal model treats all individuals from within a zone as having the same travel costs, when clearly this is often not the case."

The zonal model is, nevertheless, considered applicable for measuring the recreational value of the Hon Mun Islands, as is discussed below. First, according to the Department of Tourism, almost all tourists make between one and three visits to the Hon Mun Islands each year. As the Hon Mun Islands lie about 8 km offshore, willingness to travel by boat to the islands depends very much on the weather. This is different from the case of a park or a lake. In the case of a park, like Khao Yai National Park (DeShazo 1997) or various city parks, local residents may visit the park several times a week for recreation. In such cases, it is possible to use the individual travel cost model to estimate the recreational value. Moreover, traveling far for a holiday is not yet a habit of the Vietnamese, possibly because of the relatively low income of most Vietnamese. With few visits per visitor per year, the individual travel cost model is not the most applicable model for this study.

Secondly, the zonal travel cost method has been widely applied in evaluating recreational sites in developing countries. According to Hanley and Spash (1993), the individual travel cost model works better for fishing and hunting trips, which are likely to be individual habits rather than popular preferences.

Distribution of travel costs in cases of multi-purpose trips

A multi-purpose trip is one in which a visitor's trip is not restricted to the site in question, but includes other recreational sites. Only a portion of the total travel cost reflects the cost paid for the recreational site in question.

Tourists generally visit not only the Hon Mun Islands, but also various places in Nha Trang City and the neighboring areas. Although coral is the unique characteristic of the Hon Mun Islands, few tourists, unless they live in Nha Trang City, make a trip from their home to Hon Mun only for the purpose of admiring coral. This argument is supported by the fact that tourism is still a luxury commodity in Vietnam and that no foreign tourists come to Vietnam to visit only one site unless their journey is for some special purpose, for example, meetings or research.

However, information on transportation costs obtained from the questionnaire covered the cost of a visitor's whole trip, and not just the trip to the Hon Mun Islands. In order to estimate the recreational value of the islands, the travel cost for visiting the islands had to be identified from within the total cost of the trip.

Hanley and Spash (1993) called multi-purpose trip visitors "meanderers" and provided two options in isolating the cost of a specific trip, "The first is to ask people to score the relative importance of a visit to… This score… can be used to weight their total travel cost. Second, meanderers may be excluded from the TCM analysis…".

In the case of the Hon Mun Islands, meanderers could not be excluded from the analysis because information collected from the survey showed that almost all visitors were meanderers. Therefore, in this analysis, we considered two techniques to distribute the travel cost.

1. The time criteria basis. Time spent for the whole trip and specifically for the Hon Mun visit would be identified. The coefficient to calculate the travel cost for the Hon Mun visit would be the time spent visiting Hon Mun as a percentage of the total time spent for the whole trip to Vietnam.
2. The number of site visits basis. The number of sites that had been visited or will be visited would be counted. So the coefficient to calculate the travel cost for the Hon Mun visit would equal one (site) over the total number of sites for the whole trip.

However, neither of the above methods takes into account the satisfaction of visitors, which represents their willingness to pay for the recreational activities.

The questionnaire explored the satisfaction of visitors by asking respondents to rank the islands according to their level of satisfaction. Time criteria and the coefficient of satisfaction were jointly used to distribute the travel cost.

The contingent valuation method (CVM)

According to Hanley and Spash (1993), there are six stages in a CVM analysis:

a. Setting up a hypothetical market
b. Obtaining bids
c. Estimating the mean WTP
d. Estimating a bid curve
e. Aggregating the data
f. Evaluating the CVM exercise

a. Hypothetical market

The Hon Mun Islands will be turned into an MPA. Experts and residents of the islands believe that turning the islands into an MPA is the best way to preserve the environment around the islands, but they are not sure if it will be successful. They are uncertain as to what an appropriate budget for the MPA should be and they also lack experience in managing an MPA. It would be useful to establish a fund for the conservation of the MPA. It is assumed that visitors to the islands will derive benefit from such measures and reasonable to presume that they would be willing to invest in order to enjoy such benefit for present and future visits.

b. Obtaining bids

There are several ways to derive the WTP (Hanley and Spash, 1993) – (1) the bidding game, (2) the closed referendum, (3) the payment card, and (4) the open-ended question. For this research project, the bidding game was not considered suitable. From the authors' experience in field surveys, Vietnamese respondents tend to choose the first bid the interviewer raises. It is easier to get a more accurate result if a range of values is presented from which they can choose. Because of this, the payment card method was used.

c. Estimating the mean WTP

Willingness to pay for funding the MPA was calculated using the following formula (equation 7).

The expected value of willingness to pay E(y) is the sum of the components for uncensored and censored cases. (Censors are applied in cases where willingness to pay is considered to be zero in the data sheet but it is not a pure zero amount of money that the respondent is willing to pay.)

$$E(y) = [Pr(Uncensored) \times E(y \mid y > \tau)] + [Pr(Censored) \times E(y \mid y = \tau_y)] \quad (7)$$

where

Pr(Uncensored) is the probability of an observation not being censored
Pr(Censored) is the probability of an observation being censored

$E(y|y > \tau)$ is the expected value of WTP greater than τ

$E(y|y = \tau_y)$ is the expected value of WTP equal to τ

d. Estimating a bid curve

A bid curve traces out the impact of people's characteristics on their willingness to pay for environmental goods or services. Some respondents refused to pay any amount of money for the MPA trust fund. This does not mean that their desirability for coral biodiversity does not exist. In many cases, they do think that the coral reefs are valuable, but they are unwilling to pay because they assume their money will be wasted, or that people who pollute the coral reefs should pay. This is a case of censored outcome. The outcome is censored because the response given in the questionnaire makes it impossible to determine how much a respondent values the coral reef biodiversity. The Tobit censored regression model, was employed in this case.

In the canonical censored regression model, the observed data y is given by:

$$y_i = \begin{cases} \tau_y & \text{if } y_i^* \leq \tau \\ y_i^* & \text{if } y_i^* > \tau \end{cases}$$

where

y_i^* is the latent variable that is observed for values greater than τ and is censored for values less than or equal to τ.

e. Aggregating the data

The mean WTP estimated in step "c" was converted to the population total value figure. According to Hanley and Spash (1993), there are three issues involved in the aggregation process. The first is the choice of the relevant population. The second is moving from the sample mean to the population mean. The third is the choice of the time period over which the values should be aggregated. The population in this study was defined as visitors to the Hon Mun Islands. The number of visitors was multiplied by the sample mean. Lastly, the total willingness to pay for coral protection in the Hon Mun Islands was aggregated over the time period of one year – the current year.

f. Evaluating the CVM exercise

This step requires an assessment of how successful the application of CVM has been. It was not feasible to conduct a full assessment due to limitations on time and money. Nevertheless, some comments on the approach chosen are included in the conclusions to this report.

Addressing some relevant biases

- Time costs. If time costs are ignored, demand will be biased. The effects of both time costs and transportation costs on the demand for recreation need to be estimated separately. However, because the two may be highly correlated and separate estimations too difficult to carry out, time costs were given a monetary value and added to the transportation costs.
- Truncation bias. This stems from a lack of survey data from people who did not visit the site. In this research, because the objective was to analyze willingness to pay for funding the MPA (in other words, to find out the number of visitors who would be willing to pay for conserving the MPA), and not to get the total value of the site (which is more than just the recreational value), the WTP questions could reasonably exclude non-site visitors. So the bias from including only site visitors was avoided.
- Multi-purpose trip. Visiting the site may be a detour from a journey with a different motive. To provide for this, a multi-purpose question was asked and some crude allocation of costs was used to estimate travel costs.
- Multi-site trip. Visiting a site may be part of a round trip involving visits to other locations. Only a portion of the travel cost relates to the recreational site in question. This research project used a percentage of the day's total travel costs in order to put a value on travel cost related to the visit to the islands.
- Statistical problems. The choice of functional form will have a great influence on the consumer surplus estimates. There are varied functional forms for the travel cost model. With any given set of data, the estimated consumer surplus values can differ significantly, depending on the functional form. This research project used the two most popular forms – linear and semi-log.

Data collection techniques

Collection of primary data

The collection of primary data was geared towards visitors' experiences and socioeconomic characteristics. The questionnaire was designed to collect information on: (1) on-site and off-site recreational behavior; (2) travel experiences and trip costs; and (3) socioeconomic factors.

Sampling

In the survey, systematic sampling was employed. Scheaffer et al. (1996) stated that "A systematic sample is generally spread more uniformly over the entire population and thus may provide more information about the population than an amount of data contained in a simple random sample". Because survey data from non-residents of Nha Trang City could not be obtained, this survey only concentrated on users. Individual visitors were chosen as respondents for the interviews. A "visitor" was defined as one who used the Hon Mun Islands for recreation. Clearly, villagers who lived within the range of the islands were not included in the survey. Samples were taken using two approaches. The first approach was by directly interviewing visitors to the islands. The interviewer was required to speak to specific visitors encountered (for example, every fifth or sixth visitor.) The second approach involved handing the questionnaire to visitors on boat trips and asking them to complete the forms.

A pre-test survey was conducted to test the validity of the questions and their relevance to the planned analysis. Table 3 illustrates the samples taken.

Table 3. Number of samples collected

	TCM	CVM
Domestic visitor	180	252
Foreign visitor	210	210
Total	390	462

The number of samples was deemed both sufficient to run the regression function and relevant to a limited survey period of six months. The research population covered the urban population of Vietnam because most Vietnamese tourists are people from urban areas. Vietnamese in rural areas are too poor to afford the luxury of traveling.

Characteristics of the Study Area

Scientific importance

The study area is of considerable value to research and monitoring as it contains high genetic diversity and a combination of various reef types, and is close to the edge of the continental shelf and up-welling.

The National Institute of Oceanography of Nha Trang has conducted significant research programmes in the area in fields such as the biodiversity, biology and ecology of living coastal resources, aquaculture and restoration, biochemistry, hydrochemistry, and marine physics and geology. The Institute of Oceanography is part of the Global Coral Reef Monitoring Network.

The area is also an important research field for the Nha Trang University of Fishery, which is located only about 10 km away from Nha Trang Port.

Management

The Hon Mun Islands are considered as a freely accessible public park managed by the local government. The rights to supply services to the islands are shared among many state-owned tourism companies. For example, the Ship Chandler Company manages Hon Tam, and the Nha Trang Handicraft Import-Export Company services Hon Mun.

Shipping activities in Nha Trang Port, which is about 3 km from the nearest point of the islands, could directly affect fishing operations and tourism in the Hon Mun Islands. Nha Trang Port receives 640 000 t of goods and 18 000 passengers annually. Nha Trang Port is, at present, the most important seaport of Khanh Hoa Province. Its activities undoubtedly affect the management of the Hon Mun Islands.

Social economic characteristics of tourists

Socioeconomic information

As can be seen from Table 4, the average visitor visited the Hon Mun Islands 1.7 times in a year. Over 50 per cent of the domestic visitors visited the Hon Mun Islands for the first time (Figure 1).

This can have two implications: (1) Vietnamese are not in the habit of taking annual holidays, and/or (2) the Hon Mun Islands are not that attractive to the Vietnamese.

Most visitors visited Hon Mun only once in the analyzed year, even residents of Nha Trang.

Socioeconomic data from the survey revealed several interesting issues. The average income of visitors is around VND 1.3 million per month, which is higher than the national average level. This is understandable as travel is a luxury item and only people from the middle and higher-income brackets can afford their recreational preferences. This reality, therefore, supports the previous assumption that visitors to Hon Mun were from urban (wealthier) regions and confirms that choosing the urban population for this study was the right decision. The educational level of the visitors averaged 13.7 years of schooling and was higher than the national average. Most visitors were of working age, with the average age being 32.2 years. Seventy per cent of the respondents were male.

Looking at Table 5, the average number of visits by foreigners was 1.17 – lower than that of domestic visitors. Foreign tourists have to pay a large amount of money to visit Hon Mun, so it is reasonable to expect that the frequency of their visits in any given year would be less than that of domestic visitors.

Table 4. Statistical data on the socioeconomic characteristics of Vietnamese visitors to the Hon Mun Islands (180 respondents)

Characteristics	Mean	Standard Deviation	Median	Minimum	Maximum
Number of visits	1.7	1.19	1.00	1.00	5.00
Distance (km)	401	345	385	5	1 140
Travel time (days)	4.35	3.41	4.00	1.00	30.00
Group (persons)	15.00	25.14	8.00	1.00	160.00
Income (VND)	1 325 556	683 739	1 200 000	300 000	3 000 000
Age (years)	32.2	10.02	30.00	11.00	60.00
Education (Schooling years)	13.68	2.57	14.00	5.00	18.00
Sex (Male=1; Female=0)	0.69	0.46	1.00	0.00	1.00
Marital Status (Married=1; Not married=0)	0.51	0.50	0.00	0.00	1.00

Source: Survey data

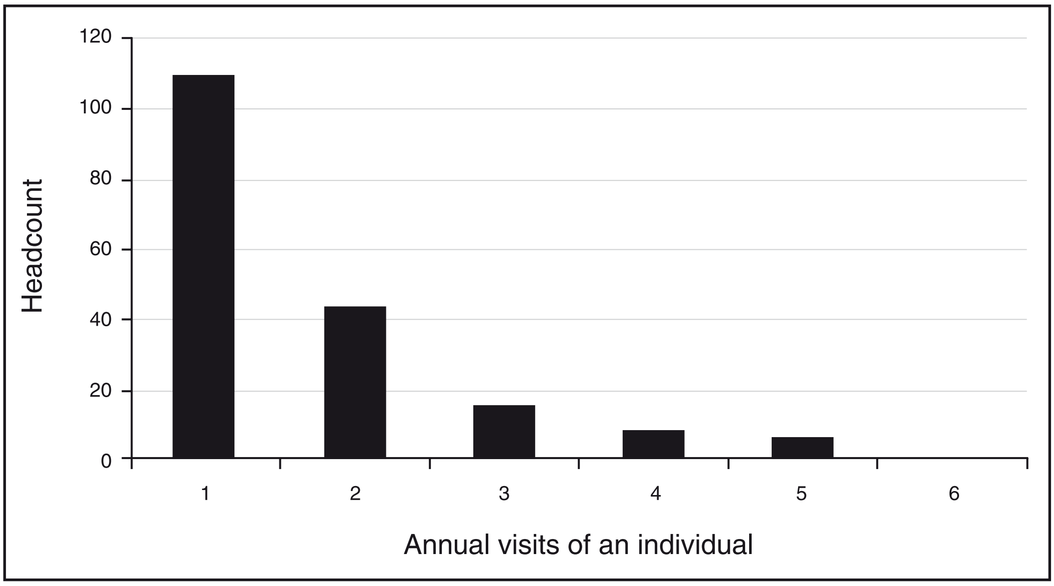


Figure 1. Graphical distribution of domestic visits, 2000

Table 5. Statistical data on the socioeconomic characteristics of foreign visitors to the Hon Mun Islands (210 respondents)

Characteristics	Mean	Standard Deviation	Median	Minimum	Maximum
Number of visits	1.17	0.65	1.00	1.00	6.00
Travel time (days)	2.4	1.15	2.00	1.00	10.00
Group (persons)	5.29	4.03	3.00	1.00	18.00
Income (USD)	3 642	2 604	3 000	500	10 000
Age (years)	32.5	10.78	30.00	12.00	68.00
Education (Schooling years)	15.17	2.4	16.00	5.00	22.00
Sex (Male=1; Female=0)	0.52	0.50	1.00	0.00	1.00
Marital Status (Married=1; Not married=0)	0.34	0.47	0.00	0.00	1.00

Source: Survey data

The foreign visitors' socioeconomic features showed that the average income was US$3 642 per month. This suggests that most visitors come from developed countries. The average number of years of schooling was 15.1, considerably higher than that of Vietnamese visitors. The average age was 32.5 years, similar to Vietnamese visitors. However, there was a difference in the gender figure. Fifty-two per cent of the foreign respondents were male, compared to 70 per cent for Vietnamese respondents.

The Hon Mun pilot MPA

The establishment of the Hon Mun pilot MPA was approved on 10 January 2001 by the Government of Vietnam, the Global Environment Fund (GEF), the World Bank, the Government of Denmark and the World Conservation Union (IUCN). The four-year project is funded to the tune of over US$2 million.

The project has four main objectives:

1. To manage and plan the MPA with the participation of all involved parties.
2. To ameliorate unsustainable use of marine biodiversity with poverty alleviation through the development of sustainable fisheries and new aquaculture employment opportunities.
3. To raise the likelihood of the successful development and implementation of the MPA through community empowerment by way of relevant training courses provided.
4. To monitor and assess the management of the project on a regular basis.

Analysis of the recreational value of the Hon Mun Islands

Visitors' travel cost structure

Table 6 presents the detailed expenditure of domestic and foreign tourists during visits to Hon Mun. A very small part of the recreational value contributes to the local economy; this consists of expenditures on food and accommodation in Nha Trang, tourist boat tickets, and services on the islands.

Table 6. Detailed expenditure of tourists to the Hon Mun Islands (VND million)

	Domestic Tourists		Foreign Tourists	
	All	Per head	All	Per head
Transportation costs	19.937	0.127	150.833	1.587
Hotel costs in Nha Trang	14.026	0.072	6.842	0.072
Time costs	0.987	0.067	14.503	0.152
On-site costs	14.806	0.089	13.322	0.140
Total	35.729	0.219	178.658	1.880

Source: Calculated from the survey data

The on-site cost is Nha Trang's gross income from tourism in 2000 earned by boat-trip tours, boat rental owners, diving services, villagers in the fishing village (Lang Chai[6]), and other tourism service suppliers. This gross income was estimated to be VND48 994 million; the contribution of foreign tourists being less than that of domestic tourists. However, the contribution of international tourists to the local economy is greater per head compared with domestic tourists

[6] There are some small fishing villages on the Hon Mun Islands. Lang Chai is the biggest and almost all tourists visit it.

because the number of foreigners to Hon Mun is only one-third of the total number of visitors to Hon Mun. It is worthwhile to make a comparison here. According to the report of the Khanh Hoa Tourism Department in December 2000, the total revenue from tourism in Khanh Hoa in 2000 was estimated at VND197.2 billion. Roughly, if we use a weighting of one-third to estimate the tourism value of Hon Mun (based on the assumption that during an average of three days of recreation in Nha Trang, tourists use one day visiting Hon Mun), we could estimate the revenue gained from Hon Mun as VND197.2 billion × 1/3 = VND 65.7 billion.

The greatest part of visitors' expenditure lies in transportation costs. For domestic visitors, these costs made up over half of their total outlay. For foreign tourists, this figure was about 85 per cent of their total expenditure. The airline companies and complementary service suppliers acquire the major part of these costs.

The individual travel cost model

Results for the individual travel cost functions with two different models are presented in Table 7.

In these models, most of the coefficients have the expected sign. More importantly, the coefficient on the travel costs is negative. Similarly, the relationship between income and the total number of visits is positive.

Table 7. The travel cost regression function for two functional forms

Variable	Linear (t-statistic)	Semi-Log (t-statistic)
Dependent variable	Visits	Log of visits
Constant	2.645 732 (4.51)	0.907 665 (3.64)
Travel costs	-0.003 350*** (-3.08)	-0.001 635*** (-3.54)
Income	2.94E-07** (1.97)	1.62E-07*** (2.56)
Substitute costs	8.12E-05 (0.14)	-8.84E-06 (-0.04)
Age	-0.008174 (-0.92)	-0.006 350 (-1.69)
Male (dummy)	0.405930*** (2.08)	0.187 193*** (2.26)
Education	-0.043680 (-1.15)	-0.021 706 (-1.34)
Number of observations	180	180
R-squared	0.09	0.12
F-test	2.91	4.13

Source: Estimated from the survey data.
*** Statistically significant at 1% ** Statistically significant at 5%

High travel costs incurred by individuals have a negative impact on visits to Hon Mun. The more respondents have to pay to get to the islands, the less the frequency of their visits. It is reasonable to infer that there is less demand for people who live far from Hon Mun to visit the islands compared with those who live near the islands.

The income variable also has significant impact on recreational demand and bears the expected positive sign. Respondents with higher wage rates are willing to take more trips to the islands. The implication here is important; as incomes increase over time, so too will recreational demand (especially in the case of the Hon Mun Islands). This will lead to an increase in the recreational value of the islands. This implication is significant for rapidly growing countries like Vietnam as they plan for future recreational opportunities.

There is an insignificant relationship between the costs of substitute sites and the demand for the Hon Mun Islands. The prices of substitute sites have no impact on the demand for the islands. This regression result is not compatible with the theoretical hypothesis that the demand for a site will rise when prices of substitute sites increase. The sampling process encountered problems at this point. Respondents were usually ambiguous about an alternative recreational site if they did not choose Nha Trang for their holiday destination. Furthermore, it was very difficult to compare travel costs for substitute sites and travel costs for Hon Mun because the former referred to the costs for visiting the whole substitute site rather than a particular site like Hon Mun. However, the results do not mean that the costs for substitute sites did not affect the demand for the Hon Mun Islands. It only reflects the fact that this aspect of the study could not be adequately controlled for the purpose of this research.

The R-squared value measures how much the multiple regression fits the data. The R-squared values for both functions were low, indicating a less than satisfactory regression fit. These results reflect random responses between the number of visits and the explanatory variables. In this empirical study, the reason for low R-squared values may lie in the substitute site costs variable. Because the collection of reliable data on costs of substitute sites was very difficult, the regression hardly explains the variation in the demand for visits. In the semi-log function, the R-squared value tells us that the regression explains 12 per cent of the total variation in the number of visits of each individual. Both the R-squared and t-statistical indices indicate that the semi-log (dependent) functional form is better than the linear form.

The semi-log form was used to estimate the consumer surplus per visit. The annual consumer surplus per visitor was computed to be VND699 103. The consumer surplus per visit, therefore, is VND422 277. The recreational benefit per visit, which is calculated by adding the consumer surplus per visit and the average travel cost per visit, is VND651 661. Based on the total number of visits to the islands of 194 810 in 2000, the total recreational benefit is estimated to be VND126.948 billion per year. (See equations 1-5 above for the relevant functions.)

The zonal travel cost model

Domestic visitors

Visitation rates for zones are calculated using equation (6) and presented in Table 8.

Table 8. Visitation rate per 1 000 of the population per year for all zones

		Sample		
Zone	Population	Persons	%	Visitation rate /1 000
1	341 000	20	11.1	63.48
2	647 700	7	3.8	11.70
3	350 200	8	4.4	24.70
4	786 200	15	8.3	20.65
5	545 900	6	3.3	13.88
6	5 155 700	85	47.2	17.48
7	925 600	8	4.4	9.35
8	1 112 600	7	3.8	6.81
9	1 456 000	6	3.3	4.46
10	5 050 500	18	10.0	3.86
Total	16 371 400	180	99.6*	

Source: Calculated from survey data
* Components are rounded numbers

The visitation rates decrease drastically with distance, from 63.48 per 1 000 of the population in the innermost zone, to 3.46 per 1 000 of the population in the outermost zone. Zone 1 (Nha Trang area) has the highest visitation rate. The visitation rate of Zone 6 (Ho Chi Minh City) highlights some specific and interesting elements. Samples from this zone make up approximately half of the total. There are reasons for this. Firstly, the population of Ho Chi Minh City is about five million (nearly one-third of the population sample size of this study), so its sample must be large. Secondly, just like Vung Tau and Da Lat, Nha Trang[7] has traditionally been a popular recreational site in the south of Vietnam. Thirdly, Ho Chi Minh City is Vietnam's largest city; the economic center of the country. Its residents can afford to take holidays and are used to doing so. Fourthly, transportation facilities (air, train and coach) between Ho Chi Minh City and Nha Trang are readily available. The most popular form of transportation for tourists is the train. Zone 2 (districts in Khanh Hoa Province) is near Hon Mun but the number of visitors from here is small due to it being a rural area.

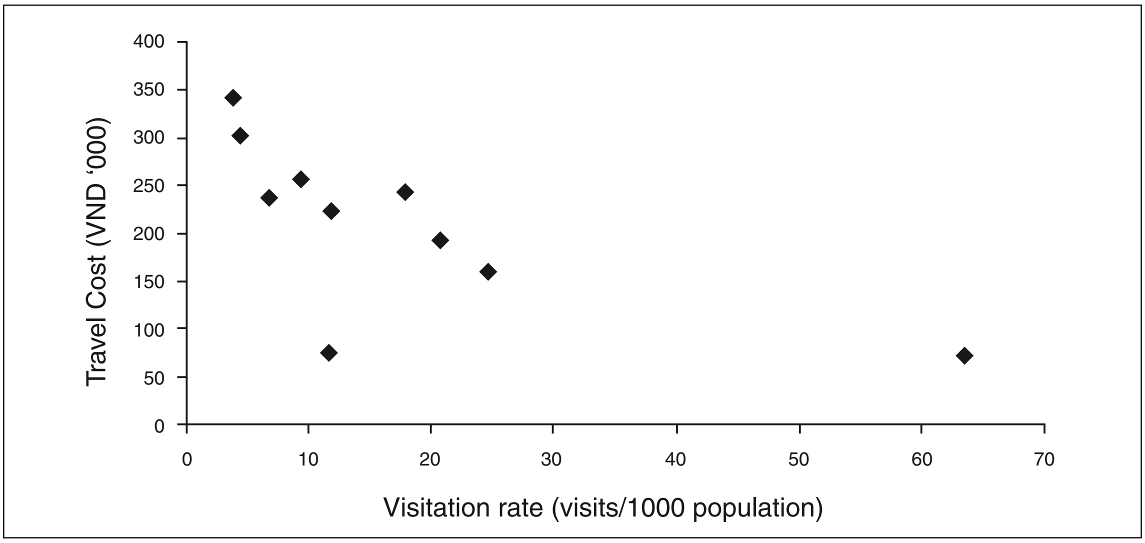


Figure 2. Graphical relationship between the visitation rate and travel cost

[7] Ho Chi Minh City's residents often choose Da Lat, Vung Tau or Nha Trang to take holidays.

Demand curve

As the calculated visitation rate variable violated the econometric assumption of normal distribution, the log of the visitation rate was used as a dependent variable in the demand function. Table 9 shows some results from the ordinary least square (OLS) regressions for zonal demand functions.

In equation 9.2, both the income variable and the cost of the substitute site variable have a relation to the cost variable, because income was used to calculate the time cost and travel cost was used to calculate the substitute price. The coefficients of cost and income have the expected signs. Although function 9.2 results in a higher R-squared value, it has multicollinearity[8] problems.

Table 9. The domestic demand for visits to the Hon Mun Islands

(Equation 9.1)
LN(VISIT) =
4.163 - 0.007 COST
(8.54) (-3.55)
R-squared = 0.61

(Equation 9.2)
LN(VISIT) =
3.408 - 0.01 COST + 0.001 INCOME + 0.002 SUBSTITUTE PRICE
(3.94) (-3.34) (0.99) (0.45)
R-squared = 0.69

Note: The t-statistics are in parenthesis. The number of observations (zones) is 10.

Figure 3 shows the user demand curve for Hon Mun visits in 2000. The curve was based on function 9.1. The user demand, or marginal willingness to pay, curve for Hon Mun's recreational resources reflects a way of summarizing users' consumption attitudes and capabilities for such resources. This user demand curve is curvilinear and convex to the origin, that is, relatively flat at low prices and steep at higher prices. At low travel costs and high rates of visitation, relatively small increases in travel prices will lead to substantial reductions in the number of visits to Hon Mun. At high travel costs and low visitation rates, however, travel price increases have a much smaller effect and they produce much smaller reductions in the number of visits.

Consumer surplus and recreational value

In Table 10, the consumer surplus was calculated zone by zone by estimating the area under the demand curve between the average travel cost of each zone and the choke price.

Foreign visitors

The visitation rates are low because the populations chosen were very large in comparison with the number of people from that region visiting the Hon Mun Islands. Unlike Vietnam, where tourist populations were restricted to urban

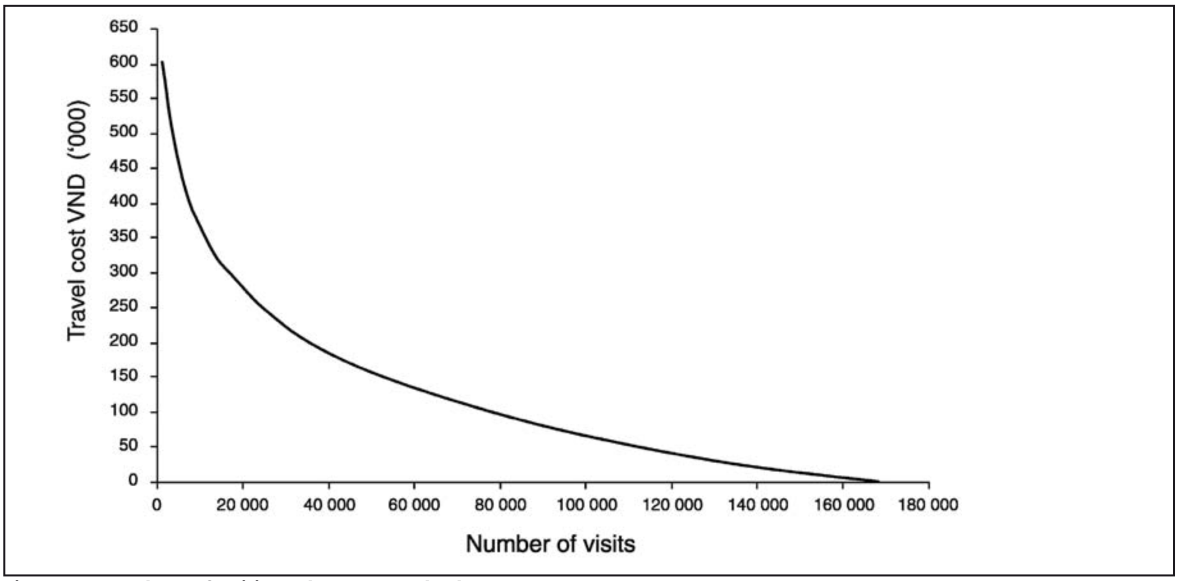


Figure 3. Demand curve for visits to the Hon Mun Islands

[8] Multicollinearity refers to where two or more explanatory variables in the regression model are highly correlated, making it difficult or impossible to isolate their individual effects on the dependent variable.

Table 10. Consumer surplus and price paid for Hon Mun visits in 2000

Zone	Number of visits	Consumer surplus (VND million)	Price paid (VND million)
1	12 811	1.672	0.898
2	23 414	3.056	1.758
3	6612	0.863	1.057
4	11 707	1.528	2.234
5	6385	0.833	1.420
6	51 865	6.769	12.553
7	8359	1.091	2.141
8	11 739	1.532	2.768
9	9320	1.216	2.806
10	23 695	3.093	8.094
Total	165 910	21.654	35.729

Source: Estimated from survey data

Table 11. Visitation rates and travel costs of foreign tourists by region

Region	Number of samples	Travel Cost (million VND)	Visitation rate (visits/1 000 pop.)
1 (Asia and Oceania)	117	1.623	0.276
2 (Europe and North America)	93	2.203	0.065
Total	210	3.826	

Source: Calculated from survey data using equation (6).

areas, statistical populations of foreigners were regional populations. Although Region 2 (Europe and North America) has a much larger population than Region 1, it is represented by fewer samples than Region 1 (Asia and Oceania), leading to a smaller visitation rate.

Based on the minimum requirement of two observations to estimate a demand curve, the linear demand function is as follows (calculated from the data given in the Table 11):

$$P = 2.381 - 2.737 \times Q$$

where

P are the travel costs (in VND million) and Q are visits per 1,000 of the population.

Given a linear demand curve, the annual consumer surplus per visitor is the choke price minus the actual price paid, divided by two, or

Individual annual CS = 0.5 x (choke price – price paid).

The total CS is equal to the sum of all the individual CSs, or
CS x number of visits.

For Region 1 (Asia and Oceania), the individual consumer surplus (CS) is given by:

CS = 0.5 × (2.381 – 1.623) = VND379 000

* Choke price = VND2.381 million
* Price paid = VND1.623 million (Table 11)

For Region 2 (Europe and North America) it is:

CS = 0.5 × (2.381 – 2.203) = VND89 000

where the choke price = 2.381
and the price paid = 2.203 (Table 11)

The weighted average consumer surplus is about VND250 000. The average recreational value for foreigners is estimated to be VND2.130 million, which is derived by adding the average consumer surplus and average travel cost to the islands.

Total recreational value

The total recreational value equals the total consumer surplus plus the total price paid.

The annual monetary recreational value of the Hon Mun Islands is about VND259.8 billion (approximately US$17.9 million). This is the value that the islands yield every year for the economy. However, this is not the revenue of Hon Mun. This value is distributed firstly, in the form of the consumer surplus of visitors who have gained recreational benefit from Hon Mun and then, in terms of the prices paid to transportation companies and agents for providers of services such as hotels, restaurants, tourist agencies, etc.

Table 12. Recreational value of the Hon Mun Islands in 2000 (Unit: VND million)

	Consumer surplus		Price paid		Recreational value	
	All visitors	Per visitor	All visitors	Per visitor	All visitors	Per visitor
Domestic visitors	21 654	0.131	35 728	0.215	57 382	0.346
Foreign visitors	23 810	0.250	178 657	1.880	202 467	2.130
Total	45 464		214 385		259 849	

Source: Calculated from survey data

A very small part of the estimated recreational value of Hon Mun goes to the local economy through expenditures on food and accommodation in Nha Trang, tourist boat tickets, and services on the islands.

The consumer surplus was estimated to be VND45.4 billion (approximately US$3.1 million), reflecting the annual recreational benefit of the Hon Mun Islands. This figure is the value of the benefit that visitors gained by visiting the Hon Mun Islands. It also reflects the amount that visitors are willing to pay to enjoy the islands' natural resources, such as the air, sea, scenic beauty, coral and fish. This figure, however, does not reflect the non-use value of Hon Mun. With fewer visits, international tourists received more surplus than domestic tourists (VND23.8 billion in comparison with VND21.6 billion). Their gained surplus per head was double that of domestic tourists, implying that foreign tourists gleaned greater enjoyment from the Hon Mun Islands than their local counterparts. International tourists value the natural resources of Hon Mun more than domestic tourists. Survey results showed that foreign tourists were also more active than domestic ones. They participated in most of the recreational activities on the islands while the main activity of Vietnamese tourists was just to enjoy the scenery.

The contingent valuation method (CVM)

There were 462 samples for the contingent valuation method, of which 252 were domestic respondents and 210 were foreigners. Table 13 and Table 14 summarize the main characteristics of domestic and foreign respondents to the CVM questionnaire.

Of the 252 Vietnamese respondents, 112 respondents were not willing to contribute to the MPA's trust fund as they believed that the money would be wasted or that the people responsible for the pollution should pay. This implies that their true willingness to pay (WTP) or their true preferences is not really zero. In order to derive these values, the Tobit model was used.

Table 15 and Table 16 presents results of the Tobit functions for Vietnamese and foreign visitors, respectively.

From the Tobit function, the willingness to pay (WTP) per person was estimated using equation (7). The WTP per Vietnamese visitor was found to be VND17 956.

So the WTP of Vietnamese visitors in 2000 can be obtained by multiplying the average WTP by the number of visits in 2000 as follows:

Table 13. Statistical data on socioeconomic characteristics of Vietnamese visitors to the Hon Mun Islands (252 respondents)

Characteristics	Mean	Standard Deviation	Median	Minimum	Maximum
WTP (VND)	17 966	31 042	5 000	0	180 000
Income (VND)	1 344 841	777 736	1 000 000	300 000	5 500 000
Age (years)	29.7	9.6	26.0	11.0	60.0
Education (Schooling years)	14.1	2.3	15.0	5.0	18.0
Gender (Male=1; Female=0)	0.67	0.47	1.00	0.00	1.00
Marital status (Married=1; Not Married=0)	0.37	0.48	0.00	0.00	1.00

Source: Survey data

Table 14. Statistical data on the socioeconomic characteristics of foreign visitors to the Hon Mun Islands (210 respondents)

Characteristics	Mean	Standard Deviation	Median	Minimum	Maximum
WTP (VND)	26 786	24 249	28 000	0	140 000
Income (US$)	3 642	2 604	3 000	500	10 000
Age (years)	32.5	10.78	30.00	12.00	68.00
Education (Schooling years)	15.17	2.4	16.00	5.00	22.00
Sex (Male=1; Female=0)	0.52	0.50	1.00	0.00	1.00
Marital status (Married=1; Not married=0)	0.34	0.47	0.00	0.00	1.00

Source: Survey data

Table 15. Tobit function for WTP of Vietnamese visitors for the Hon Mun MPA

Dependent variable: WTP Maximum likelihood – Censored normal (TOBIT)		
Explanatory description	Coefficient	z-statistic
Constant	-13 342.64	-0.55
Monthly wage rate	0.0094***	2.38
Age	-2 275.790***	-3.99
Education	4 806.69***	3.05
Gender	395.69	0.05
Marital status	-2 809.27	-0.31
R-squared	0.15	
Left censored observation 112	Right censored observation 0	
Uncensored observation 140	Total observation 252	

Source: Estimated from survey data
*** Statistically significant at 1% level

Table 16. Tobit function for WTP of foreign visitors for the Hon Mun Islands MPA

Dependent Variable: WTP Maximum Likelihood – Censored Normal (TOBIT)		
Variable	Coefficient	z-statistic
Intercept	10323.58	0.72
Monthly wage rate	2.007***	2.45
Age	115.06	0.46
Education	85.58	0.09
Gender	3185.05	0.77
Marriage	-2987.92	0.59
R-squared	0.036	
Left censored observation 44	Right censored observation 0	
Uncensored observation 166	Total observation 210	

Source: Estimated from survey data.
*** Statistically significant at 1% level

WTPdomestic = Average WTP x Number of visits

$WTP_{domestic}$ = 17 956 x 194 808
= VND3 498 million (about US$241 239)

From the Tobit function, the willingness to pay (WTP) per person is estimated using equation (7). The WTP per foreign visitor is VND 26 786.

So the WTP of foreign visitors in 2000, obtained by multiplying the average WTP by the number of visits in 2000, is:

$WTP_{foreigner}$ = 26,786 x 94,960 = VND 2,544 million (about US$175 420)

Thus, the total willingness to pay for the Hon Mun Marine Park Area is:

VND3 498 million+ VND2 544 million
= VND6 042 million

Conclusions and Policy Implicatons

Conclusions

With the growing development of ecotourism and the increasing attention given to conservation, it is necessary to use non-market valuation techniques to provide estimates of the economic benefits of projects in these areas. This study has used the travel cost model and the contingent valuation method for analyzing and measuring the recreational value of the Hon Mun Islands, a recreational and marine protected area.

Using the individual travel cost model (ITCM), the R-squared value was found to be too small (12 per cent in the semi-log function) to explain the variation in the demand for visits. The consumer surplus per visit was estimated to be VND422 277. The recreational benefit per visit was VND651 661. Based on the total number of 194 810 visits to the islands in 2000, the total recreational benefit was estimated at VND126.948 billion per year. However, the ITCM in this study applied only to domestic visitors. It was not practical to include foreign visitors because it was found that on average, a foreign visitor made only one trip a year to Hon Mun. Therefore, the result would be underestimated by the ITCM.

The travel cost model is a relevant approach to evaluating the recreational value of the Hon Mun Islands. It may also be used for other recreational sites in Vietnam. However, to establish a reliable demand curve for it, the site must be a developed recreational place, meaning that it must attract a large number of visitors in a year. Sampling becomes difficult when there are very few visits to a site.

Using the zonal travel cost model (ZTCM), the linear and semi-log demand curves for domestic visits to Hon Mun were plotted. The semi-log demand curve was chosen, as the linear form was skewed with autocorrelation and heteroscedasticity[9] problems. The recreational value of the Hon Mun Islands to domestic visitors in 2000 was estimated at VND57.3 billion, of which the recreational benefit or consumer surplus was VND21.6 billion. Similarly, a demand curve for Hon Mun foreign visitors was plotted, but in linear form. The recreational value from foreign visitors in 2000 was VND202.4 billion, of which the consumer surplus was VND23.8 billion. Therefore, the recreational value of the Hon Mun Islands is estimated to be VND259.8 billion annually, of which Hon Mun's consumer surplus is estimated at VND45.4 billion, based on 2000 statistics.

Using the contingent valuation method, the WTP for funding an MPA project for the Hon Mun Islands was estimated to be VND6.0 billion annually. The WTP per Vietnamese visitor is VND17 956 and per foreign visitor VND26 786. These WTP values are relatively low compared with WTP values estimated for other recreational sites in the world. Possible reasons for this include:

(1) The use of "exit surveys" instead of "before surveys". Interviews were done on boats on the way back to shore. About one-third of the questionnaires for Vietnamese visitors focused on the non-user. It is generally believed that people who have not yet availed themselves of the recreational benefits of a natural resort tend to be willing to pay more than people who have done so.

(2) It may have been difficult for the interviewers to explain the importance of coral reefs in the area to foreign visitors due to language constraints.

(3) The payment card format may have been biased by the limited number of choices. The range of choices on the payment card was based on the price of a full day package tour around the islands. Visitors were deemed to be willing to pay an amount equivalent to this price for conservation activities. The price was relatively low – US$7 for a day traveling around the islands with snorkeling, lunch and pick-up services included.

Clearly, the Hon Mun Islands represent a valuable environmental resource and, even though people do not presently pay an admission fee, there is a large consumer surplus of welfare to be gained from the existence of the islands. In future, as the number of visits to the islands increases, it is expected that the islands will become relatively more valuable. Although the estimated recreational value is only one aspect of the total value of the islands, it shows that, with proper conservation and management, tourism can be a significant source of benefit.

Specific Problems

One problem that the study had to overcome was that of multi-site trips. The Hon Mun Islands form part of the recreational attraction of Nha Trang. Tourists to Nha Trang visit not only Hon Mun, but also other sites, such as Chong Rock, Ponaga Tower or Nha Trang beach. Information collected in the questionnaire included travel expenditure for the whole trip to Nha Trang, and not exclusively to the Hon Mun Islands. A means of eliciting the travel costs for only Hon Mun had to be found. Two special factors were taken into account. These were (1) the respondent's satisfaction with the Hon Mun Islands in comparison with other recreational sites in Nha Trang; and (2) the time the respondent spent on the Hon Mun Islands out of the total time spent in Nha Trang. The problem was accentuated with

[9] If the ordinary least square (OLS) assumption that the variance of the error term is constant for all values of the independent variables does not hold, we face the problem of heteroscedasticity. This leads to unbiased but inefficient (i.e. larger than minimum variance) estimates of the standard errors (and, thus, incorrect statistical tests and confidence intervals). When the error term in one time period is positively correlated with the error term in the previous time period, we face the problem of autocorrelation. This leads to downward-biased standard errors (and, thus, incorrect statistical tests and confidence intervals).

respect to international tourists. Foreigners do not visit just Nha Trang, but also travel to various other sites in Vietnam (i.e. Da Lat, Hoi An, Hue, Ha Long Bay, Ha Noi, Sa Pa, and Mai Chau). Hon Mun is just a small stopover for them. The tourism value of sites that attract an insignificant number of international tourists may be omitted. However, for sites like Hon Mun where foreign visitors make up about a third of the total, inclusion of their behavior is compulsory. In this study, travel costs of both domestic and foreign visitors to the Hon Mun Islands were calculated and included in the estimates. It should be noted, however, that it was not possible to accurately isolate the travel costs for Hon Mun; only rough estimates sufficient for purposes of this study were derived.

Policy implications

Sustainable tourism

On average, 290 000 people visit the Hon Mun Islands each year, resulting in a total annual recreational value of VND259.8 billion (US$17.9 million). However, the local community earns only a small part of this amount (VND48.9 billion). So, although the local community is the direct stakeholder of the islands and is responsible for managing and protecting the islands, it receives a very small share of the benefits. This existing distribution mechanism may result in weak incentives to manage the islands sustainably. Hence, it may be appropriate to create funds for the proper management and conservation of the islands. Establishment of a fund based on donations from visitors would be feasible because estimates from both the ITCM and ZTCM show that consumer surpluses derived from the site are quite large (64 per cent[10] and 18 per cent of the total recreational value, respectively). The magnitude of this fund is already estimated in this study using the CVM (section 4.4). However, although the TCM-derived estimates of consumer surplus show that there is considerable potential revenue to support a fund, nearly half of the respondents to the CVM survey reported unwillingness to contribute, due to skepticism that a fund would be well-managed. This skepticism is consistent with findings from similar studies elsewhere.

This suggests that, while revenue potential exists, it can only be realized if tourists feel that their payment will translate into improved management. This suggests that the fund should: (a) be available to local resource managers; (b) be managed by an accountable entity with transparent transactions; and (c) yield meaningful visible results within a short time period.

The visible benefits need not be direct conservation benefits (e.g. healthier corals). They could be things like more support infrastructure (i.e. mooring buoys to prevent boats from dragging anchors and damaging coral) or improvements that enhance tourists' appreciation of the sites (e. g. signboards). If tourists notice visible improvements to infrastructure, it will signal to them that funds are indeed being used for local benefit.

Financial and technical support from international organizations can also be another source of funds. A four-year fund to create and manage a pilot MPA including the Hon Mun Islands, valued at over US$2 million, was initiated in early 2001 with the support of the Government of Vietnam, the Global Environment Fund, the World Bank, the Government of Denmark and the World Conservation Union (IUCN). Such funds need to be expanded and extended.

A sustainable tourism development plan is essential. It should address not only conser-vation activities, but also the expansion and marketing of tourist facilities, including protection of tourists from harassment and other dangers. Sustainable tourism must support local economic activities as well as take into account environmental costs and values. The local economy and the environ-ment must be protected.

Adjustment of the Port Expansion Plan

Although recreational value is only a part of the total value of the islands, the results from this study show that tourism can generate significant revenue; in fact, some VND259.8 billion annually. According to the Nha Trang Port Upgrading Feasibility Study (Ministry of Transportation 1997), the estimated revenue of the new port is about VND45.8 billion per year. Since the new port would not cause a total loss of the

[10] Note that the ITCM was applied only for domestic visitors who paid less than foreign visitors for transportation.

recreational benefit of the Hon Mun Islands,[11] a direct comparison of the revenue of the new port with the recreational value of the Hon Mun Islands is not appropriate. A full cost-benefit analysis (CBA) of the port expansion versus recreational development would be the best basis for comparison but is, however, not feasible within the scope of this study. This project only measures the maximum recreational value that would be lost (in other words, the value at risk) and compares it with the benefits projected from the port expansion. The large estimated recreational value of the islands is a strong indicator of the potential of the islands' tourism business. It is estimated that the new port would handle 1.8 times the volume currently handled and carry three times as many passengers. Such increases would pose the risk of increased air, water and noise pollution in the surrounding areas, including the coral islands. If the islands' tourism activities were to be reduced by 20 per cent due to increased pollution created by the new port, the resulting decrease in the recreational value of the islands would be more than the annual revenue of the port. While there are substitutes for the port expansion, there is no national substitute for the Hon Mun Islands in terms of coral-related tourism and research. Hence, the proposed port expansion plan needs to be seriously reconsidered.

Coral Reef Management

The coral reefs of the Hon Mun Islands are the most important and unique of all marine recreational sites in Vietnam, but they have not been marketed appropriately to attract tourists. In 2000, only about 4 000 tourists of the 290 000 visitors to the islands took the opportunity to scuba-dive to look at the coral There are three reasons for this. First of all, the coral around the islands has been seriously damaged. The opportunity to view good coral reefs decreases day by day. It is obvious that as the quality of the coral around the islands deteriorates, fewer tourists would want to pay for a diving trip to look at it. The second problem lies in pricing. The price of a scuba diving tour is considered expensive, even for foreigners. The average price is US$30 per hour, whereas the price for a day's tour around the islands, complete with lunch and a tourist guide, is only US$7. The third reason centers on marketing and advertising. Tourists are not provided with enough interesting information about the natural properties of the islands. Many visitors to the Hon Mun Islands are not even aware of the existence of coral reefs there. So they just look at the scenery and swim. The survey data confirms that about 80 per cent of the tourists to the islands participated in these two activities. The demand for the Hon Mun Islands will increase and their tourism value rise if their coral reefs are conserved and their inherent beauty and worth are marketed appropriately.

The management of the marine park area (MPA)

The challenge of managing a marine protected area is to allow multiple uses while conserving nature (Cesar 2000). This calls for knowledge of the compatibility of the various functions as well as the impacts of threats to the ecosystem. One of the biggest challenges that the pilot MPA in the Hon Mun Islands will face is achieving financial sustainability. A possible solution could be to impose a "conservation fee" on users of the islands. The large consumer surplus accruing to tourists (see Table 12) and their willingness to pay suggest there are grounds for such a fee. Estimating tourist response to a fee, deciding the fee, and drawing up an efficient MPA management scheme would require further research.

References

Brown, G. and W. Hendry. 1990. The economic value of elephants. Environment Economics Centre Paper 89-12. International Institute for Environment and Development, London, UK.

Cesar, H. S. J. (ed.). 2000. Collected essays on the economics of coral reefs. CORDIO, Sweden.

DeShazo, J. R. 1997. Using the single-site travel cost model to value recreation: An application to Khao Yai National Park. EEPSEA Research Report. EEPSEA, Singapore.

DOSTE (Department of Science, Technology and Environment). 1996. Investment project– Establishment of the Hon Mun Marine Protected Area Nha Trang. Khanh Hoa. Unpublished paper.

Dixon, J. A. and M. Hufschmidt (eds). 1986. Economic valuation techniques for the environment. Johns Hopkins University Press, USA.

Driml, S.M. 1999. Dollar Values and Trends of Major Direct Uses of the Great Barrier Reef Marine Park. Research Publication 56. Great Barrier Reef Marine Park Authority, Townsville, 12 p.

Francisco, H. A. and D. Glover (eds). 1999. Economy and environment: Case studies in Vietnam. International Development Research Centre (IDRC), Singapore.

Georgiou, S., D. Whittington, D. Pearce and D. Moran. 1997. Economic value and the environment in the developing world. Edward Elgar Publishing Ltd., UK.

[11] Except for accidents like oil spills.

General Statistical Office. 1998. Socioeconomic statistical data of 61 provinces and cities in Vietnam. Statistical Publishing House, Hanoi, Vietnam.

Hanley, N. and C. L. Spash. 1993. Cost-benefit analysis and the environment. Edward Elgar Publishing Ltd., UK.

Ministry of Transportation. 1997. Feasibility of Nha Trang port upgrading. Hanoi.

Scheaffer, R. L., W. Mendenhall III and R. L. Ott. 1996. Elementary survey sampling (5th edition). Duxbury Press, USA.

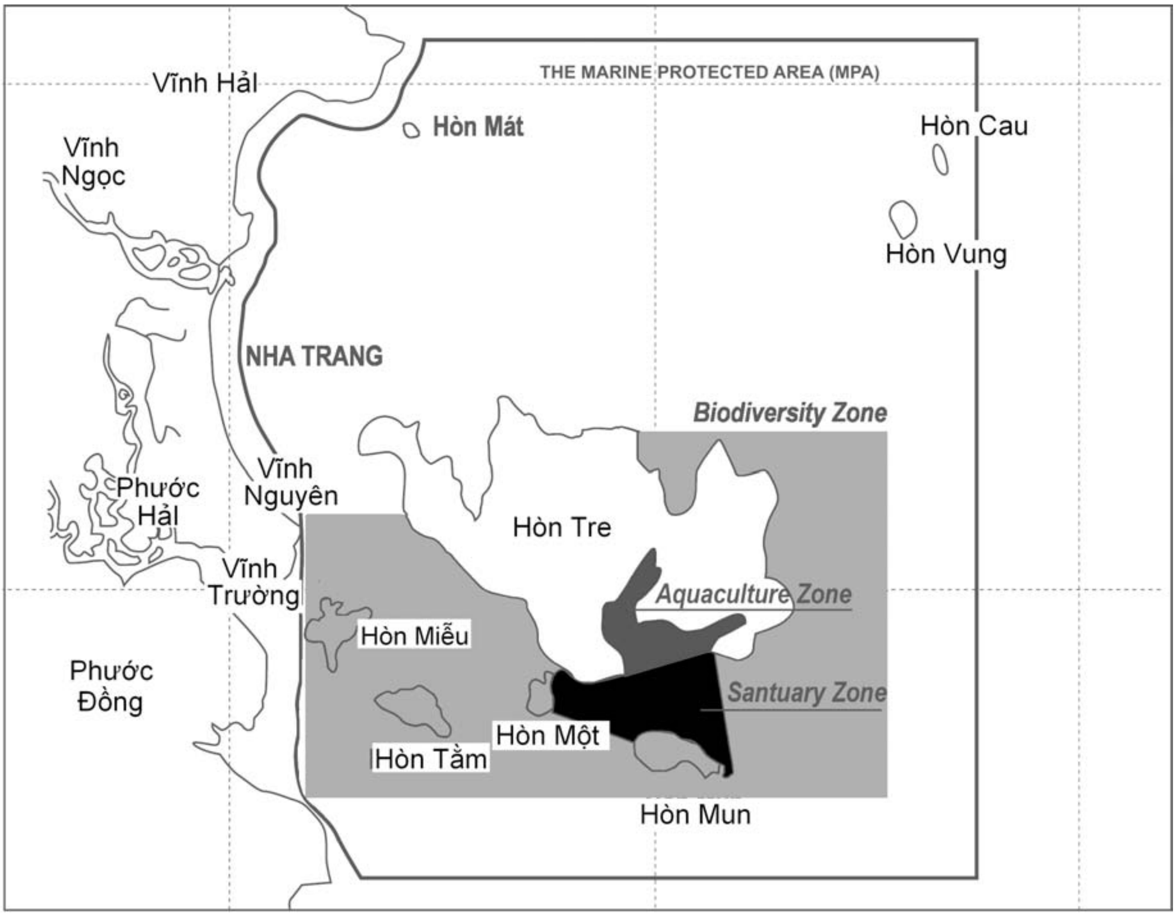
Tran, V. H. S. 1998. Environmental economic assessment activities aimed at developing a proposal for establishing and managing marine protected areas. Nha Trang. Unpublished paper. So Du Lich Khanh Hoa. 1997. Bao Cao Tong Ket 5 Nam Ve Du Lich 1993 – 1997. [Khanh Hoa Tourism Department (1997): Report of the 5–year period on tourism 1993 –1997] Nha Trang.

So Du Lich Khanh Hoa 1998, 1999, 2000. Bao Cao Tinh Hinh Thuc Hien Thang 12. [Khanh Hoa Tourism Department, 1998, 1999, 2000: Report of December] Nha Trang. Unpublished papers.

Vo, S.T. 1998. The establishment of marine protected areas based on coral reefs in Vietnam. Institute of Oceanography, Nha Trang. Unpublished paper.

APPENDIX A

Map of the Hon Mun Islands



Note: The Hon Mun Islands were declared an MPA in January 2001. When this research project commenced, the proposal for the Hon Mun Islands to be declared an MPA was still being considered. The map above highlights the proposed map before the declaration of Hon Mun Islands as an MPA.

APPENDIX B

Questionnaire

A Marine Protected Area (MPA) is being planned in Nha Trang Bay around the Hon Mun islands and other islands. The Bay is now being damaged by over-exploitation, including too much fishing, harmful fishing methods, pollution and careless use by tourists. The purposes of the MPA are to maintain biodiversity, protect the coral reefs, improve fisheries, control pollution, manage tourism, and create new jobs for local people who will be hired to manage the MPA. This survey is about your use of the area. Please tick the appropriate boxes to indicate your choice. Your answers to these questions will be used to help plan and manage the MPA. Keep in mind there are no right or wrong answers to these questions. Your best opinions are fine. Thank you for your cooperation.

Name of interviewer: ________________________

Date:_____________________________________

Reviewed by:______________________________

1. What country and city are you from?

   Country ________________

   City ___________________

2. How many times have you visited these islands, including this trip? ____times

3. How many people are in the group you are traveling with in Nha Trang ? _______

4. How many nights are you staying in Nha Trang? ____ nights

5. Why are you visiting Nha Trang? (Please tick)

   Vacation or holiday
   Work
   Study and research
   Other reason ___________

6. How did you get to Nha Trang from your home? (Please tick one or more)

   Airplane
   Train
   Tour bus
   Hired car

7. In Vietnam, which places did you visit or are you going to visit, besides Nha Trang?

   (Please specify the name of the places) _____________________________

8. What activities have you participated at the islands? (Please tick all that apply):

Use beaches / Sun bathe	Boating / Sailing / Jet skis
Swim	Just visit and relax / look at scenery
Snorkeling	Eat seafood
Scuba diving	Visit fishing village

9. Please indicate your expenditure (estimate thereof) in the islands

Return trip ticket .... USD/person
Food and drinks .... USD/person
Souvenirs .... USD/person
Scuba diving .... USD/person
Others .... USD/person

10. Please rank the places you have visited in Nha Trang in the order of their satisfaction to you.

Place	Rank
The Islands	....
Nha Trang beach	....
Ponaga tower	....
Hon Chong rocks	....
Long Son pagoda	....

Willingness to pay for the Marine Protected Area

Experts and people on the islands believe that creating the Marine Protected Area is the best approach to preserving the environment around the islands, but they are not sure if the MPA will be successful. New source of funds will be needed to pay for programs and offer jobs to people who will no longer be able to earn their living from fishing.

The next questions concern your willingness to pay new fees to visit the islands and use the Marine Protected Area.

11. Would you be willing to pay an additional fee each time you visit and use the islands to help fund new programs to manage the Marine Protected Area?

    Yes → go to question 12
    No → go to question 13

12. If you answer Yes to question 11, what is the **highest user fee** that you would be willing to **pay** (not including the return trip ticket paid to the tourist agency) for new programs to manage the Marine Protected Area?

    0.5 U.S. / 7,000 VND
    1.0 U.S. / 14,000 VND
    1.5 U.S. / 21,000 VND
    2.0 U.S. / 28,000 VND
    2.5 U.S. / 35,000 VND
    3.0 U.S. / 42,000 VND
    3.5 U.S. / 49,000 VND
    4.0 U.S. / 56,000 VND
    4.5 U.S. / 63,000 VND
    5.0 U.S. / 70,000 VND
    6.0 U.S. / 84,000 VND
    7.0 U.S. / 98,000 VND

13. If you answer No to question 11, what is the main reason that you said no:

    I do not care about the Marine Protected Area
    The Marine Protected Area is not needed
    It costs too much already to visit the islands
    The money would be wasted
    Other people and businesses that pollute should pay
    Not enough information

Questions about you

14. Are you male or female?

Male
Female

15. How old are you? _________ years

16. What is the highest grade you completed in school?

Primary school
Secondary school
High school
College/University
Masters or other graduate degree

17. Are you married?

Yes

No

18. What is your approximate net MONTHLY income ?

For foreigner:	For Vietnamese:
0 - 1,000 USD	0 - 400.000 VND
1,001 - 2,000 USD	400.000 - 600.000 VND
2,001 - 3,000 USD	600.000 - 800.000 VND
3,001 - 4,000 USD	800.000 - 1.000.000 VND
4,001 - 5,000 USD	1.000.000 - 1.200.000 VND
5,001 - 6,000 USD	1.200.000 - 1.500.000 VND
6,001 - 7,000 USD	1.500.000 - 2.000.000 VND
7,001 - 8,000 USD	2.000.000 - 3.000.000 VND
8,001 - 9,000 USD	More than 3.000.000 VND
9,001 - 10,000 USD	
More than 10,000 USD	

Thank you very much!

The Recreational Benefits of Coral Reefs: A Case Study of Pulau Payar Marine Park, Kedah, Malaysia[1]

Yeo, B.H.[2]

Abstract

Coral reefs are increasingly recognized as valuable assets in terms of supporting local economies, maintaining national heritage and conserving global biodiversity. Nevertheless, coral reefs are under pressure from a number of threats. In response, resources are being committed to address and minimize the impacts of these pressures on the reefs. Economic valuation studies highlight the monetary values of coral reefs and help to reflect the true value of the related environmental attributes. In so doing they provide important information about sustainable resource use and management.

A case study based on Pulau Payar Marine Park, Kedah, Malaysia, estimated the recreational benefits of the coral reefs at that location. It involved a contingent valuation (CV) study using both face-to-face interviews and self-administrative questionnaires. The willingness to pay (WTP) to access the marine park of visitors to marine park was elicited. In practice, the respondents were asked whether or not they would visit the marine park if an entry fee were charged and what their WTP would be in terms of an entry fee. The study found that 91 per cent of respondents would accept an entrance fee. The average WTP was estimated at RM$16.00 (US$4.20). In terms of the tourist numbers recorded during the year of the study, this estimate reflects a potential recreational value of the reefs in the park in the order of RM$1.48 million (US$390,000) per year.

This estimate provides an important indication as to the value of recreational benefits from the coral reefs in Pulau Payar Marine Park.

Introduction

Protected areas are increasingly recognized for the myriad of benefits that they provide. In marine parks, coral reef ecosystems harbor diverse marine resources, such as colorful reef fishes and invertebrate and algal species. The uniqueness of coral reef ecosystems makes them a prime attraction for recreation and nature-based tourism. Coral reefs also perform significant ecological functions, such as providing nursery grounds for fish, protecting coastlines, and storing carbon.

In view of these important values of protected areas, it is crucial to strike a balance between economic development and environmental protection. Fortunately, there is growing emphasis on exploring win-win situations that balance the conservation of natural resources with their potential to generate economic benefits. Nevertheless, the increasing global tourism demand for natural area experiences (ecotourism), accompanied by increasing natural resource scarcity, pose new challenges in terms of management and policy issues.

The system of marine parks in Malaysia was established in 1989 in recognition of the potential benefits of marine resource protection. However, in order to effectively manage marine parks and provide assured protection, adequate financial resources are needed to enhance institutional strengths and human capacity, provide proper infrastructure and maintain facilities. With pressing social and economic priorities, Govern-

[1]Study undertaken as partial fulfilment of the MSc. course in Environmental and Resource Economics (September 1998), University College London, U.K. Support from the Department of Fisheries, and funding from the World Wide Fund for Nature (WWF) Malaysia are gratefully acknowledged.
[2] World Wide Fund for Nature (WWF) Malaysia 49, Jalan SS23/15, Taman SEA, Petaling Jaya, 47301, Selangor, Malaysia.

ment funds for nature conservation are limited. In view of this, options to complement existing Government funding of marine park management need to be explored.

In the past, decisions on natural resource use and management have been based on traditional economic theory, in which only market costs and benefits are considered. Under this system, natural resources are deemed as free and not accounted for in decision-making processes. Valuation of non-marketed goods, in this case, protected areas, can help provide a step towards better-informed decision-making. This requires evaluating natural resources in monetary terms.

The main objective of this paper is to present the results and lessons learned from an economic valuation case study of Pulau Payar Marine Park that used the contingent valuation method (CVM). The study concentrated on the values of coral reefs in terms of recreational benefits. In this paper, the concept of economic valuation is presented, followed by a brief description of the study site and the methodological framework. The empirical results are then discussed and policy implications explored before conclusions are drawn. The results provide preliminary findings supporting policy research focusing on the development of effective pricing strategies.

Economic valuation

Economic values refer to how much a particular good or service is worth to people, and is reflected in their willingness to pay (WTP) a monetary price. In the context of this paper, the economic benefits of marine parks are "priced" by attaching monetary values to their attributes. This differs from conventional practice whereby natural resources are considered to be free. Such economic valuation contributes towards informed decision-making by helping reflect the true value of the natural resource, while also raising awareness of the importance of the resource.

The total economic value (TEV) concept is an important component of economic valuation. It incorporates the range of environmental benefits offered by natural resources. The TEV concept has been presented by a number of authors (Pearce and Turner 1990; Aylward and Barbier 1992; Munasinghe and Lutz 1993). Munasinghe and Lutz (1993) present an overview of the concept by providing a table of use and non-use benefits.

The TEV concept applied here is based on the coral reef ecosystem of Pulau Payar Marine Park, adapted from Spurgeon and Aylward (1992) and Munasinghe and Lutz (1993) and illustrated in the figure below.

Total Economic Value		
Use values*		**Non-use values**
Direct uses	**Indirect uses**	**Existence values**
Extractive: Capture fisheries	**Biological support to:** Fisheries Turtles Sea birds	Endangered species Charismatic species Threatened reef habitat Cherished "reefscapes"
Non-extractive: Tourism Recreation Research Education Aesthetic	**Physical protection to:** Ecosystems Landforms Navigation Coastal extension	
	Global life support: Calcium store Carbon store	

Decreasing "tangibility" of value to individuals →

* Use values also include option values that reflect a premium or discount on direct and indirect use values in the presence of uncertainty.

Source: Adapted from Spurgeon et. al. (1992) and Munasinghe and Lutz (1993).

Figure 1. Total economic value concept applied to Pulau Payar Marine Park

Use values can be divided into direct use values and indirect use values.

Direct use values depend directly on resources for outputs and services. Direct use values are further divided into extractive and non-extractive uses. In this case, extractive use values include benefits from capture fisheries. While, under national legislation, no fishing is permitted within two nautical miles of the marine park, capture fisheries are included here, as fishers are able to catch fish by casting their nets just outside this radius and schools of fish often move outside the coral area.

Non-extractive direct use values include benefits from recreation and ecotourism, research and education. The value of ecotourism and recreation is partly reflected in the revenue they generate. However, the extra benefit from tourism in terms of consumer surplus (CS) – the difference between what people would have been willing to pay for the experience and what they did pay – is not reflected. In an example, Hundloe (1990) found that people were willing to pay AU$5 million above and beyond what they already pay for reef activities on Australia's Great Barrier Reef.[3] In other words the CS was AU$5 million.

Indirect use values provide a wide range of important benefits that are less tangible as they are not directly consumed. The provision of biological support for diverse fish populations and marine organisms by coral reefs is an example of an indirect use value. Other important indirect uses include ecological functions and global life support, such as carbon sequestration. In relation to the latter, increasing scientific research has begun to show the importance of coral reefs for carbon storage, and, although the process is yet to be fully understood, Whittaker (1975) has indicated that coral reefs fix more carbon per annum than rainforests.[4] To date, the economic significance of these benefits has yet to be determined; and the fact that they are less tangible and are not observable in existing market structures makes such determination difficult.

Non-use values include benefits that arise without any physical use. There are three types of non-use values – option value, existence value and bequest value. Option value involves the opportunity to preserve a resource for future use instead of using it at the present time. For example, coral reefs may have yet-to-be-discovered important medicinal properties and ecological functions. The option of preserving these resources could potentially be critical to – and thus have huge value to – human life in the future. Existence value is derived from the knowledge that a particular natural resource or endangered animal is preserved. For example, an individual may never see coral reef fish, but may derive satisfaction from the knowledge that coral reef fish exist. Bequest value is derived from the desire to pass on value to future generations. All three of these values are intangible and difficult to value. Nevertheless, the concept of TEV as discussed above is important for illuminating the benefits that can be derived and that can help in decision-making.

Study site

The Pulau Payar Marine Park includes four small islands, of which Pulau Payar is the largest and the main tourist area. These islands and surrounding waters constitute one of the few coral reef areas found off the west coast of Peninsular Malaysia that is established for tourists. Tourism is a booming industry in Malaysia. It has been identified as the third largest sector in terms of the country's foreign exchange earnings (Ibrahim 1995).[5] Tourism growth can be seen in the marine park, with the number of visitors increasing from just 1 373 in 1988 to 106 780 in 2000.[6] The majority of tourists to Pulau Payar are day-trippers, as there are no commercial accommodation facilities on the island.

Permits and conservation fee

The Malaysian Department of Fisheries documents the number and nationality of tourists by issuing visitor permits. Since 1 January 1999, a conservation fee has been imposed on visitors to the marine park. This brings Pulau Payar into line with all marine parks in Malaysia, which charge visitor fees to assist with the maintenance and protection of the parks. The conservation fee charged for adults is RM$5.00 (US$1.32) – half this for students, retirees and children. No price differential is made between local and foreign tourists.

---

[3] From Spurgeon and Aylward (1992).
[4] *Ibid*.
[5] Quoted in Lim 1996.
[6] Source: Department of Fisheries Malaysia.

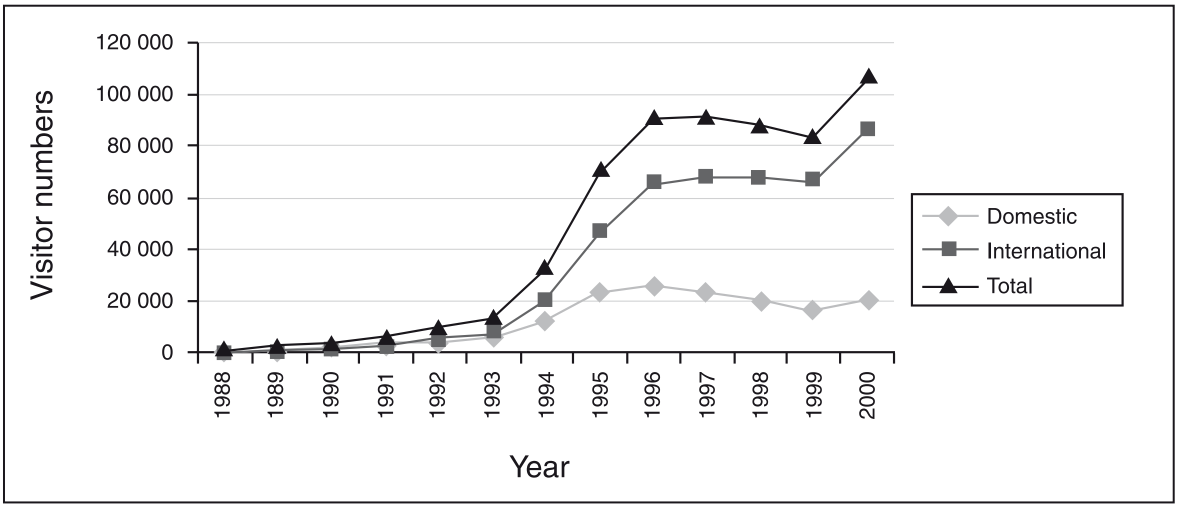


Figure 2. Annual visitor numbers to Pulau Payar Marine Park

Facilities

There are two main sites at the island. These are the Marine Park Centre area and a 50 m x 15 m floating pontoon that is moored off the beach, south of the Marine Park Centre and known as the Langkawi Coral pontoon. The Marine Park Centre is the main tourist area, occupying a small area of 0.6 ha and a beach approximately 100 m long. Picnic tables and benches are provided at the beach, further limiting space. Two toilets are provided at the Marine Park Centre, and there are two nature trails on Pulau Payar. The Langkawi Coral pontoon can accommodate up to 250 people at one time.

The high number of tourists could potentially threaten the attraction of the marine park. Appropriate measures to lessen this threat are needed. The main problems have been recognized as pollution caused by sewage and solid waste generated by tourists, and direct physical damage caused by tourists while snorkeling and swimming (Lim 1997).

Method

The contingent valuation method (CVM) was used to estimate the WTP, determined using surveys of tourists. CVM is a means of valuing an environmental good or service where either markets do not exist or market substitutes cannot be found. For these reasons, CVM is widely used to measure existence values, option values, indirect use values and non-use values. CVM questionnaires need to be carefully designed and well executed in order to increase the likelihood of consistent and valid estimates.

Questionnaire design

The questionnaire was based on work conducted by Lim (1997),[7] Mourato (1998) and Krug (1997).

A series of rigorous pre-tests were conducted with individual and group respondents. The first focus group concentrated on the structure and valuation components of the questionnaire. The second pre-test focused on the overview of the questionnaire and language flow. A trip to the study site was arranged before the field surveys in order to gain insights and experience according to the actual trip taken by tourists. The questionnaires were pre-tested and revised again after the trip. In order to capture the views of Japanese and Taiwanese tourists and those from Hong Kong, the questionnaire was translated into Japanese and Mandarin.

Questionnaire outline

The questionnaire includes a short introduction explaining the reason for it. The first section is designed to elicit respondents' background information, reasons for visiting and opinion on the marine park. Follow-up questions on other marine parks in Malaysia and nearby attractions are also asked in order to assess the potential of substitute sites. The next section contains contingent valuation questions in which the attributes of coral reefs in terms of recreational benefits form the hypothetical market good.[8] A

[7] 1009 sample size.
[8] See Appendix 1 for example of the contingent valuation scenario.

description of the marine park and related information in terms of challenges and possible solutions are provided as background information to elicit WTP. This is followed by a section on socioeconomic and background characteristics of the respondents. The final part of the questionnaire contains questions on the questionnaire and interview.

Field sampling

Sampling was carried out between 26 July and 3 August 1998. Face-to face interviews and self-administrative questionnaires were used at the two main sites. Two university graduates assisted by interviewing respondents. Non-selective sampling, sufficient for an experimental study, was applied at the two sites, with the aim of obtaining the highest possible number of responses.

Sample size

Completed questionnaires were obtained from 211 respondents.[9] The main challenge was to obtain responses from Taiwanese and Hong Kong tourists. Their tour package allocates only two to three hours to the marine park, with the balance of their time being spent on other nearby islands. This time constraint resulted in the collected sample not representing the population. In order to minimise this population bias, it would have been necessary to carry out the survey over a longer period of time and at different intervals. In order to minimise the impact of this sample bias, the estimated WTP responses were weighted to reflect the population composition in order to obtain a more representative mean WTP.[10]

Results

Table 1 shows the sample size in relation to the population.

Table 1 shows that Malaysian visitors represent 28.5 per cent of all visitors to the park (number of visitors tabulated and averaged over three years reflect the changes in visitor composition) but

Table 1. Proportion of sample versus population size

Country of origin	Population (Average annual number of visitors, 1995-97)	Sample size
Malaysia	71 912 (28.5%)	18 (7.6%)
Japan	51 377 (20.4%)	103 (43.2%)
Taiwan and Hong Kong	96 215 (38.2%)	66 (27.8%)
Europe	14 396 (5.8%)	30 (12.6%)
Others	17 993 (7.1%)	21 (8.8%)
Total	251 893 (100%)	238 (100%)

Source: Department of Fisheries Malaysia

Table 2. Socioeconomic characteristics by country of origin

	Malaysia, n=18	Japan, n=95	Taiwan &HK, n=53	Europe, n=30	Other nationalities, n=21
Demographic variables					
Males (%)					
Mean age (years)	72.2	29.0	45.3	50.0	57.1
Age range (years)	29	29	33	32	36
Education: Primary school (%)	16 – 43	16 –52	18 – 75	18 – 59	21 – 62
Secondary school (%)	-	1.1	2.6	-	4.8
Professional degree/diploma (%)	33.3	9.5	35.9	10.0	33.3
	33.3	16.8	17.9	46.7	23.8
University (%)	33.3	72.6	43.6	43.3	38.1
Economic variables					
Employment: Self-employed full-time (%)	22.2	4.5	13.2	13.3	28.6
Employed full-time (%)	55.6	75.3	71.1	66.7	52.4
Employed part-time (%)	5.6	3.4	7.9	10.0	-
Housewife (%)	5.6	4.2	2.6	-	9.5
Student (%)	5.6	10.5	5.3	10.0	9.5
Unemployed (%)	5.6	1.1	-	-	-
Retired (%)	-	-	-	-	-
Income non-response (%)	11.1	21.0	30.2	0.0	0.0
Monthly household income in US$ after tax (using mid-points of intervals)	1 000	2 894	2 419	6 519	4048
Range in US$	183 – 2 317	360 – 7 200	728 – 5 100	565 – 16 666	250 – 10 000

[9] 238 questionnaires were collected in total.
[10] See discussion below.

only 7.6 per cent of those sampled. Because of this, the WTP measures were weighted to improve the coverage of the results.

The sample was divided on the basis of country of origin into Malaysia, Japan, Taiwan and Hong Kong, Europe and other countries. Taiwanese and Hong Kong tourists are grouped together as they follow the same travel package to Pulau Payar, and because both responded to the same translated Mandarin questionnaire.[11]

The socioeconomic characteristics presented in Table 2 provide an explanation and insight into the WTP figures offered by respondents. For example, the employment status provide explanation in terms of the WTP figures indicated by respondents.

Analysis of WTP

In the questionnaire, respondents were asked whether or not they would visit the marine park if an entry fee were charged. Of the total, 91 per cent of the respondents answered "yes" but only if the money collected were to be used exclusively to improve the management of the park. The respondents were also asked to state their maximum WTP to visit the marine park. Answers were obtained using a payment ladder.[12] The results are presented in Table 3.

WTP results are weighted and organised into four different sample groups: full sample, sample without protests, sample without unusual observations and sample without either protests or unusual observations. Protest answers and unusual observations are identified and filtered to minimise bias in the estimated average WTP. Examples of protest answers are provided in Appendix 3.

As discussed in Section 5, the WTP estimates were weighted in order to get a representative measure. The weighting factor was:

WEIGHT = (% in population) / (% in sample)

A conservative mean WTP estimate as shown in Table 3 is RM$16.00.[13] Transposing this figure to the total visitor population would provide an indicative TOTAL annual WTP figure of RM$1.48 million (US$390 000).

The mean WTPs for domestic and foreign tourists are shown in Table 4.

From Table 4, it can be seen that, on the whole, foreign tourists seem to be willing to pay more. This may be due to the fact that the entry fee would be a very small proportion of the high travel costs they are already paying to reach the park, whereas for local tourists it would be a much higher proportion. The estimates provided

Table 3. Statistics of Weighted WTP in Ringgit Malaysia (RM$)

	Full sample	Sample without protests	Sample without unusual observations	Sample without protests or unusual observations
Mean	15.10	17.80	13.50	16.00
95% Confidence Interval				
Lower bound	12.10	14.40	10.90	13.20
Upper bound	18.20	21.20	16.00	18.80
Median	8.00	10.00	8.00	10.00
Minimum	0.00	0.00	0.00	0.00
Maximum	100.00	100.00	100.00	100.00
n (valid answers)	209 (199)	190 (180)	199 (189)	181(171)

Table 4. WTP of Domestic and Foreign Tourists[14]

	Domestic tourists (Malaysians)	Foreign tourists
Mean WTP (RM$)	9.40	19.50
95% Confidence Interval		
Lower bound (RM$)	4.80	16.10
Upper bound (RM$)	13.90	22.90
Median (RM$)	6.00	10.00
Minimum (RM$)	2.00	0.00
Maximum (RM$)	30.00	100.00
n (valid answers)[15]	15 (15)	166 (156)

[11] Hong Kong respondents make up 17 per cent of the Taiwan and Hong Kong category.
[12] Appendix 2 provides the example of the payment ladder used to elicit respondents' WTP.
[13] Based on average WTP values of respondents.
[14] The values for domestic tourists are not weighted as it is assumed that each country's sample is representative. In contrast, the values of foreign tourists are weighted because of the unrepresentative sample.
[15] Numbers in brackets shows the number of valid answers.

in Table 4 show the marked differences in WTP between the two groups and suggest that differential pricing may contribute to an effective pricing structure. While a bigger sample size would be needed to make strong assertions on this matter, the available results provide some justification for further exploring a two-tier entry fee system.

However, using 1997 visitor numbers, Table 5 shows that differential pricing would raise a total of RM$1.54 million compared with the RM$1.48 million raised with no price differential. This analysis shows that, despite the large difference in WTP between local and foreign park visitors, with the current relatively small number of foreign visitors, there would be no marked difference in the total recreational benefits between two-tier and one-tier pricing.

Table 5. Potential recreational values with two-tier pricing

	Domestic tourists (Malaysians)	Foreign tourists
Average WTP values	RM$9.40	RM$19.40
Visitor numbers in 1997	23 174	67 993
Potential value (reflected as collection) if fully captured according visitor groups	RM$217 835	RM$1 319 064
Total values of local and foreign visitors	RM$1 536 899	

It should be noted that the WTP figures could be affected by several external factors. For example, the economic downturn in Asia in 1997 could have affected the WTP figures. It could have reduced the WTP figures given by Asian tourists and increased the WTP figures given by other international tourists because of the significant changes in the currency exchange rates. Secondly, tourists could have given WTP figures that they are used to (i.e. entry fees that they face when entering a protected area or park in their own country) rather than a figure that reflected the value to them of Pulau Payar Marine Park. Thirdly, tour operators may affect answers by respondents. (This happened in instances where tour operators tried to influence tourists to state a lower figure or not agree to pay. Another example involved a tour operator telling tourists that entry fees had already been charged in the package.[16])

Discussions and policy implications

Assuming that the mean WTP of RM$16 can be fully captured, based on the visitor numbers in 1997, approximately RM$1.48 million could potentially be collected. This substantial amount demonstrates the high value of environmental attributes related to recreation at Pulau Payar Marine Park. The findings show that 91 per cent of respondents are willing to pay entrance fees. The WTP reflects their satisfaction with their visit to the marine park. An important policy finding was that respondents were willing to pay only if the money collected was to be channeled back to improve the management of the park.

Increasing resources by charging entry fees would contribute significantly to solving the problems identified at Pulau Payar Marine Park. They could be used, for example, to install a proper sewage disposal system and/or to establish a strong and effective marine awareness program that would motivate a sense of responsibility and encourage users of fragile natural ecosystems to help preserve such areas, wherever those areas might be.

Entrance or user fees for protected areas are often kept low in order to ensure wide acceptance. It may be sensible to follow this strategy for a user fee at the marine park, until such time as further studies are completed.

Lindberg (1991) discusses justifications for levying multi-tiered entry fees. He points out that "international tourists receive substantial enjoyment from the experience, yet pay low (if any) entrance fees, they do not pay taxes to support the park and do not bear the opportunity costs of not using the resource for agriculture, logging or other activities". Hence, a multi-tiered structure may be more equitable than the single fee. The notion of differential fees could both satisfy equity issues and increase efficiency.

Conclusions

Indicative estimates using CVM in this study show considerable benefits associated with recreation values of the coral reef ecosystem at Pulau Payar Marine Park. It is important to note that the figures should be interpreted with caution, as a larger sample may be required for a

[16] These situations occurred with the Taiwan and Hong Kong groups. The observations were noted and some questionnaires were identified as protest answers. This shows the importance of careful execution of questionnaires to ensure minimum bias.

more stable and representative estimate. In addition, careful studies need to be conducted and considered individually to learn the implications of entrance fees and benefit sharing if set within an area where communities are stakeholders. Lastly, a CVM approach should incorporate information from the disciplines of ecology, psychology and market research.

This WTP estimation of entry fees shows the potential of natural resources to generate economic benefits that enable continued conservation efforts. The use of valuation techniques could play an important role in the future, when more rigorous studies can be carried out to estimate non-user values, such as the benefits of carbon dioxide absorption by coral reef ecosystems.

This paper contributes to an understanding of the potential role of economic analysis in protected area management. Recommendations for future research for a more rigorous and complete study may include:

1) Research on two-tiered entry fees and differential pricing to reflect the values of marine parks.
2) Combining the analysis of entrance fee levels and the concept of 'limits of acceptable change' (LAC) to develop policies that minimise damage to the parks while capturing the potential economic benefits.
3) Extending the scope of the study to carry out an economic evaluation of the linkages between socioeconomic activities and biodiversity, especially in marine parks where communities are important stakeholders. This could provide some insights into potential mechanisms for benefit sharing.

Appendix 1: Contingent valuation scenario

Pulau Payar is the only established clear water coral reef area in the West Coast of Peninsular Malaysia. Pulau Payar continues to attract high number of visitors because of the suitability of its beautiful and unique coral reef environment for activities such as snorkeling, scuba diving and appreciation of its aquatic flora and fauna (including fish feeding and viewing).

Visitor numbers have increased dramatically from 1 300 in 1988 to 90 000 in 1997. This has caused damage to the fragile coral reefs that take many years to build up. The two main causes of damage to the coral reefs in Pulau Payar are:

1. *Careless snorkeling activities by tourists.*
2. *Pollution due to sewage and waste from tourists.*

In order to continue the enjoyment and benefits we get from coral reefs and tourism in Pulau Payar as a whole, actions need to be taken to conserve the corals.

The park managers could help solve the problem by:

1. *Introducing an effective and strong marine awareness education programme so that visitors will be able to learn more about corals and be careful not to harm the corals when snorkeling.*
2. *Installing a proper sewage and solid waste disposal system to reduce pollution.*

These steps need money to be carried out. Presently, no income from the tourism industry is used for the conservation and maintenance of the park.

The park managers could collect money by charging an entry fee that would be used directly to help conserve the marine park in its natural settings. The facilities available at the marine park will remain the same.

Q16) Would you still visit the marine park if an entry fee were charged?
____Yes ____ No go to **Q19 in page 6**

Appendix 2: Willingness to pay question and payment ladder

Q17) The following table (show table, pg. 6) consists of a list of prices from RM$0.50 to RM$100. Ask yourself: **"What is the MAXIMUM price that I would be willing to pay to enter the marine park (per entry)?"**

➔ (Note: Consider other expenses that you have already paid or will pay for on this trip and remember that you could also spend your money on other things such as visiting other islands nearby or spending more money on souvenirs and on other activities on your whole trip.)

Your willingness to pay for an entry fee will be used to finance:
A) marine awareness and education programme
B) installation of a proper sewage and waste disposal system

RM$ PER ENTRY	
0.50 ____	Please do not agree to pay if:
1.00 ____	1) you **cannot afford it**
1.50 ____	2) you have more important things
2.00 ____	to spend your money on.
2.50 ____	3) you are not sure about being
3.00 ____	prepared to pay or not.
4.00 ____	
5.00 ____	
6.00 ____	
7.00 ____	
8.00 ____	
9.00 ____	
10.00 ____	
15.00 ____	
20.00 ____	
25.00 ____	
30.00 ____	
40.00 ____	
50.00 ____	
60.00 ____	
70.00 ____	
80.00 ____	
90.00 ____	
100.00 ____	

Appendix 3: Reasons for not being willing to pay and examples of protest answers

The following table lists respondents' reasons for not being willing to pay. The protest answers are marked with *.

Reasons for not paying	n
Marine parks should be financed by the government*	18
Cannot afford to pay more	3
Rather visit other islands not charging the entry fee	6
The traveling costs to the island is high enough*	2
Tour operator should pay*	3

*Protest answers

References

Aylward, B. and E. Barbier. 1992. Valuing environmental functions in developing countries. Biodivers. conserv. 1:34-50

Hundloe, T.J. 1990. Measuring the value of the Great Barrier Reef. Australian Parks and Recreation 26(3): 11-15.

Krug, W. 1997. Questionnaire from the Etosha environment and tourism study, University College London, U.K.

Lim, L.C.1996. Tourism, pollution and the marine environment in Malaysia. World Wide Fund for Nature (WWF) Kuala Lumpur, Malaysia.

Lim, L.C. 1997. Carrying capacity assessment of Pulau Payar Marine Park. WWF Project Report, MYS341/96. World Wide Fund for Nature (WWF) Kuala Lumpur, Malaysia.

Lindberg, K.1991. Policies for maximizing nature tourism's ecological and economic benefits. International Conservation Financing Project Working Paper. World Resources Institute. Washington, D.C., U.S.A.

Mourato, S. 1998. Contingent valuation studies of sanitation and drinking water improvements in Malacca. Report to the Economic Planning Unit, Prime Minister's Department, Malaysia (DANCED/ EPU Institutional Strengthening and Capacity Building Project).

Munasinghe, M. and E. Lutz. 1993. Environmental economics and valuation in development decision-making. *In* Mohan Munasinghe (ed.). Environmental economics and natural resource management in developing countries. Committee of International Development Institutions on the Environment (CIDIE). United Nations Environment Programme, Nairobi, Kenya.

Pearce, D. and R.K. Turner.1990. Economics of natural resources and the Environment. Harvester Wheatsleaf, London.

Spurgeon, J. and B. Aylward. 1992. The economic value of ecosystems: 4 – coral Reefs. Gatekeeper Series No. LEEC GK 92-03. International Institute for Environment and Development, London, U.K.

Coral Bleaching and the Demand for Coral Reefs: A Marine Recreation Case in Zanzibar

Z. Ngazy, N. Jiddawi and H. Cesar

Abstract

Coral reefs and their associated marine life are one of the greatest natural endowments of the Zanzibar islands. They provide direct and indirect sustenance to rural and urban populations, and protect thousands of organisms that have long been used as a source of protein and minerals to human populations, especially in the rural areas. Recreational scuba diving is among the benefits delivered by coral reefs. It is increasingly becoming a conspicuous component of international tourism, creating employment opportunities for a considerable number of people and contributing to national income. In 1998, coral bleaching was witnessed in many parts of the world. It was related to a mixture of stresses, both natural and human-induced, and threatened the livelihoods of local communities and tourism industries. This paper looks at the impact of coral bleaching on tourism. Specifically, it estimates the demand for recreational scuba diving in Zanzibar using the contingent valuation method (CVM) and it assesses tourists' perceptions of the condition of coral reefs in Zanzibar. The survey was conducted in Unguja, Zanzibar. Findings from 157 questionnaires completed by tourists suggested that most of the respondents visited Zanzibar as part of a larger trip that included other destinations in the region. About 72 per cent had some knowledge of coral bleaching. At the 95 per cent level, sex, annual income and diving experience were found to be significant in the estimation of the willingness-to-pay (WTP) equation, whereas the number of dives that a tourist made depended significantly on duration of stay in Zanzibar and on annual income. Diving experience and the condition of Zanzibar's reefs were found to be insignificant in the demand equation. Variables such as age and education, initially included, were later omitted in the model due to their strong correlation with other explanatory variables. The majority of the respondents perceived the coral reef condition in Zanzibar to be good and the average WTP for experiencing high quality reefs was US$84.7 annually over and above what they had already paid for the experience.

Background

As a result of numerous and varied opportunities for leisure time and employment creation, tourism has become the fastest growing and most important economic sector in many countries. This is especially true in coastal areas, where there are few other opportunities. Tourists with money to spend are no longer satisfied with a package of just the "Three Ss" (sand, sun and sea). Instead, they are also keen to experience coral reefs and associated marine life. In this respect, tourists' preferences have shifted towards recreational scuba diving and snorkelling, both of which are currently a rapidly growing component of international tourism.

Coral reefs, sometimes referred to as the flowers of the ocean due to the diversity of beautiful colors as well as their physical appearance, are one of the most important marine ecosystems. The coral reef ecosystem plays a significant role in the provision of valuable economic and ecological benefits to society. It provides tangible and intangible benefits to rural and urban populations by providing food, medicine, income, marine recreation and environmental protection as well as psychological satisfaction. Reefs constitute the habitat for several species that are directly used for food fisheries, aquarium fisheries and the curio trade. They also contribute to the provision of sand for beaches and low islands, as well as to the protection of land against wave action.

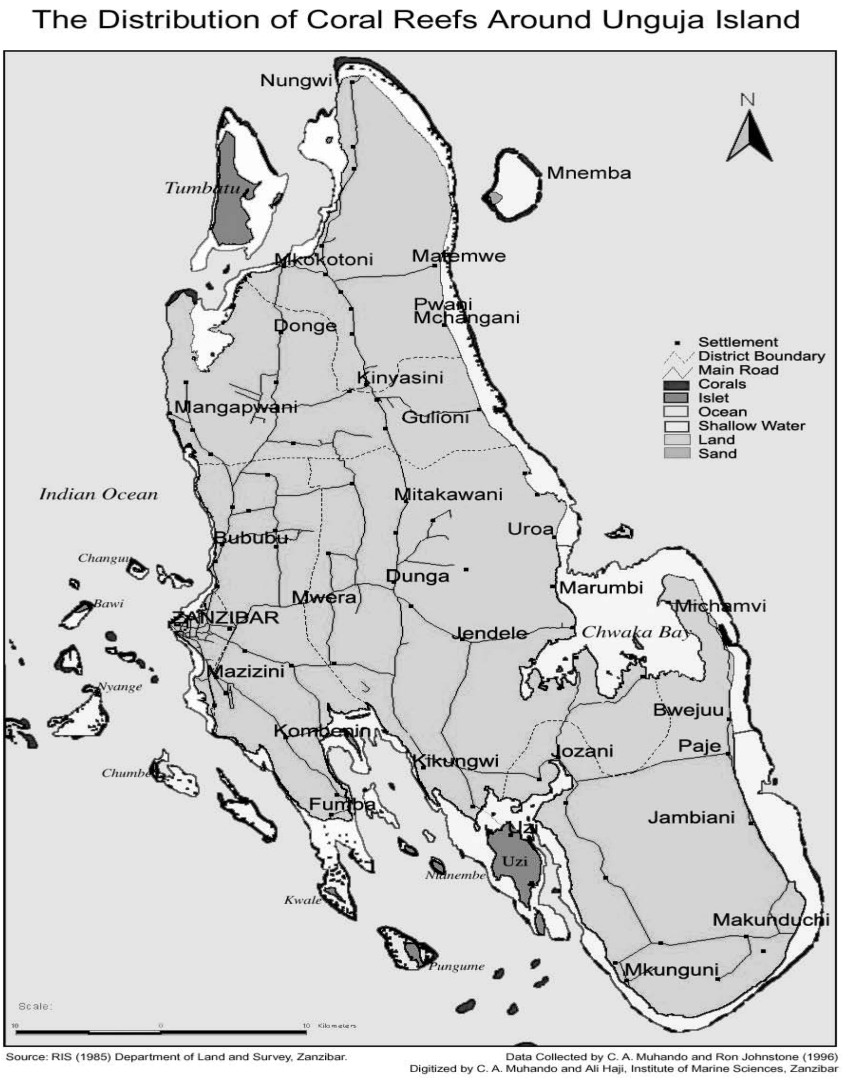


Figure 1. The main island of Zanzibar (Unguja) surrounded by coral reefs

Despite their importance, reefs have been experiencing natural and anthropogenic stresses, which cause coral bleaching and degradation. Stressors that cause bleaching include high sea temperature, high levels of ultraviolet light, low light conditions, high turbidity and sedimentation, bacterial infection, crown-of-thorn starfish predation and various anthropogenic toxicants (Westmacott et al. 2000b, Francis et al. 2001). Since the 1997-98 El Niño and a subsequent 1998 bleaching, there has been much concern among marine protected area managers, those in the tourism industry and policy-makers about the impact of coral bleaching. In this regard, research initiatives have been geared towards monitoring changes in coral reefs and their functionality. This has involved the livelihood of the local communities, and tourism in general, which currently deliver a significant contribution to the local economies. One such initiative is the Coral Reef Degradation in the Indian Ocean (CORDIO) program (see: www.cordio.org).

While the benefits that come from the reef resource are well recognized, most research has concentrated on the supply side of the coral reef ecosystem and less has been done on the demand side. This paper, therefore, specifically seeks to estimate tourist recreational demand for coral reefs in Unguja, the main island of Zanzibar (see Figure 1). The island is highly dependent on tourism, which, from 1990 to 2000, experienced an average annual growth rate of about 8.4 per cent. Zanzibar, part of the United Republic of Tanzania, is made up of two sister islands, Unguja and Pemba, flanked by many smaller islands, of which some are habitable and others are not. The main island - referred to in this paper as Unguja - is commonly known as Zanzibar because of the name given to Stone Town. The island is located in the Indian Ocean off the coast of mainland Tanzania at longitude 39 East and latitude 6 degrees South of the equator. It is endowed with a wide variety of coral formations due to its differing water quality, depth, currents and wave strength. Branching corals dominate the western side of the island, while the eastern side encompasses a wide range of soft corals and encrusting corals that can withstand currents and waves (Francis et al. 2001). Moreover, the fringing reefs on the east coast of Zanzibar play a crucial role in seaweed farming[1] due to lagoon formation that allows farming to take place.

The study

The study was undertaken on Unguja Island between September and December 2001, using sets of questionnaires that were administered to 157 tourists at the end of their vacation on Unguja. The interviews were conducted at the airport and hotels, with very few conducted at the seaport.[2] The questionnaire, written in English, elicited information on, amongst other things, the respondents' socioeconomic background as well as their length of stay in Zanzibar, number of dives, diving experience and experience with coral reefs in other places. The second part of the questionnaire consisted of a set of CVM[3] questions. It provided three colored pictures (photos) each showing a different scenario. Photo A showed mainly dead coral but high fish abundance. Photo B showed pristine corals but no fish. Finally, Photo C showed both abundant fish life and healthy corals. Based on the scenario, the respondent was asked to reveal his/her preference among the three reefs in the pictures. The respondent was also questioned about his/her "willingness-to-pay" (WTP) for the selected pristine reef C, in comparison with the situation that the divers experienced in Zanzibar. In this question, demand for coral reef was assumed to come from extra money that a tourist would be willing to pay per holiday in Zanzibar to experience such a better reef. This is in accordance with economic theory, in which individual WTP for a commodity depends on the amount of satisfaction/utility that the individual expects to derive from its use. Hence, the WTP varies according to income, preference for the commodity or service and other socioeconomic characteristics. Basically, there are three ways to elicit WTP information. These are, open-ended questions; bidding game/dichotomous choice; and choice experimental models. Although both the bidding game/dichotomous choice and the choice experiment would have been better to use, due to a time constraint, this study used the open-ended question method to elicit WTP. The main drawback in this approach is the effect of strategic bias and starting point bias. This, however, was handled by formulating the questions in such a way that the value judgement could be enhanced through visual presentation of the corals in all three pictures. Also, it was taken that the amount the tourists had already paid for their holiday in Zanzibar would form a starting point for WTP.

The recreational demand model

The demand for coral reefs is a derived demand, that is, it is demanded not for its own sake, but for its ability to support marine life for food and recreational purposes. Looking at the recreational aspects, the demand for coral reefs is approximated by the number of dives a tourist makes during his/her holiday. This is determined by the characteristics of the reefs in question and the socioeconomic characteristics of the tourists. Conversely, the value or benefit of coral reefs that tourists derive from diving or snorkelling is determined by the diver's WTP for experiencing such a coral reef. Hence, an inverse demand function relates WTP as a function of the number of dives a tourist makes on a site, his/her preference for the site, the condition of Zanzibar's reef, and individual socioeconomic characteristics. Generally, demand is assumed to be a linear function as specified below.

NUDIVE=
f (DUSTAY, EXPER, ZAREEF, ANUINCO)

where:

NUDIVE = Number of dives made by tourist
DUSTAY = Duration of stay; EXPER = Tourist's diving experience; ZAREEF = Condition of Zanzibar's reef
ANUINCO = Tourist's annual income

WTP = f (SEX, ANUINCO, PREFC, EXPE, ZAREEF, NUDIVE)

[1] Seaweed farming is the most lucrative marine resource-related activity for many people on the east coast of Zanzibar (Jiddawi and Ngazy 2000).
[2] At the seaport it was inconvenient to administer the questionnaire.
[3] CVM was defined by the National Oceanic and Atmospheric Administration (NOAA) of the United States as a survey or questionnaire-based approach to the valuation of non-market goods and services, whereby monetary values are obtained for the goods or services contingent upon a constructed (hypothetical or simulated) survey scenario involving the good or service described.

where:

SEX = Gender of tourist
ANUINCO = Tourist's annual income
PREFC = Preference for coral reef C
EXPE = Tourist's diving experience
NUDIVE = Number of dives made by tourist.

Both models above are based on economic theories. However, the number of dives (demand) did not consider WTP (value) as one of the determinants that could have influenced the respondents' diving decisions. This is because the stated WTP in this case was not specifically tied to the dive experience, but to the scenery depicted in the photo. Conversely, the WTP function encompasses the number of dives as one of the influencing variables. This is because the value judgement involved relates to the actual reef condition in Zanzibar with the coral reef scenery shown in the picture.

Results of the analyses

A sample survey consisted of 157 tourists from 23 countries – namely, Austria, Belgium, Canada, Denmark, Finland, France, Germany, India, Ireland, Italy, Malaysia, the Netherlands, New Zealand, Norway, Pakistan, the Philippines, Romania, Singapore, South Africa, Spain, Sweden, United Kingdom, and the U.S.A. The sample representative countries are grouped according to categories of tourist arrival by nationality. This representation is summarized in Figure 2.

The majority of the respondents were young people between the ages of 18 and 35 years. The annual income for the majority was less than US$10 000 (Table 1 below). A survey sample (Figure 2) superimposed on the tourist arrival statistics for 2001[4] indicates misrepresentation of Kenyans, other Africans, Americans and Japanese. Furthermore, the number of Italians is relatively

Table 1. Age distribution and annual income for surveyed tourists on Unguja Island, 2001

Age (in years)	%	Annual Income distribution (in US$)	%
Below 18	3.2	Below 10 000	32.3
18 – 25	35.0	10 000 – 19 999	18.5
26 – 35	33.1	20 000 – 29 999	20.0
36 – 45	15.3	30 000 – 49 999	20.0
46 – 55	3.8	50 000 – 74 999	3.1
Over 55	1.3	75 000 – 99 999	4.6
Missing values	8.3	Over 100 000	1.5
		Missing values	1.0

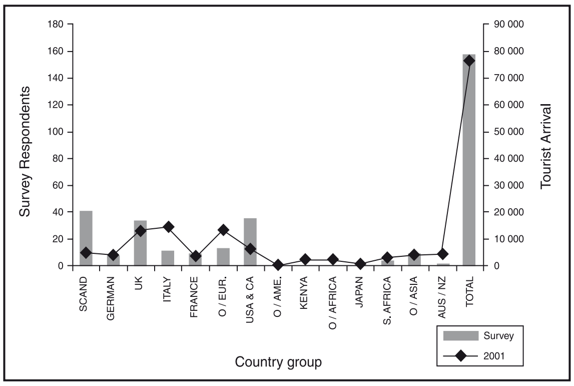


Figure 2. Survey sample (September– December 2001) compared with tourist arrivals to Zanzibar by nationality in the year 2001

small in the sample, whereas the numbers of Scandinavians and North Americans are relatively high. Nevertheless, the general trend for both appears similar.

Respondents were asked to indicate what they liked most and what they liked least while on holidays in Zanzibar. In relation to their likes, approximately a quarter (24.3 per cent) of the respondents mentioned the option "people and culture"; 19. 7 per cent mentioned "beaches"; 17.9 per cent mentioned "marine life"; approximately 17 per cent mentioned "nice weather"; and 16.1 per cent mentioned "marine sports". As for the disappointments, 50 per cent did not have any disappointments while on their holiday, 14.6 per cent were disappointed with the high prices in the restaurants, and 8.5 per cent were disappointed with dead corals. Only 4.8 per cent and 4.2 per cent mentioned being disappointed with "food and beverage" and "peoples and culture", respectively.

Divers' experience with coral reef in Zanzibar

The level of diving experience differed amongst respondents. Around 64 per cent were "open water" beginners, who had made fewer than 10 dives; 25.2 per cent had advanced level certificates; 3.7 per cent had certificates other than PADI; 2.8 per cent were dive instructors; 2.8 per cent were dive rescuers; and 0.9 per cent were dive masters. Analysis suggested that the majority of the respondents were students of diving. Around two-thirds (65.9 per cent) of the respondents enjoyed marine life by diving and around one-third (34.1 per cent) enjoyed it by snorkelling. Responses suggested that marine life is of importance to divers, with 28.5 per cent finding it

[4] Tourist arrival statistics for 2001by nationality as obtained from the Commission of Tourism Zanzibar.

very important; 52 per cent finding it quite important; and 18.5 per cent finding it not important.

Knowledge of coral bleaching and its impact on society is limited among many coastal people, especially non-reef users who have never experienced coral reefs despite their dependence on marine resources and the ecological benefits that are derived from them. Of those who are aware of coral bleaching, most believe that it is a natural phenomenon. In contrast, 72 per cent of the tourist respondents knew about coral bleaching. However, the extent of their knowledge differed. Just over one-fifth (21.2 per cent) were very well informed about coral bleaching, while 52.1 per cent were reasonably informed, and 26.6 per cent knew a little bit about it. About one-quarter (24.2 per cent) had "quite a few" friends who had information on coral bleaching, while 36.3 per cent had very few friends knowledgeable about the phenomenon, and 39.5 per cent mentioned that none of their friends knew anything about it.

From the surveyed tourists' point of view, there are still good reefs in Zanzibar. Of the respondents who had dived, 74.8 per cent had enjoyed the coral reefs a lot, 15.6 per cent did not notice anything special compared with other places, while 9.6 per cent were shocked by the poor condition of the coral reefs in Zanzibar. The above responses were supplemented by questions on the respondent's experience of coral in other countries. It was revealed that 79.9 per cent had snorkelled in other places with beautiful coral, whereas 20.1 per cent had never come across beautiful corals before. Jiddawi (1997) makes a similar validation of the condition of the coral reefs in Zanzibar. It is noted that Zanzibar possesses some of the most attractive and valuable coral reefs in East Africa in terms of the diversity of marine resources.

Preference for coral reefs

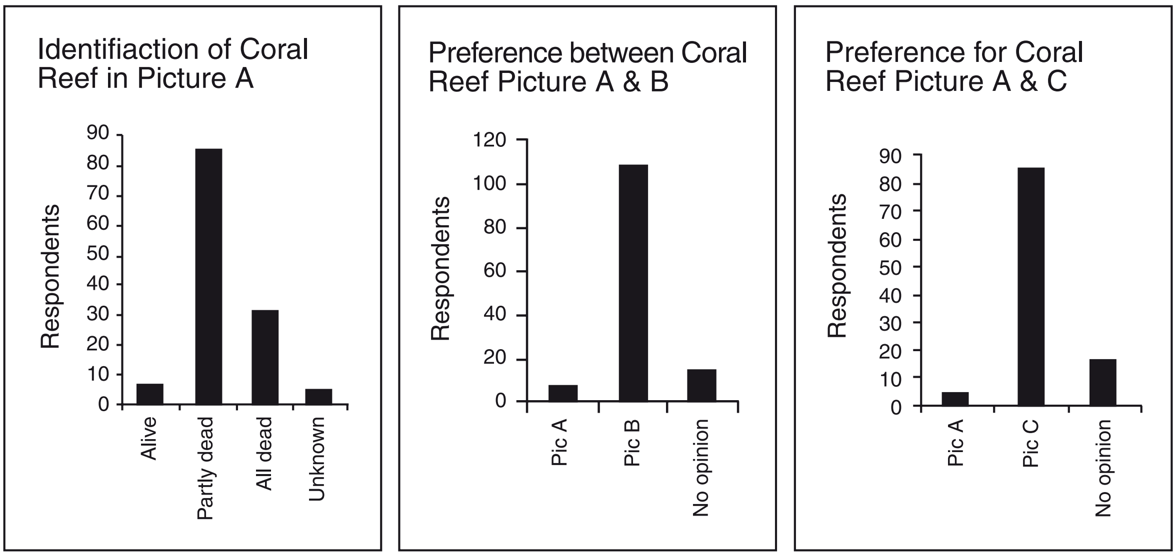
The questionnaire elicited preferences for coral reefs provided in the three pictures, A, B and C, discussed above. The responses formed the basis for follow-up questions that indicated the extra amount one is willing to pay per holiday in Zanzibar to experience better reefs. The responses are indicated in Figure 3. The majority of respondents chose reef B. Those who opted for reef C were the ones who stated a willingness to pay.

Several independent variables were considered in the models that were used to run a multiple regression using ordinary least square (OLS). Tables 2 and 3 report the results for the demand

Table 2. Tourist recreational demand for coral reefs in Zanzibar

Multiple R			0.566132
R^2			0.320505
Adjusted R			0.246647
Standard error			4.185690
	DF	F	Insignificance F
Regression	5	4.339468	0.002562
Residual	28		
Coefficients			P- value at 95 per cent
Intercept	-10.988		0.036304
DUSTAY	0.385947		0.031248
EXPER	2.519083		0.066745
ZAREEF	2.009103		0.156704
ANUINCO	1.16546		0.058566

Figure 3. Tourists' identification for coral reef A and contrast of preferences between reefs B and C



function and the inverse demand model for coral reefs, respectively. While the former relates to the neo-classical economics relationship between demand as a function of price and income *ceteris paribus*, the latter relates to the price as a function of quantity demanded and other exogenous variables. For the purpose of this study, the number of dives is considered as a proxy for recreational demand, whereas WTP is a proxy for the value accruing to divers who enjoy coral reefs.

Multiple regressions at the 95 per cent level for the number of dives showed a multiple R-value of 0.56 and a corresponding F-value of 4.3, indicating that the overall regression equation is significant. The explanatory power indicated by R^2 is less than 50 per cent, but this does not account for a multicollinearity problem in the model, because of reported P-values and F-value. Hence, the regression gives DUSTAY, EXPE, and ANUINCO as significant variables to be considered in recreational demand for coral reefs. In contrast, ZAREEF (condition of the Zanzibar reefs) did not have a significant influence on the number of dives. The estimated regression results with beta coefficients are given below.

The multiple regression based on the data in Table 2 is:

NUDIVE = -10.77 + 0.41DUSTAY + 2.5EXPER + 2.0ZAREEF + 1.2ANUINCO
The multiple regression for the WTP is:

WTP = -380.263 + 101.987SEX + 56.295EXPE – 1.147NUDIVE + 33.266PREFC
– 12.260ZAREEF + 42.981ANUINCO

The multiple regression of the WTP equation generally gives significant results as expressed by the multiple R, R^2 and F-value (see Table 3). From the results, the WTP is well explained by the parameters, although "number of dives" and "condition of Zanzibar reefs" as well as PREFC are insignificant. Otherwise, the beta coefficients for SEX, EXPE, PREFC and ANUINCO are significant and indicate a direct relationship with WTP. The results obtained from the regressions above reflect the fact that several attempts were made to run regressions for different model specifications and to eliminate socioeconomic variables such as age and education. These were found to be highly insignificant considering the R^2, F-value and P-values that signal the presence of multi-collinearity in the model (Maddala 1997).

Table 3. Tourist WTP for coral reef recreation in Zanzibar

Multiple R	0.785529		
R^2	0.617056		
Adjusted R	0.540468		
	DF	F	Insignificant F
Regression	6	8.056752	3.12E-05
Residual	30		
	Coefficients	P-Value at 95 per cent	
Intercept	- 380.263	0.004868	
SEX	101.987	0.000144	
EXPE	56.295	0.044487	
NUDIVE	-1.147	0.683182	
PREFC	33.266	0.326581	
ZAREEF	-12.260	0.548258	
ANUINCO	42.981	0.000002	

The average WTP is US$84.70 per year. This amount is surprisingly similar to the US$87 identified by tourists to the Maldives for a visit to hypothetical, intact coral reefs shown in a picture (Cesar 2000). In this Zanzibar study, the individual WTP amounts ranged from US$5 to US$500 a year. To put this into perspective, the maximum amount charged was US$120 for four dives (PADI Zanzibar Dive Center price list, 2001). The WTP distribution by country is shown in Figure 4. South Africans, despite their small number in the sample, stated the highest WTP. Italians, on the other hand, who comprised the majority in the tourist arrival statistics (Figure 2), offered a lower WTP, and tourists from Singapore stated the lowest amount of WTP.

Important reef characteristics for scuba divers

Divers' demand for coral reef depends on the individual utility function, and demand determinants vary from one person to another. However, according to previous studies, some determinants or characteristics are quite common amongst divers. In this study, the most important characteristics were found to be, in descending order of importance, the overall condition of the reef, variety of fish, wilderness feeling, and visibility. Davis and Tisdell (1995) give similar reasons, albeit in a different order of importance, in which a desire for wilderness feeling is mentioned as the most important reason. Tabata (1992) describes the most important criterion for selection of destination by divers as being the quality of the dive site. Quality is defined as clear water, healthy reefs with natural and geological formations, and abundant fish life. Andersson (1998) found high fish diversity to be the pinnacle of a dive, while coral diversity and reef condition were of secondary importance.

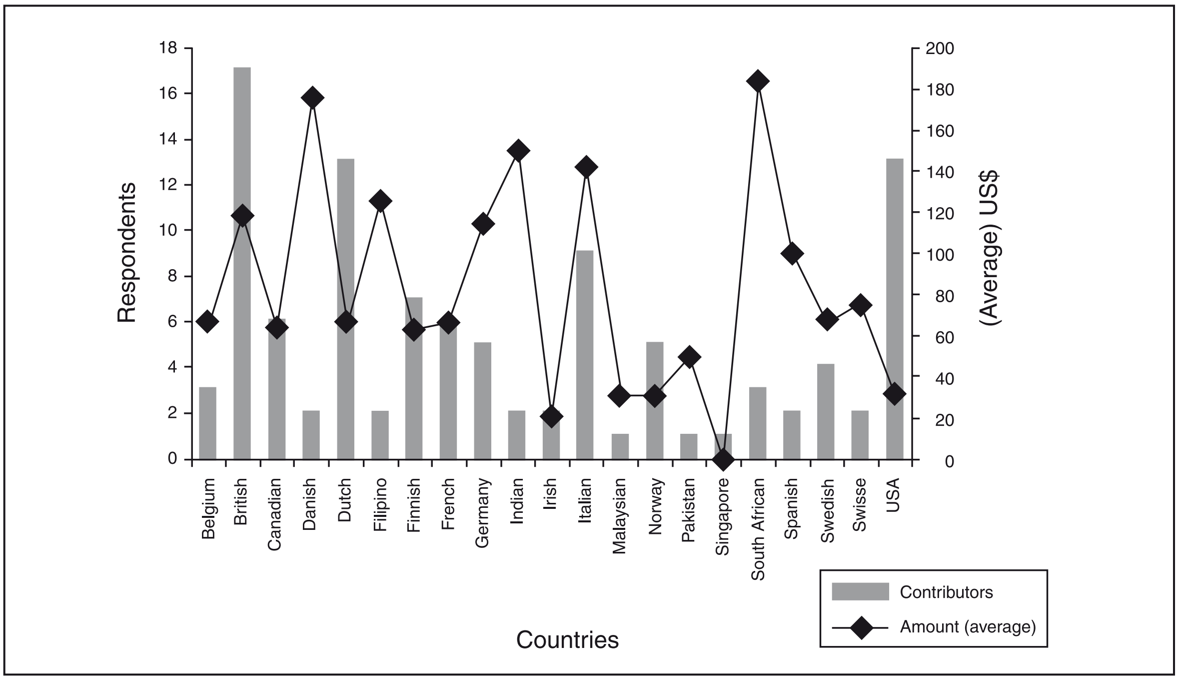


Figure 4. Average WTP by individual countries

Economic values

Around 72 per cent of the tourists surveyed dived in Zanzibar. This is very high when compared with estimates by Westmacott et al. (2000a, 2000c) on the percentage of tourists diving in Zanzibar. They assumed that 25 per cent of visitors to Zanzibar dive. Given the large difference between our sample statistic and the Westmacott et al. assumption, we use here three scenarios with the following percentages of tourists diving: 25 per cent, 50 per cent and 75 per cent. For each, the economic loss and financial revenues are estimated. The economic loss of bleaching is calculated by multiplying the number of divers by the estimated WTP to visit more pristine reefs (US$84.70). The financial revenues of diving are similarly calculated by the number of divers multiplied by the US$120 dive package mentioned above. In 2001, 76 329 tourists visited Zanzibar (Zanzibar Commission for Tourism, Tourist Arrival Statistics). The total economic loss and financial revenues calculated are given in Table 4.

As shown in Table 4, there are economic losses of value as a result of coral bleaching ranging from US$1.6 to US$4.8 million depending on the number of tourists who dive (25 per cent versus 75 per cent). The financial revenue from dive tourism ranges from US$2.5 million to US$7.4 million, depending on the number of divers.

Table 4. Economic losses due to bleaching, and financial revenues from dive tourism

Scenarios	Economic losses of bleaching	Financial revenue from diving
25% of visitors dive	US$ 1.6 million	US$ 2.5 million
50% of visitors dive	US$ 3.2 million	US$ 4.9 million
75% of visitors dive	US$ 4.8 million	US$ 7.4 million

Discussion of the results

According to dive operators (personal communication) in Zanzibar, the number of divers has recently declined by 50 per cent as a result of poor visibility in some coral reef areas, specifically adjacent to Zanzibar town, where there is sewage disposal in the sea. This number does not appear to sit well with the survey finding that 74.8 per cent of the divers enjoyed the coral reefs a lot, 15.6 per cent did not notice anything special compared with other places, and only 9.6 per cent were shocked by the poor condition of the coral reefs. This apparent discrepancy might be explained by the majority of the surveyed divers having dived only on the coral reefs off Zanzibar town. This could be the case, as the respondents were not asked to specify their comparative diving sites.[5] It could also be explained by the fact that a large proportion of the divers surveyed were inexperienced (fewer than 10 dives) and so had little knowledge on which to base comparisons. From a management perspective, appropriate

[5] See also Johnstone et al. 1998.

information on the current condition of the coral reef and the threats to it should be apparent to all divers of all categories of experience. Similarly, despite the knowledge of coral bleaching of some of the surveyed tourists, education about the phenomenon by way of different media is deemed crucial in motivating coral reef protection and management.

Generally, the results showed that the variables "number of divers", "tourist's annual income", and "diving experience" are significant in the estimation of the demand functions. These variables are important for decision-makers in order to target marketing and tourism services and infrastructure to the type of tourists that Zanzibar receives or plans to receive. However, the quality of the reef was found to be insignificant in both the demand and WTP function.

The results of this study might have been affected by data inadequacies and by inconsistencies in answering the questions due to language barriers (for non-English speaking tourists). Any future study would have to improve the quality of data in terms of sample size, questionnaire translation and administration of the questionnaire. The stated WTP in this study exceeds what divers are currently paying for diving in Zanzibar. At the same time, the condition of Zanzibar's reefs is still regarded by most of the interviewed tourists as enjoyable, despite coral bleaching that might effect specific areas in Zanzibar. This apparent satisfaction is a challenge for coastal zone managers who want to take appropriate measures to prevent deterioration of the reef condition through control of untreated sewage, and mitigation of other threats.

References

Andersson, J. 1998. The value of coral reef for the current and potential tourism industry in Unguja Island, Zanzibar. *In* R. Johnstone, J. Francis and C.A. Muhando (eds). Coral reefs: Values, threats, and solutions. Proceedings of the National Conference on Coral Reefs, Zanzibar, Tanzania, Sida, UDSM, UNEP. December 1997.

Cesar, H.J.S. (ed.) 2000. Collected essays on the socioeconomics of coral reefs. CORDIO. Kalmar, Sweden, 244 p.

Davis, D. and C. Tisdell. 1995. Recreational scuba diving and carrying capacity in marine protected areas. Ocean and Coastal Management 26(1):19-40.

Dixon, J.A. and P.B. Sherman. 1990. Economics of protected areas: A new look at benefits and costs. Island Press, Washington, D.C.

Francis, J., S. Mahongo and A. Semesi. 2001. The coastal environment in Eastern Africa. Atlas for coastal resources Tanzania. United Nations Environment Programme. Nairobi, Kenya, 111 p.

Jiddawi, N.S. 1997. Fisheries resources: Their importance to the livelihood security of the people of Zanzibar. Proceedings of the Economic Valuation Workshop held at the Reef Hotel, Zanzibar. (Unpublished)

Jiddawi N.S. and Z. Ngazy. 2000. A gift from the Ocean: the importance of Eucheuma Farming to the Livelihood Security of the People of Zanzibar. *In* E. Mshigeni, J. Asman and Bisanda (eds). Opportunities for Africa bio-resources. Proceedings of the 2nd International Training Workshop for Zero emission - UNDP University of Namibia:132-146.

Johnstone, R., C.A. Muhando and J. Francis. 1998. The status of the coral reefs of Zanzibar: One example of a regional predicament. AMBIO 27(8):700-707.

Maddala, G.S. 1977. Econometrics. Mc Graw-Hill Inc., New York.

Tabata, R.S. 1992. Scuba diving holidays. *In* B. Weiler and C. M. Hall (eds). Special interest tourism. Belhaven Press, New York.

Westmacott, S., H. Cesar and C. Pet-Soede (eds.) 2000a. Socioeconomic assessment of the impact of the 1998 coral reef bleaching in the Indian Ocean. Resource Analysis and Institute for Environmental Science (IVM). Report to the World Bank, African Environmental Division for the CORDIO Programme.

Westmacott, S., K. Teleki, S. Wells and J. West. 2000b. Management of bleached and severely damaged coral reefs. AMBIO 27(8).

Westmacott, S., H. Cesar, C. Pet-Soede and O. Linden. 2000c. Coral bleaching in the Indian Ocean: Socioeconomic assessment of effects. *In* H.S.J. Cesar (ed.). Collected essays on the economics of coral reefs. CORDIO, Kalmar University, Sweden.

Valuing the Recreational and Conservation Benefits of Coral Reefs in Bolinao, Philippines[1]

Mahfuzuddin Ahmed[2], Gloria Magnayon Umali[3],
Chiew Kieok Chong[4], Mary Franz Rull[5], and Marissa C. Garcia[6]

Abstract

The recreational and conservation value of coral reefs along the Lingayen Gulf, Bolinao, in the Philippines is evaluated using travel cost and contingent valuation methods. Empirical results show a consumer surplus of PhP10 463 (US$223) per visitor per annum, or a potential net annual return to the local economy of PhP220.2 million (US$4.7 million) from the estimated 21 042 visitors to Bolinao in 2000. However, low willingness-to-pay (WTP) values for the conservation of coral reefs at Bolinao were elicited (in absolute terms and as a percentage of income), particularly among domestic tourists. This implies that the preservation of natural resources and the environment may not be an immediate priority among local travelers. This may be due to the socioeconomic conditions in developing countries such as the Philippines, and the public good nature of the recreational services provided by coral reefs.

Introduction

Coral reefs are among the most vital, diverse, and productive marine ecosystems, providing goods and services and performing numerous coastal protection functions (Lal 2003; Yeo 2003). In the Philippines, coral reefs are primarily valued because the fish harvested from them provide food security; reef fish contribute about 10 per cent of the protein intake of Filipinos, 8-20 per cent of the total fish harvest in the country as a whole, and as much as 70 per cent of total fish catch in numerous small islands across the country (DENR 1998; Licuanan and Gomez 2000; Mamiit 2000). Local communities in coastal areas, particularly those with lower incomes, depend on coral reefs as an important source of employment, income, and tourism revenues (BFAR 1997; Cesar 2000b; Mamiit 2000; White et al. 2000). In addition, coral reefs act as natural wave breakers, protecting villages located near shorelines from erosion and the impact of strong waves. Moreover, coral reefs provide shelter to numerous and diverse marine organisms, research and educational opportunities, and aesthetic services that benefit millions worldwide (White and Savina 1987; Gomez et al. 1994; Courtney et al. 1999; Cesar 2000b; Mamiit 2000; Mathieu et al. 2000; White et al. 2000; Lal 2003; Yeo 2003).

However, despite this wide range of benefits, coral reefs are among the most threatened marine resources in the Philippines. Surveys conducted during the past two decades have shown that more than 75 per cent of the estimated 27 000 km^2 of coral reefs in the country have been degraded due to human activity, and only 24.8 per cent are in good to excellent condition, with coral cover between 50 and 100 per cent[7] (Yap and Gomez 1985; Chou et al. 1994; Gomez 1991; Gomez et al. 1994; White et al. 2000). Deterioration in the physical conditions of these resources has resulted in huge losses in fisheries, tourism, and coastal protection values. In 1996 these losses were conservatively estimated at US$1.35 billion annually, with local fishing villages and

---

[1] WorldFish Center Contribution No. 1757
[2] WorldFish Center, Batu Maung, 11960 Penang, Malaysia
[3] Former Assistant Scientist, WorldFish Center, Penang, Malaysia
[4] Former Research Associate WorldFish Center, Penang, Malaysia
[5] Former Research Assistant, WorldFish Center, Philippines
[6] De La Salle University-Manila, Philippines
[7] The remaining coral reefs are classified as follows: 23.5 per cent in poor condition, with 0-24 per cent coral cover, and 51.7 per cent in fair condition, with between 25 and 50 per cent coral cover (Gomez et al. 1994).

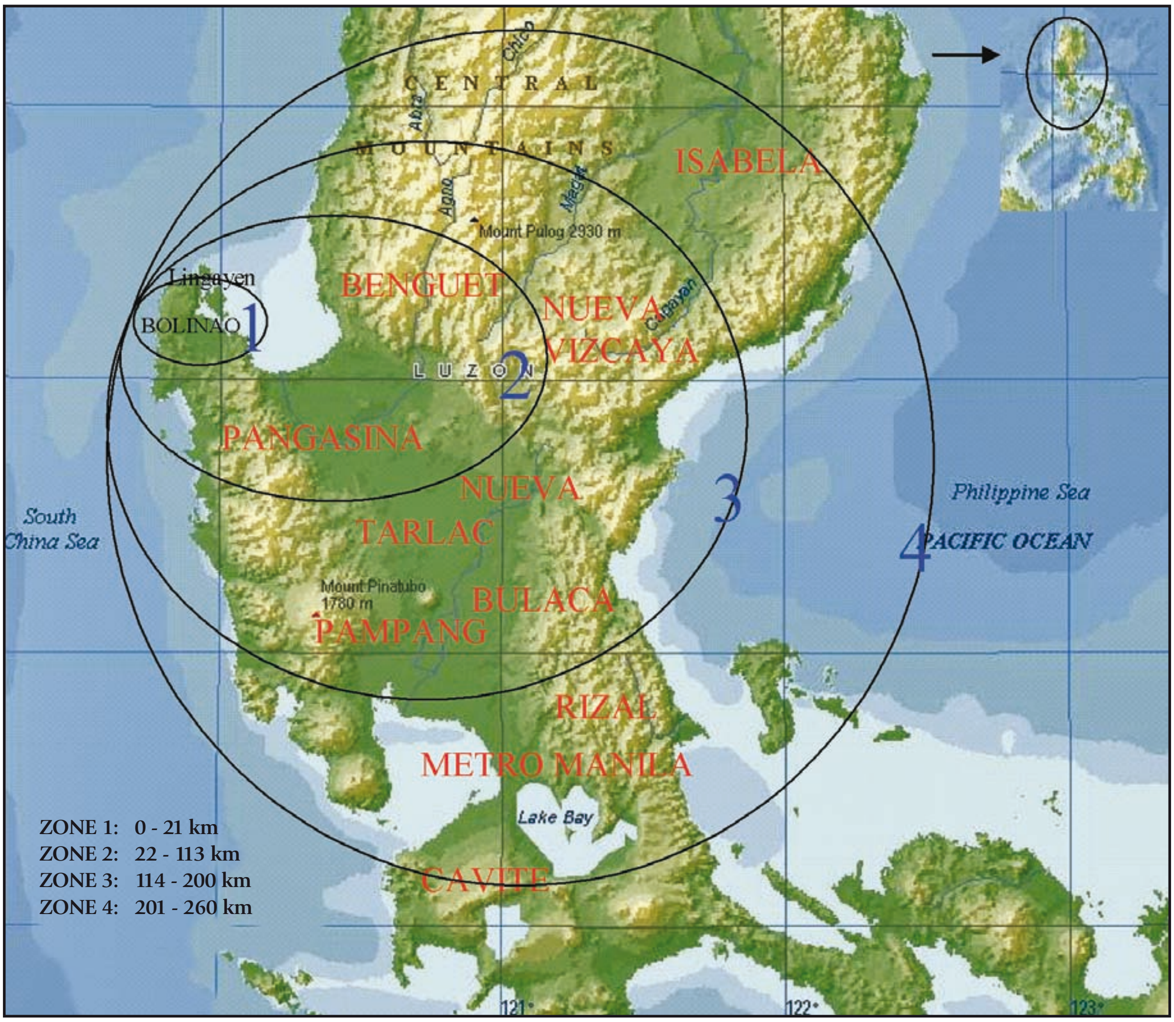


Figure 1. Travel zones around the Bolinao coral reef area

tourism establishments hit the hardest (White and Trinidad 1998; White et al. 2000).

A case in point is the Bolinao coral reefs in Pangasinan (Figure 1), which directly support approximately 50 000 fisherfolk and an additional 20 000 people engaged in fishery-related occupations (such as selling fish and making shell crafts) whose family members depend on their earnings for survival (Bryant et al. 1998). Over the past decade, the combined effects of overexploitation resulting from the continued expansion of fishing effort, open access fisheries, and the absence of any significant policy instruments and of management intervention that protect coral reefs from irreversible damage, has seriously threatened their existence.

Although the Philippine Constitution of 1987 states that fisheries and other natural resources are owned by the State, and provides for protection by the State, open access generally prevails; this is due to the generally "non-competitive, non-excludable, and non-divisible" nature of marine resources (Alcala and Vande Vussee 1994; Lal 2003). In the case of coral reefs, for example, the absence of clearly defined property rights means that there is no effective mechanism by which to exclude newcomers or control fishing effort. Thus, resource users treat coral reefs as public goods and have every incentive to use the resource as much as possible before others do. Short-lived resource rents accrue to various resource users, encouraging entry into the industry and increased level of effort; this eventually leads to the dissipation of resource rents and environmental degradation (Lal 2003).

In addition to market failure, the problems of coral reefs stem, in part, from the unclear delineation of management responsibility for marine and coastal resources in the country; responsibility has moved back and forth between the local authorities and the central government (La Viña 1999). During the pre-colonial period, for example, barangays[8] had control over coastal resources, but, during the Spanish regime, authority was transferred to the central government, with policy formulation and implementation coming from the top (Kalagayan 1990). Some jurisdictional authority was granted to local municipalities during the American period, but policy formulation and general management remained under central control. It was only with the enactment of the *Republic Act 1991* (RA 7160)[9] that primary control over marine and coastal resources was formally returned to local government units.

Several earlier studies on Bolinao warned about the pressures from current use patterns, and recommended a number of mitigation measures to avoid irreversible damage to the coral reefs. For example, McManus et al. (1992) recommended, among other things, a 60 per cent reduction in fishing effort in order to attain optimal sustainable yield, elimination of illegal fishing methods, such as blast and cyanide fishing, establishment of marine reserves, and formulation of a tourism regulatory committee to monitor the level of use. However, to date, very few measures have been taken to manage coral reefs effectively.

The case of coral reefs in the country is a classic example of market and government failure. Economic valuation can help address these issues by providing much-needed information on the benefits of coral reefs, the social costs of their degradation and/or loss, and the true costs of extractive activities and other uses. By putting actual figures to the fore, valuation can help stakeholders and decision-makers make informed choices between various options, and promote sustainable resource use and management (Mathieu et al. 2000; Spurgeon 2001; Lal 2003; Yeo 2003; Burke and Maidens 2004; Roxburgh and Spurgeon 2005).

This paper aims to estimate both the recreational net benefits provided by the coral reefs in Bolinao, and the conservation values attached to them by visitors. A description of the study area is presented in section 2. An overview of the research methods, including model specification and data information, is provided in section 3. Survey results for both the travel cost and contingent valuation methods are discussed in section 4. The implications for improved management of the coral reef area are presented in the final section.

The study area

Located on the northwestern tip of Luzon Island, the municipality of Bolinao covers an area of about 23 320 ha, of which 8 000 ha are coral reefs (mostly fringing coral reefs) located around the northern side of the Santiago and Dewey islands and off the northern mainland from barangay Patar to Arnedo (Willmann 1994). Almost half of the land area (10 991 ha) is dedicated to agriculture.

The main sources of income in Bolinao are farming, fishing and small-scale and cottage industries (e.g., salt, dried fish and fish paste production, shell craft, etc.). Fisheries account for 31 per cent of total employment in a municipality with a population of 53 127 (National Statistics Office 1995; McManus et al. 1992). Coral reefs mainly provide food, both for home consumption and trade. Other extractive and marketed uses of the resource, and the main beneficiaries are summarized in Table 1.

Recreational activities related to the Bolinao coral reefs include swimming, sailing, snorkeling and scuba diving. Because the tourism industry is currently in its gestation stage, commercial establishments related to aquatic recreation (e.g., dive shops) are, with the exception of tourist accommodation facilities, non-existent. However, local businessmen believe that, in the future, dive shops and other tourist-related services are likely to prosper. Thus, Bolinao, in view of its tourism potential and its established reputation as an important fisheries location and base for scientific and other types of research, presents an ideal site on which to base an economic valuation.

[8] Refers to a community of around 50 to 100 families.
[9] Otherwise known as the Local Government Code of 1991.

Table 1. Uses of the Bolinao coral reef resources

Reef resource	Use/Purpose	Beneficiary
Seaweeds	Food: Salad vegetables, flavoring, garnish	Local consumers
	Source of industrial products: additive in food industry, raw materials for agar production	Local industries; export to the United States
	Source of livelihood	Local coastal communities
	Liquid fertilizer and soil conditioners	Export market
Invertebrates	Food: 26 per cent of the total landed catch consumed by families in the coastal areas	Domestic and local consumers
Sea urchin		Export market
Sea cucumber		
Lobsters		
Mollusks		Shell craft industry
Shells		
Fin fishes	Food	
Grouper		Aquarium trade
Surgeon fish		

Sources: McManus et al. 1992; Juinio-Meñez et al. 1994; Trono, Jr 1999

Research methods

This study used both the travel cost method (TCM) and the contingent valuation method (CVM) to estimate the benefits arising from the Bolinao coral reefs. TCM and CVM are the most widely used economic valuation methods for measuring the recreation or tourism values of coral reefs (Seenprachawong 2003). TCM was used to derive the demand of and consumer surplus accruing to local and foreign tourists for recreational visits to the Bolinao coral reefs. Although entrance or user fees may not be charged, the value that visitors attach to their recreational experience in Bolinao can be approximated by the cost of travel or travel time (Clawson 1959; Clawson and Knetsch 1966; Cesar 2000a; Cesar and Chong 2003). The underlying principle behind TCM is the direct relationship between distance and number of trips made to the recreational site, i.e., the number of visits to a recreational site increases with proximity to it. This is illustrated in Figure 1, which shows Bolinao and the travel zones around it. Implicit in this figure is that travel costs increase with distance traveled, and that fewer trips to the recreational area are taken as travel costs increase. In as much as travel cost represents a payment (price) for acquiring a visit (commodity) to a site, it can be used as a proxy for market price; quantity is represented by the number of visits to the site. By plotting the information on travel cost against the number of trips taken, a pseudo-market trip demand curve (TDC) that measures the economic value of the recreation site can be traced (Figure 2). Variants of the original travel cost technique described above have been developed to model the various complexities of recreational behavior.[10]

The TCM has also been used to estimate the consumer surplus associated with various types of recreational sites, such as marine, national, and agricultural parks. Consumer surplus is the marginal benefit derived from a recreational experience. It is the difference between the utility value of visiting a recreational site – or the maximum amount that visitors are willing to pay for the enjoyment of the place – and what they actually pay.

Several studies have used TCM to measure the demand for and/or consumer surplus attached to coral reefs. The common denominator in all these studies is the large potential net benefits from coral reefs or the huge impending losses from their degradation. For example, using TCM, Mattson and DeFoor (1985) derived recreational values from diving, sightseeing, and snorkeling at the John Pennekamp Coral Reef State Park and the adjoining Key Largo National Marine Sanctuary amounting to

[10] See Fletcher et al. (1990) and Bockstael et al. (1991) for details.

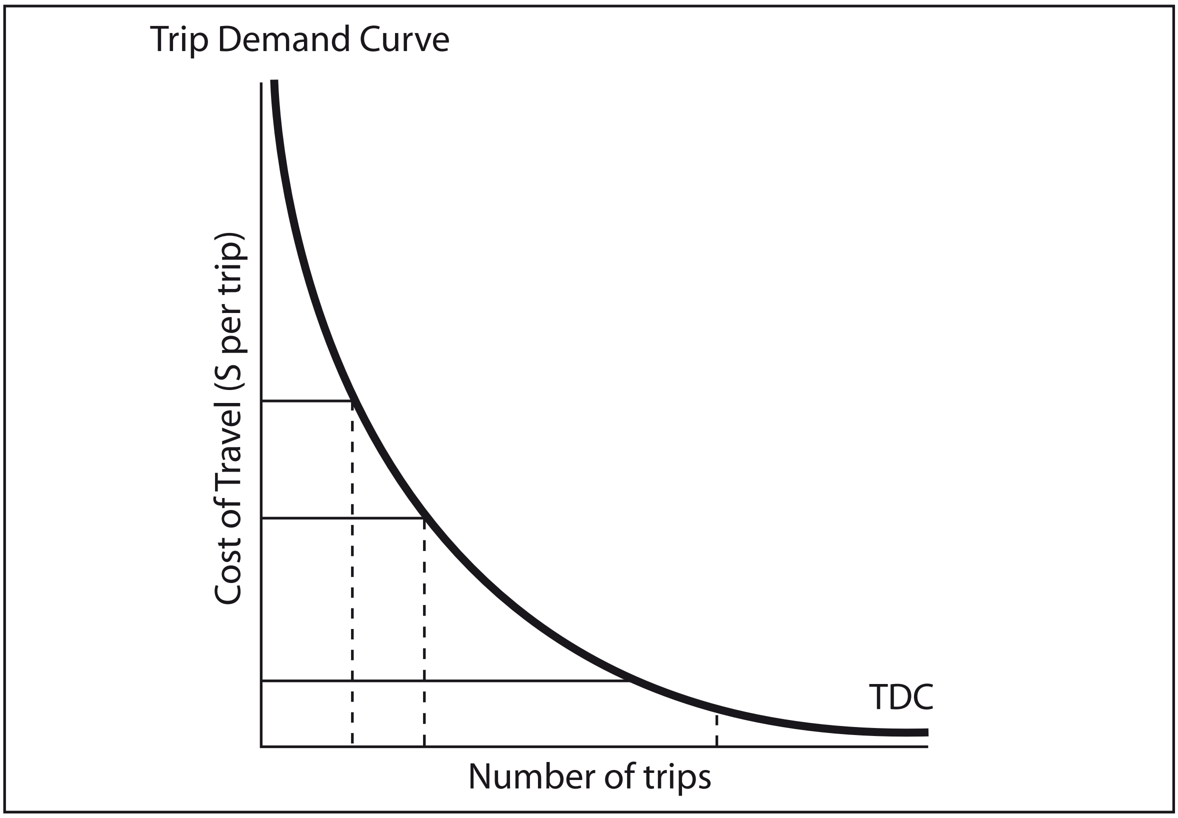


Figure 2. A pseudo-market trip demand curve to measure the economic value of the recreation site

US$47.6 million for 1984-85. A similar study by Hundloe (1990) using TCM on the Great Barrier Reef Region in Australia elicited net values of AU$106 per year over and above travel expenditures for both local and foreign tourists. The study also investigated consumer surplus related to the preservation of the coral reefs in their current condition and reported willingness-to-pay (WTP) values from a contingent valuation survey of AU$6 million per year. Pendleton et al. (1995) evaluated diving experience at the Bonaire Marine Park and reported consumer surplus valued at US$19.2 million per year, or net present value amounting to US$179.7 million based on a 20-year time period and a discount rate of 10 per cent. Carr and Mendelsohn (2003) extended earlier studies on the Great Barrier Reef by using two alternative recreation demand functions (i.e., log-linear and polynomial) and actual travel cost for international travel to measure recreational reef value. Regression results showed that the polynomial model provided a better fit and had more significant coefficients compared with the log-linear functional form. Given an estimated 2 million annual visitors, total recreational value of the reef is estimated as between US$700 million and US$1.6 billion per year.

It has only been in recent years that valuation studies on coral reefs in developing countries have caught up. Studies conducted thus far have been based predominantly in Southeast Asia, where the reefs are considered to be the richest but the most severely threatened among the reef ecosystems worldwide (Bryant et al. 1998). Based on both TCM and CVM, coral reef tourism benefits were estimated by Seenprachawong (2003) for the Phi Phi Islands, Thailand. Travel cost survey data estimated a consumer surplus from recreational activities, such as diving, snorkeling, and fishing, of US$1.75 million per year for domestic visitors and US$203.66 million per year for international visitors. Assuming that the total revenue stream from recreational values remains constant at US$205.41, and using a real interest rate of 5 per cent, the net present value of recreational benefits from coral reefs at the Phi Phi Islands is US$3.16 billion. At the same time, coral reef preservation benefits, estimated using the contingent valuation method (CVM), showed WTP responses from tourists valued at US$496 million per year. In Vietnam, Pham and Tran (2003) estimated the recreational value of the coral-surrounded Hon Mun Islands using TCM. Annual recreational values using individual TCM accounted for less than half (US$8.7 million) of the zonal TCM estimate of US$17.9 million.

As the results of the TCM study of Bolinao include all of the attributes attached to a recreational experience in Bolinao, CVM is employed in order to account for the benefits accruing exclusively to coral reefs. This approach is similar to that of Hundloe et al. (1987) and Seenprachawong (2003). In particular, visitors were asked about their WTP to prevent further degradation of the Bolinao coral reefs. Consistent with utility maximization theory, a visitor expresses his/her WTP based on the benefit he/she expects to receive for keeping the reefs in their current state (Hannemann 1984). Following a dichotomous choice survey format, if a 'yes' response is elicited for an initial amount P_1, a second question is then asked to find out if the respondent would be willing to pay a higher amount, P_2. If the response to P_2 is 'no', then P_2 is greater than the individual's maximum WTP. The maximum amount quoted by each respondent is assumed to be the value that the individual attaches to coral reef preservation. However, unlike the TCM, where only the non-extractive recreational use value of coral reefs is included, the CVM estimates both use and non-use values of coral reefs (Seenprachawong 2003).

Theoretical framework

Until the 1970s, TCM relied on the correlation between travel costs and market prices. In the 70s more general models of individual behavior, such as the household production function, established a link between travel cost and individual utility-maximizing behavior (Becker 1965; Becker and Lewis 1973; Deyak and Smith 1978). According to this approach, the household can be viewed as a producer who purchases market inputs, supplies labor, and produces commodities, which it then consumes and from which it derives utility, either directly from the purchase of a particular good or from a combination of purchased goods and time. This utility decision framework can be represented as follows:

$$\begin{aligned} &\text{Maximize } U(\mathbf{Z}) \\ &\text{Subject to:} \\ &\mathbf{Z} = f(\mathbf{X}, \mathbf{t}_z) \\ &\mathbf{Y}(\mathbf{t}_w, \mathbf{w}) + \mathbf{R} - \mathbf{XP} = 0 \\ &\mathbf{T} - \mathbf{t}_z - \mathbf{t}_w = 0 \end{aligned} \qquad (1)$$

where **Z** is a vector of n products produced by the household for its own consumption, **X** is a vector of market goods used in the production of **Z**, **P** is a vector of market prices for **X**, such that X_j is purchased in the market for price P_j, **Y** is wage income, **w** is wage rate, **R** is rental or non-wage income, **T** is total time endowment, $\mathbf{t}_z$ is total time spent producing household products, and $\mathbf{t}_w$ is time spent working.

If Z_1 is one of the Z_is representing recreation for household consumption, and if Z_1 requires time, transportation, lodging, equipment, etc. as inputs, then the equations designated as (1) constitutes a mathematical formulation of a theoretical recreation model. This implies that, using the framework of the household production function to model the economic benefits of recreation, travel cost is no longer treated as a proxy for market price but becomes a principal input into and determinant of recreation. Following the notation above, Z_1 can be defined as:

$$Z_1 = f(X_1, X_2, X_3, \ldots, X_n, t_1) \qquad (2)$$

where Z_1 = recreation, X_1 = transportation, X_2 = lodging, X_3 = equipment, X_n = all other inputs, and t_1 = time spent on recreation.

Demand for individual trips

Individual trips, or first stage demand (V/Pop), are expressed in terms of the number of visits to the Bolinao coral reefs from a given point of origin, and modeled as a function of travel costs (TC) and a vector of demographic variables (**X**):

$$V/Pop = f(TC, \mathbf{X}) \quad (3)$$

where V is the number of visits to Bolinao, and Pop is the population at the point of origin. One advantage of the per capita specification of the zonal TCM is that it automatically accounts for the reduced visitation rate related to higher travel costs (Brown et al. 1983).

Predicted visitation rates are obtained by simulating different levels of travel cost as an indicator of user fees, and then generating the expected visitation rate by feeding the simulated user fees into the trip demand equation. For each of the i origins (i = 1,…, k), the predicted visitation rate (VR^*_{ij}) at entry fee level j (j = 1,…, l) is calculated as follows:

$$VR^*_{ij} = (V_i/Pop_i)^*_j \quad (4)$$

The expected number of visits (EV_{ij}) from origin i at entry fee level j is then estimated by multiplying the predicted visitation rate by the population of origin i as shown by:

$$EV_{ij} = VR^*_{ij} * Pop_i \quad (5)$$

The total number of visits to the site at entry fee level j (TV_j) is obtained by summing the expected number of visits (EV_{ij}) across all i origins as specified by:

$$TV_j = \sum_{i=1}^{k} EV_{ij} \quad (6)$$

Aggregate demand for trips

An aggregate or second stage demand equation (TV_j) is estimated by regressing the expected number of visits on the different price levels (P_j):

$$TV_l = f(P_j) \quad (7)$$

The Marshallian (uncompensated) consumer surplus (CS_j)[11] is computed by estimating the area under the aggregate demand curve (TV_l) between P_0 and the maximum price P_C (otherwise known as the choke price), where demand falls to zero.

$$CS_j = \int_{P_0}^{P_C} f(P_j)\, dp \quad (8)$$

Tobit model

A Tobit model is developed to handle censored dependent variables, such as WTP. The maximum likelihood estimation for the Tobit model is used in lieu of ordinary least squares (OLS), which does not distinguish between qualitative differences censored and uncensored (Tobin 1958; Greene 1998; Madalla 2001). The Tobit model is defined as:

$$y = \begin{cases} b_0 + \Sigma b_i X_i + \varepsilon & \text{if } \beta_0 + \Sigma \beta_i X_i + \varepsilon > 0 \\ 0 & \text{if } \beta_0 + \Sigma \beta_i X_i + \varepsilon \leq 0 \end{cases} \quad (9)$$

where y is a vector that contains the observed values of the dependent variable, β is the vector of coefficients to be estimated, X_i is the $kx1$ vector of observed values of each independent variable, and ε is the error term (Tobin 1958; Madalla 2001).

In general, y is assumed to be distributed logistically, such that the closer the value of a bid price P is to zero, the higher is the probability of a 'yes' response. The probability distribution of a 'yes' response traces a cumulative density function (CDF). The area under the estimated CDF gives the expected value of the mean WTP necessary to preserve the quality of the Bolinao coral reefs. The mean WTP can then be aggregated over the number of visitors per year to estimate the potential amount of coral reef protection funds.

Empirical model

Demand for individual trips

Trip demand is modeled as a function of travel cost, education, age, and income. The log-log functional form is used, based on its statistical significance, low variance, and economic plausibility of the estimated coefficients. Refinements to the model were made to enhance model specification. Variables with grossly insignificant t-values, such as education and age, were dropped from the final trip demand specification. The resulting equation is given by:

$$V_i/Pop_i = \exp(\alpha)\, TC_i^{\beta}\, Y_i^{\gamma} \quad (10)$$

where Y_i is average income of visitors from origin i. This trip demand curve can be used to predict, for example, the responsiveness of visitation rates

[11] Carr and Mendelsohn (2003) point out that there is only a small difference between the consumer surplus estimates derived from the Marshallian (uncompensated) and Hicksian (compensated) demand curves.

to changes in entry fees or population densities at the origin. The TCM assumes that hypothetically increasing travel costs simulates visitors' WTP for recreation at different entry fee levels.

Willingness-to-pay

Using a Tobit model, the responsiveness of WTP for coral reef preservation is tested against demographic variables, such as age (AGE), educational attainment (DED), employment status (DEMP), monthly income (INC), number of visits to Bolinao (NVIS), rating of coral reef conditions in Bolinao (RATE), number of days spent for recreation (RDAY), travel cost (COST), and attitude towards the imposition of user fees (DFEE). Categorical data are specified as dummy variables. These include DED for those who have completed college or higher education, DEMP for respondents who are currently employed, and DFEE for respondents who think that it is unfair to charge user fees to support reef management and preservation.

Data

A two-part survey was pre-tested and carried out by the WorldFish Center at various resorts in Patar, Bolinao, Pangasinan, during the months of March to May 2000.[12] A total of 92 respondents participated in the on-site survey. The first part of the survey included questions on the individual's demographic profile, reasons for visiting the site, and demand for recreation. Participants were asked about the purpose of the trip, number of persons included in the trip, length of stay, number of visits made to the recreation site, point of origin, and expenditures incurred during the trip. The travel cost survey, along with supplementary data obtained from various sources, provided the information to estimate demand for recreation.

To standardize information on the different variables used in the study, distance was measured as the straightline distance (in kilometers) between the point of origin and Bolinao. On the other hand, travel cost was computed as roundtrip distance between the point of origin and Bolinao, multiplied by a constant per kilometer cost based on 1999 vehicle operating costs information from a report by the National Center for Transportation Studies (2000). Annual per capita income was estimated from wages and salaries statistics obtained from the Bureau of Labor and Employment Statistics (1998) for the occupation categories indicated by the respondents.

The second part of the questionnaire was designed to examine closely visitors' awareness of coral reefs and their WTP for their protection and sustainable use in Bolinao. Respondents were provided with background information on the importance of coral reefs and their conditions based on the percentage of coral cover (e.g., excellent, good, fair, and poor). They were then shown pictures of the Bolinao coral reefs and were asked to choose the condition that best applies to Bolinao. Respondents were than provided with summary information on the importance of resource management in promoting environmental improvements or preventing degradation of coral reefs, and their financing options, such as user fees; after this, responses to WTP questions were elicited following a dichotomous choice format. To complete the contingent valuation survey, a question was posed as to the relevant payment mechanism for carrying out a hypothetical resource conservation program.

Results and discussion

Sample characteristics

The socioeconomic characteristics of respondents are shown in Table 2. The majority of the respondents were in their mid-twenties to mid-thirties, college graduates and professionals. People in this age category with this level of education and professional background are likely to be aware of environmental issues. However, survey results, as reflected in their WTP values and discussions with respondents, reveal that environmental concerns were low in their priority list.

Travel cost estimates

Demand for individual trips

Estimates of the trip demand equation are shown in Table 3. The log-log function is highly significant and provides an adequate fit with the regression. The log-log function is highly significant and provides an adequate fit with the regression. The individual coefficients conform to the expected signs and are significantly

[12] According to the resort owners in the area, the tourist season in Bolinao is divided into two seasons: March-April when visitors are mostly locals or tourists from the US, and November-February when visitors from Europe predominate.

Table 2. Socioeconomic profile of survey respondents

Variable	Percentage
Age	
19–25	22
26–35	30
36–45	24
46–55	13
56 & above	10
No response	1
Educational attainment	
Elementary level	1
Elementary graduate	4
High school level	4
High school graduate	13
College level	17
College graduate	48
Vocational level	3
Graduate studies level	3
Graduate studies graduate	5
Occupation	
Self-employed	10
Administrator	8
Agricultural	8
Clerical	2
Professional	33
Sales workers	4
Service Workers	11
Others	25

different from zero. Visitation rate is negatively correlated with travel cost, consistent with both a downward-sloping demand curve and the underlying assumption that fewer visits are taken from origins further away from the site. Income level also shows a negative correlation with the number of visits made to Bolinao; one possible explanation of this is that the Bolinao area is considered inferior to other coral reef sites in the Philippines. Thus, when income increases, visitors tend to visit more up-scale resource-based recreation sites.

Table 3. Individual Trip Demand Equation

Variable	Coefficient estimate
Intercept	37.1465** (2.17)
Cost of travel	-1.7614*** (-11.96)
Income	-3.1615** (-2.07)
Number of observations	92
R-squared	80
F-statistic	72.64***

t-values are in parentheses.
** Significant at the 5 per cent probability level.
*** Significant at the 1 per cent probability level.

Aggregate demand for trips

Aggregate demand estimates presented in Table 4 show that the trip demand equation appropriately captures the inverse response of visitation rate to changes in user fees. In general, resource managers can expect reduced visitor participation (quantity consumed) with increases in user fees (price). In addition, changes in user fees also affect consumer surplus, i.e., increases in user fees decrease the area under the demand curve above the appropriate price level. Thus, net benefits to visitors are highest when user fees are nominal or non-existent.

Table 4. The aggregate demand equation

Variable	Coefficient estimate
Intercept	5.9541*** (30.67)
Price	-0.0004*** (-20.05)
Number of observations	92
R-squared	0.53
F-statistic	401.97***

t-values are in parentheses.
*** Significant at the 1 per cent probability level.

Consumer surplus

From Table 4, the consumer surplus (CS) obtained by integrating the aggregate demand equation over the range of prices used in the estimation of the function yields the following:

$$CS = \int e^{5.9541-0.0004P} dP \qquad (11)$$

Net economic benefit accruing to visitors to the Bolinao coral reefs was valued at PhP962 660 (US$21 069), or an average CS of PhP10 463 (US$229). Based on a crude visitor count of 21 042 in 2000,[13] annual aggregate CS generated by people visiting the Bolinao coral reefs for the purpose of recreation is about PhP220.2 million (US$4.8 million).

Contingent valuation estimates

Linear and log-log income functional forms are regressed using Tobit estimation. Regression results indicate a better fit of the linear model with estimated coefficients, corresponding with *a priori* expectations. As with the TCM, highly insignificant variables, such as NVIS, RATE, DFEE,

[13] Based on information provided by 11 resort operators relating to visitor count s of 5 845 between the last week of March and May 2000. Assumes that, during the peak months – November to April – visitor count (2 338) is twice that of other months.

and COST are dropped from the succeeding model specifications. The resulting linear Tobit regression model for WTP is shown in Table 5. Regression estimates are interpreted in terms of conformity with the expected signs and statistical significance.

Table 5. Tobit regression for willingness-to-pay

Variable	Coefficient estimate
Intercept	-50.5207 (37.6067)
AGE	-0.2104 (0.4798)
DED	13.6824 (11.9600)
DEMP	14.3968 (21.6469)
INC	0.0100*** (0.0034)
RDAY	2.1268** (1.0728)
Number of observations Log likelihood	63 -306.7842639

Standard errors are in parentheses.
** Significant at the 5 per cent probability level.
*** Significant at the 1 per cent probability level.

Demographic variables, such as AGE, DED, and DEMP had no significant impact on WTP for improved coral reef quality in Bolinao. The influence of these variables on WTP for environmental services is not conclusive in the economic literature. For example, an earlier valuation study conducted by Leeworthy and Bowker (1997) on the non-market benefits of the Florida Keys, find AGE to be both a positive and significant determinant of WTP. On the other hand, a later study by Parker et al. (2002) on the value of snorkeling visits to the Keys shows that AGE has a positive, but insignificant, correlation with WTP. Although these studies lend support to the direct relationship between age and WTP, most studies (e.g., Mohai and Twight 1987; Van Liere and Dunlap 1980; Booth 1990) highlight the negative relationship between these two variables; this is probably due to the income constraint faced by the elderly or those close to retirement (Booth 1990).

Consistent with the findings of the travel cost regression reported earlier in the study and with the Tobit regression by Parker et al. (2002), income is a significant variable in the analysis. High income respondents put a premium on environmental improvements compared with their lower income counterparts, suggesting that income is a major constraint among lower income groups in valuing natural resources and environmental services. However, as with demographic variables, there seems to be no consensus in the economic literature as to the sign and importance of income on environmental concerns (Booth 1990).

The number of days spent on recreation is a positive and statistically significant explanatory variable for WTP. Visitors who spend more time on recreational activities at the reefs are more willing to pay for improvements in reef quality that are likely to benefit them directly by increasing the utility that they derive from their recreational experience, than are other visitors.

Evaluating the Tobit regression at the sample mean of the independent variables yields a predicted individual WTP value equal to PhP20.46 (US$0.45) per visit or PhP73.17 (US$1.60) per year; this represents approximately 0.04 per cent of the average annual income among survey respondents. Aggregating across the total number of visitors per year yields potential user fee revenues totaling PhP1.54 million (US$33 695.9); such fees could be used to partially finance improvements in reef quality.

It is worth noting that the mean WTP value quoted by local respondents per visit (PhP25.01 or US$0.55) is roughly 38 per cent below the mean WTP value of foreign respondents (PhP40.33 or US$0.88). This disparity in WTP can be attributed to the fact that foreign visitors have higher incomes and, therefore, a greater ability to pay compared with local visitors. Also, as a foreign tourist is likely to have already spent a substantial amount on travel cost to Bolinao, an additional, relatively small, impost to improve his/her vacation experience will be less keenly felt than it would be by a visitor from close-by.

Low WTP for natural resources is not unusual in developing countries, where daily survival, rather than environmental concerns, is the immediate priority. Some respondents to the questionnaire explicitly mentioned that household income could be better spent on food or their children's education than on conservation, while others found it completely unacceptable to pay for the preservation of the Bolinao coral reefs as they did not consider the resource as their property and therefore should not be held liable for its protection. In fact, only 35.4 per cent of the respondents thought that resource users (through user fees) or the general public (through taxes) should bear the cost of public resource maintenance, while a sizeable proportion (29.2 per cent) believed that the government should be held liable for environmental preservation.

This brings to the fore another important aspect of natural-resource-based recreation services – the free rider problem that characterizes public goods.[14] This problem is a result of the non-excludable nature of this type of good, whereby beneficiaries are reluctant to contribute the corresponding user charges, because the service will be provided to them regardless of whether or not they pay the required fees.

Conclusions

Coral reef values in Bolinao are estimated in terms of the recreational benefits and the use and non-use values attached to their conservation. Empirical results using TCM show that visitors derive an average net economic value of PhP10 463 (US$229) above their average expenditure on recreation at the Bolinao reefs. Using 2000 figures on visitation rate as a base, the annual net economic value from recreation in Bolinao is estimated at PhP220.2 million (US$4.8 million). Strong demand and the high value attached to recreational services in the area lend support to the importance of coral reefs and provide justification for their conservation. After all, the realization of these potential revenues can only be made possible through effective reef management measures that ensure healthy reef conditions for a sustained period of time.

On the other hand, results of the contingent valuation survey showed that the WTP for reef quality improvements was low – just PhP20.46 (US$0.45) per individual per visit, or PhP1.54 million (US$33 696) per year. The reason for this low WTP probably results from the low socioeconomic status of respondents and the free rider problem attached to public goods. Although the current capacity to finance conservation efforts on the Bolinao coral reefs by charging visitors user fees may be limited (especially among domestic tourists), economic valuation provides the necessary initial step in putting a price to coral reefs; coral reefs can no longer be treated as free goods that are subject to abuse. Thus, part of the strategy for sustainable reef management should include massive advocacy and education campaigns to increase awareness and understanding of the importance of coral reefs. Such campaigns would be designed to increase the appreciation and promote responsible stewardship of these currently under-priced resources. Moreover, as both the recreational demand and WTP for coral reef preservation are determined by income, future studies should further explore the relationship between environmental services from coral reefs and income, possibly through the empirical application of elasticities or an inverted U-shaped Kuznets curve, among others, similar to Hökby and Söderqvist (2001).

Acknowledgement

The authors acknowledge with thanks the generous support provided by the visitors and resort operators in Bolinao and the assistance provided by the staff of the Bolinao Marine Research Center, University of the Philippines-Marine Science Institute (UP-MSI), Bee Hong Yeo, Ferdinand Paraguas and the rest of the staff at the WorldFish Center. We also acknowledge the generous funding support provided by the Swedish International Development Cooperation Agency (Sida) under the "Policies for Sustainable Management of Coral Reefs" Project.

References

Alcala, A.C. and F.J. Vande Vusse. 1994. The role of government in coastal resource management, p. 12-19. *In* R.S. Pomeroy (ed.). Community management and common property of coastal fisheries in Asia and the Pacific: Concepts, methods, and experiences. ICLARM Conf. Proc. 45, 189 p. International Center for Living Aquatic Resource Management, Manila, Philippines.

Becker, G.S. 1965. A theory of the allocation of time. Economic Journal 75:493-517.

Becker, G.S. and H.G. Lewis. 1973. On the interaction between the quantity and quality of children. Journal of Political Economy 81:279-288.

Bockstael, N.E., K.E. McConnell and I. Strand. 1991. Recreation. *In* C.D. Kolstad (ed.). Measuring the demand for environmental quality. Elsevier Science Publshers, B.V., North Holland.

Booth, D.E. 1990. Biocentric environmental values and support for the ecological restoration of urban watersheds. Institute for Environmental Urban Risk Management Technical Report #8, Marquette University, Milwaukee, Wisconsin, USA (November).

Brown, W., C. Sorhus, B. Chou-Yang and J. Richards. 1983. Using individual observations to estimate recreation demand functions: A caution. American Journal of Agricultural Economics 65:154-157.

[14] Defined as goods that exhibit two characteristics: 1) non-rivalry in consumption, i.e., an individual's consumption does not prevent others from using it; and 2) non-excludability, i.e., it is impossible to prevent others from experiencing the benefits (Stiglitz 2000).

Bryant, D., L. Burke, J. McManus and M. Spalding. 1998. Reefs at risk. World Resources Institute, Washington, D.C.

Bureau of Fisheries and Aquatic Resources (BFAR). 1997. 1996 Philippine profile. Department of Agriculture-Bureau of Fisheries and Aquatic Resources, Manila, Philippines.

Bureau of Labor and Employment Statistics. 1998. 1997 Philippine yearbook of labor statistics. Bureau of Labor and Employment Statistics, Manila, Philippines.

Burke, L. and J. Maidens. 2004. Reefs at risk in the Caribbean. World Resources Institute, Washington, D.C.

Carr, L. and R. Mendelsohn. 2003. Valuing coral reefs: A travel cost analysis of the Great Barrier Reef. Ambio 32(5):353-357.

Cesar, H. 2000a. Collected essays on the economics of coral reefs. CORDIO, Sweden.

Cesar, H. 2000b. The biodiversity benefits of coral reef ecosystems: Values and markets (Draft 1) (December, 2000). Available: http://guide.conservationfinance.org/download.cfm?File=42_Cesar-CoralReefEcoBenefits0101.pdf [22 June 2005].

Cesar, H. and C.K. Chong. 2004. Economic valuation and socioeconomics of coral reefs: Methdological issues and three case studies, p. 14-40. *In* these Proceedings.

Chou, L.M., C. Wilkinson, E. Gomez, and S. Sudara. 1994. Status of coral reefs in the ASEAN region, p. 8-12. *In* C. Wilkinson (ed.). Living coastal resources of Southeast Asia: status and management. Report of the Consultative Forum, Bangkok, Thailand, (May), Australian Institute of Marine Science, Townsville.

Clawson, M. 1959. Methods of measuring the demand for and the value of outdoor recreation. Reprint No. 10. Resources for the Future, Washington, D.C.

Clawson, M. and J. Knetsch. 1966. Economics of outdoor recreation. Resources for the Future, Washington, D.C.

Courtney, C.A., J.A. Atchue III, M. Carreon, A.T. White, R.P. Smith, E. Deguit, R. Sievert, and R. Navarro. 1999. Coastal resource management for food security. Coastal Resource Management Project, Cebu City, Philippines, Document No. 39-CRM/1998. Bookmark, Inc., Makati City, Philippines.

Department of Environment and Natural Resources (DENR). 1998. Coral reefs: God's gift to mankind. DENR, Manila, Philippines.

Deyak, T.A. and V.K. Smith. 1978. Congestion and participation in outdoor recreation: A household production function approach. Journal of Environmental Economics and Management 5:63-80.

Fletcher, J.J., W.L. Adamowicz and T. Graham-Tomasi. 1990. The travel cost model of recreation demand: Theoretical and empirical issues. Leisure Science 12(1):119-147 (January-March).

Gomez, E.D. 1991. Coral reef ecosystems and resources of the Philippines. Canopy International 16(5):1-12.

Gomez, E.D., P.M. Alino, H.T. Yap and W.Y. Licuanan. 1994. A review of the status of Philippine reefs. Marine Pollution Bulletin 29(1-3):62-68.

Greene, W.H. 1998. Econometric analysis, 3rd Edition. Prentice Hall, Englewood Cliffs, NJ.

Hannemann, W.M. 1984. Welfare evaluations in contingent valuation experiments with discrete responses. American Journal of Agricultural Economics 66:332-341.

Hökby, S. and T. Söderqvist. 2001. Elasticities of demand and willingness to pay for
environmental services in Sweden. Paper presented during the 11th Annual Conference of the European Association of Environmental and Resource Economics, Southampton, UK, 28-30 June 2001.

Hundloe, T. 1990. Measuring the value of the Great Barrier Reef. Journal of the Royal Australian Institute of Parks and Recreation 26(3):11-15.

Juinio-Menez, M.A., R.N. Castor, R.O. Dones and S.G. Salmo III. 1994. Preliminary valuation of economically important marine invertebrates in Bolinao, Pangasinan. Terminal Reports 1998, International Development Research Center.

Kalagayan, B.N.V. 1990. Institutional and legal framework, p. 44-62. *In* L.T. McManus and T.E. Chua (eds). The coastal environmental profile of Lingayen Gulf, Philippines. ICLARM, Manila, Philippines.

Lal, P. 2004. Coral reef use and management—the need, role, and prospects of economic valuation in the Pacific, p. 59 - 78. *In* these Proceedings.

La Viña, A.G.M. 1999. Management of fisheries, coastal resources and the coastal environment in the Philippines: Policy, legal and institutional framework. PRIAP Working Paper No. 5.

Leeworthy, V.R. and J.M. Bowker. 1997. Nonmarket economic user values of the Florida Keys/Key West. National Oceanic and Atmospheric Administration, Strategic Environmental Assessments Division, Silver Spring, MD.

Licuanan, W.Y. and E.D. Gomez. 2000. Philippine coral reefs, reef fishes, and associated fisheries: Status and recommendations to improve their management. Global Coral Reef Monitoring Network (GCRMN) Report.

Madalla, G.S. 2001. Limited dependent and qualitative variables in econometrics. Cambridge University Press, New York.

Mamiit, R.J. 2000. Local scuba divers willingness to pay (WTP) to increase resilience of Philippine coral reefs against the impacts of coral bleaching. Undergraduate Thesis. University of the Philippines at Los Baños.

Mathieu, L., I.H. Langford and W. Kenyon. 2000. Valuing marine parks in a developing country: A case study of the Seychelles. CSERGE Working Paper GEC 2000-27.

Mattson, J.S. and J.A. DeFoor. 1985. Natural resource damages restitution as a mechanism to slow destruction of Florida's natural resources. Journal of Land Use & Environmental Law 1(3):295-319.

McManus, J.W., C.L. Nañola Jr., R.B. Reyes Jr. and K.N. Kesner. 1992. Resource ecology of the Bolinao coral reef system. ICLARM Studies Review 22, Manila, Philippines.

Mohai, P. and B.W. Twight. 1987. Age and environmentalism: An elaboration of the Buttel model using national survey evidence. Social

Science Quarterly 68:798-815.
National Center for Transportation Studies. 2000. 1999 Vehicle operating costs. National Center for Transportation Studies, Quezon City, Philippines.
National Statistics Office, Philippines. 1995 Census. Available: http://www.census.gov.ph/data/sectordata/prov55.html [21 March 2002].
Parker, T., J.M. Bowker and V.R. Leeworthy. 2002. Valuing snorkeling visits to the Florida Keys with stated and revealed preference models. Journal of Environmental Management 65:201-312.
Pendleton, L.H. 1995. Valuing coral reef protection. Ocean & Coastal Management 26(2):119-131.
Pham Khanh Nam and Tran Vo Hung Son. 2004. Recreational value of the coral surrounding the Hon Mun Islands in Vietnam: A travel cost and contingent valuation study, p. 84-107. *In* these Proceedings.
Roxburgh, T. and J. Spurgeon. 2005. Enhancing the role of economic valuation in coral reef management. Paper presented at the International Coral Reef Initiative (ICRI) General Meeting, Seychelles (April).
Seenprachawong, U. 2003. Economic valuation of coral reefs at Phi Phi Islands, Thailand. International Journal of Global Environmental Issues 3(1):104-114.
Spurgeon, J. 2004. Valuation of coral reefs: The next 10 years, p. 50-58. *In* these Proceedings.
Stiglitz, J. 2000. Economics of the public sector, 3rd edition. W.W. Norton & Company, New York, USA.
Tobin, J. 1958. Estimation of relationships for limited dependent variables. Econometrica 26:6-36.
Trono Jr., G.C. 1999. Diversity of the seaweed flora of the Philippines and its utilization. Hydrobiologia 398/399:1-6.
Van Liere, K.D. and R.E. Dunlap. 1980. The social basis for environmental concern: A review of hypotheses, explanations, and empirical evidence. Public Opinion Quarterly 44:181-197.
White, A.T. and G.C. Savina. 1987. Reef fish yield and non-reef catch of Apol Island, Negros, Philippines. Asian Marine Biology 4:67–76.
White, A.T. and A.C. Trinidad. 1998. The values of Philippine coastal resources: Why protection and management are critical. Coastal Resource Management Project, Cebu City, Philippines.
White, A.T., M. Ross and M. Flores. 2000. Benefits and costs of coral reef and wetland management, Olango Island, Philippines. Coastal Resource Management Project, CRMP Document No. 04-CRM/2000.
Willmann, R. 1994. Integrated coastal fisheries management in Bolinao, Lingayen Gulf, Philippines. Pilot project of INT/91/007. Inception Report. Food and Agriculture Organization of the United Nations, Rome.
Yap, H.T. and E.D. Gomez. 1985. Coral reef degradation and pollution in the east Asian seas region. *In* Dahl, A.L. and J. Carew-Reid (eds). Environment and resources in the Pacific. UNEP Regional Seas Report and Studies No. 69.
Yeo, B.H. 2004. The recreational benefits of coral reefs: A case study of Pulau Payar Marine Park, Kedah, Malaysia, p. 108-117. *In* these Proceedings.

Section III

Policy Instruments and Management Measures of Coral Reefs and Marine Resources

Policy Instruments and Implications

Case Studies

Policy Instruments for Coral Reef Management and their Effectiveness

Alan T. White[1] and Catherine A. Courtney[2]

Abstract

The various issues affecting the health of coral reefs in the tropical world are many and complex, yet they can be grouped for analysis and policy formulation into "local" or "global". The local issues generally include physical destruction caused by fishing gear, mining, boats, anchors, divers, etc.; over-extraction and use by fishers and/or visitors; and pollution or sedimentation from local sources (shoreline development, boats, people and other causes). The global issues generally include warmer water and climate change; pollution from distant sources (rivers, upland areas, ships, industry); and storms, disease, crown-of-thorns and others. As issues become better understood and causes better known, it becomes easier to determine appropriate and effective policies, strategies and actions to address them.

Policies supporting coral reef protection and management are grouped into three categories – governance, regulatory (limits to access or use) and economic (incentives or disincentives) – and discussed in relation to local and global scales. Policies that support localized management mostly revolve around decentralization of authority to local governments and communities; use of marine protected areas and integrated coastal management regimes; various types of regulations governing use of an area or the resource; education; and appropriate economic incentives such as user fees, trust funds or compensation payments. Policies that support global (national and international) protection of reefs include international or national marine parks; transnational or national integrated coastal management programs; legal frameworks that recognize local management regimes; long-term lease agreements and management rights; education; valuation tools to raise awareness; privatization of common property; various national laws; bans on import/export of vulnerable species; pollution taxes; conservation tax write-offs; market entry fees; debt-for-nature swaps; carbon emission taxes and others.

The relative effectiveness of various policies and strategies is discussed in relation to management of coral reefs in several Philippine case studies. Marine protected areas are analyzed as management approaches that can work in a supportive policy context. Institutional arrangements that facilitate coral reef management in the Philippines and other countries are presented. Finally, a matrix analysis compares various, mostly successful, coral reef management projects or areas, with the whole range of potential policies and strategies in order to determine the relative effectiveness and importance of the policy/strategy mechanisms.

Introduction: Types of policy instruments

Policy instruments refer to tools and measures, which can be a set of actions (direct), or mere incentives or disincentives designed to provide directions to regulators to achieve designated outcomes. Policies for coral reef management will often lead to management strategies and actions, although policies are not interchangeable with the latter. Policies set the stage for management and provide direction and incentives. Policies are

1. Chief of Party, Coastal Resource Management Project, 5th Floor, CIFC Towers, Cebu City, Cebu, Philippines
2. Technical Advisor, Coastal Resource Management Project, Tetra Tech EM Inc., Honolulu, Hawaii, USA

normally created in response to an understanding of issues and their causes, so that policies support actions to solve a problem, such as coral reef destruction, that results from any one of many causes.

The various issues affecting the health of coral reefs in the world are many and complex, yet they can be categorized into groups for analysis and policy formulation. Issues may initially be grouped as "local" or "global" and then further broken down as shown in Table 1. As issues become better understood and causes better known, it becomes easier to determine appropriate and effective policies, strategies and actions to address them.

and local governments. To be effective, national government must devolve jurisdiction to local governments and local governments must have the ability and desire to plan and implement MPAs. The effectiveness of this approach has been borne out in the Philippines and Indonesia where most effective coral reef management is being done within the institutional context of community-based and local government ordained MPAs (White et al. 2001). These two countries also have national MPAs that are effective but successes appear more difficult to attain at the national level of management. In contrast, the Great Barrier Reef Marine Park is considered highly effective but it is located in a developed country (Kelleher 1991). Policies that support local autonomy in managing coral reefs through MPAs also include strategies that support either more generalized coastal resource management (CRM) or integrated coastal management (ICM) programs that focus on multiple local government jurisdictions or ecological regions, such as the bay-wide management being tested in the Philippines (Figure 2) (Christie and White 1997; Chua and Scura 1992). Policies or strategies that operate through CRM or ICM programs often support successful MPA programs and generally include:

Table 1. Categories of issues affecting coral reefs and important causative factors

Scale	Broad Issues	1st level causes	2nd level causes
Local	Physical destruction from fishing gear, mining, boats, anchors, divers, other	Weak law enforcement and/or regulation	Lack of education and low awareness
	Over extraction and use by fishers and/or visitors	Open access and/or weak management	Food security, Poverty, Lack of alternatives to fishing, Low awareness
	Pollution or sedimentation from local sources (shoreline development, boats, people, other)	Weak law enforcement, regulation or monitoring	Low awareness, Cost of prevention, Difficulty of solution
Global	Warmer water and climate change	Uncontrolled carbon emission	Lack of alternative energy source, Waste
	Pollution from distant sources (rivers, upland areas, ships, industry, mining)	Deforestation, Dumping from industry and ships, Waste from cities and towns, other	Lack of monitoring, access control, law enforcement, policy, regulation and others
	Storms, disease, Crown-of-thorns and others	Natural events, climate change, pollution	Lack of monitoring, knowledge, prediction

Policies that address the broad issues shown in Table 1 can also be divided into "local" and "global" in a manner that roughly follows the kinds of issues to be addressed. A difference in the grouping for policies is that local will refer to the very local context of a reef area but global will refer to legal and institutional contexts at the national as well as the true global levels. A listing of policies for guiding coral reef management, grouped by type, is shown in Table 2, and the overall global and local issue and policy structure is shown in Figure 1.

Local management policies and their effectiveness

Governance policies

Governance policies that encourage marine protected areas (MPAs) as a basic approach to coral reef management emanate from national

- Implementation of "best practices", such as well-managed MPAs, zoning, functional local resource management organizations, effective coastal law enforcement units, shoreline development plans and regulation, and other habitat management mechanisms particular to coral reefs (Figure 2) (Courtney and White 2000).

Table 2. Policies and strategies for coral reef management

Scale/ Level	Policy type	Potential policies and strategies
Local	Governance	Community-based, cooperative or local government marine protected areas Marine protected area networks Integrated coastal management planning and implementation Traditional natural resource management regimes Certification of coastal resource management (best practice) implementation Municipal fisheries management or stewardship councils Periodic monitoring (biophysical, socioeconomic, management/governance) Information networks that disseminate the results of monitoring Planning for biophysical effectiveness and geographical priorities Education support and programs to raise awareness and encourage action Valuation tools to raise awareness and incorporate economic analysis Penalties for non-compliance
	Regulatory (limits to access or use)	Ban on logging and destructive fishing techniques Restrictions to access through zoning, boundary demarcation Restriction to access through community-owned land or marine tenure Use of catch quotas, size limits, seasons for fishing Restrictions on fishing gear by type and place Rules and guidelines for visitor use of dive sites
	Economic incentive or disincentive	Sustainable tourism Dive or visitor fee or tax system Boat/gear permits or licensing with fees Community coastal resource management trust funds Price incentives to fishers using sustainable methods Compensation payments to local fishermen or traditional users Alternative livelihoods for coastal resource dependent communities Fines for non-compliance
Global and/or national	Governance	National and international policies on coastal and coral reef management International or national marine parks Marine protected area networks Transnational or national integrated coastal management programs Certification of best practices in coastal management, shoreline development Legal framework to facilitate and recognize local management regimes Training programs on coastal resource management Standardize management and evaluation approaches and rating criteria Standardize criteria for management site selection Standardize biophysical and management descriptions and rating systems Long-term lease agreements and management rights Education support and programs to raise awareness and encourage action Valuation tools to raise awareness and incorporate economic analysis
	Regulatory (limits to access or use)	Privatization of common property, freehold property permits Laws controlling land-based pollution Laws banning or controlling destructive fishing techniques Ban import/export of vulnerable species and trade regulation Human population management
	Economic incentive or disincentive	Sustainable tourism Eco labeling for sustainable practices Pollution taxes based on "polluter pays principle" Conservation tax write-offs and market entry fees Debt-for-nature swaps Reduction of government land rents, fees, taxes as conservation incentive Reforms that improve security of tenure and the investment climate Carbon emission taxes and alternative energy sources

Supporting references:

Barber and Pratt 1997
Bettencourt and Gillett 2001
Bryant et al. 1998
Burke et al. 2001
Calumpong 1996
Cesar 1996
Cicin-Sain 1993
Courtney et al. 2000
DENR et al. 2001b
Gustavson and Huber 2001
Hatziolos et al. 1998
Huber 2001
Kuperan et al. 1999
Mascia 2001
Murray et al. 1999
Oracion 2001
Ross et al. 2001
Seenprachawong 2001
Spurgeon 2001
White et al. 1994
White and Trinidad 1998
White et al. 2001

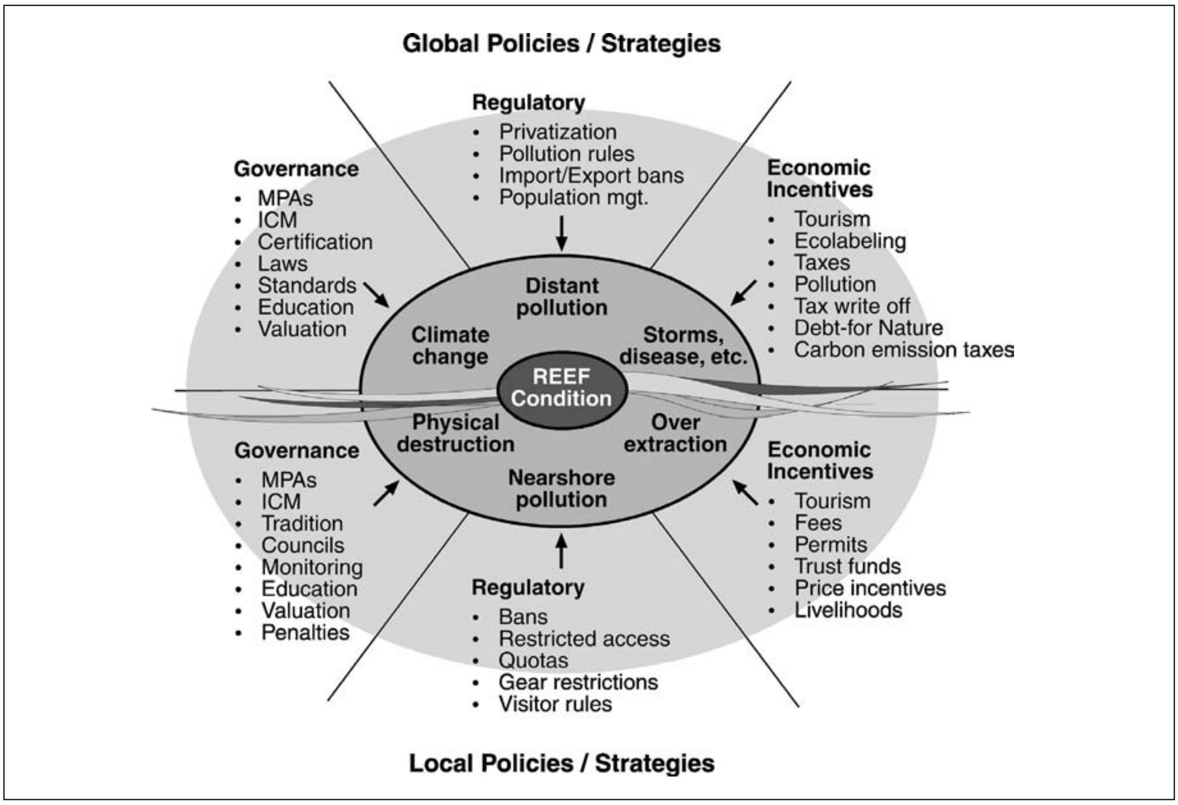


Figure 1. Global and local issues and policy structure for reef management

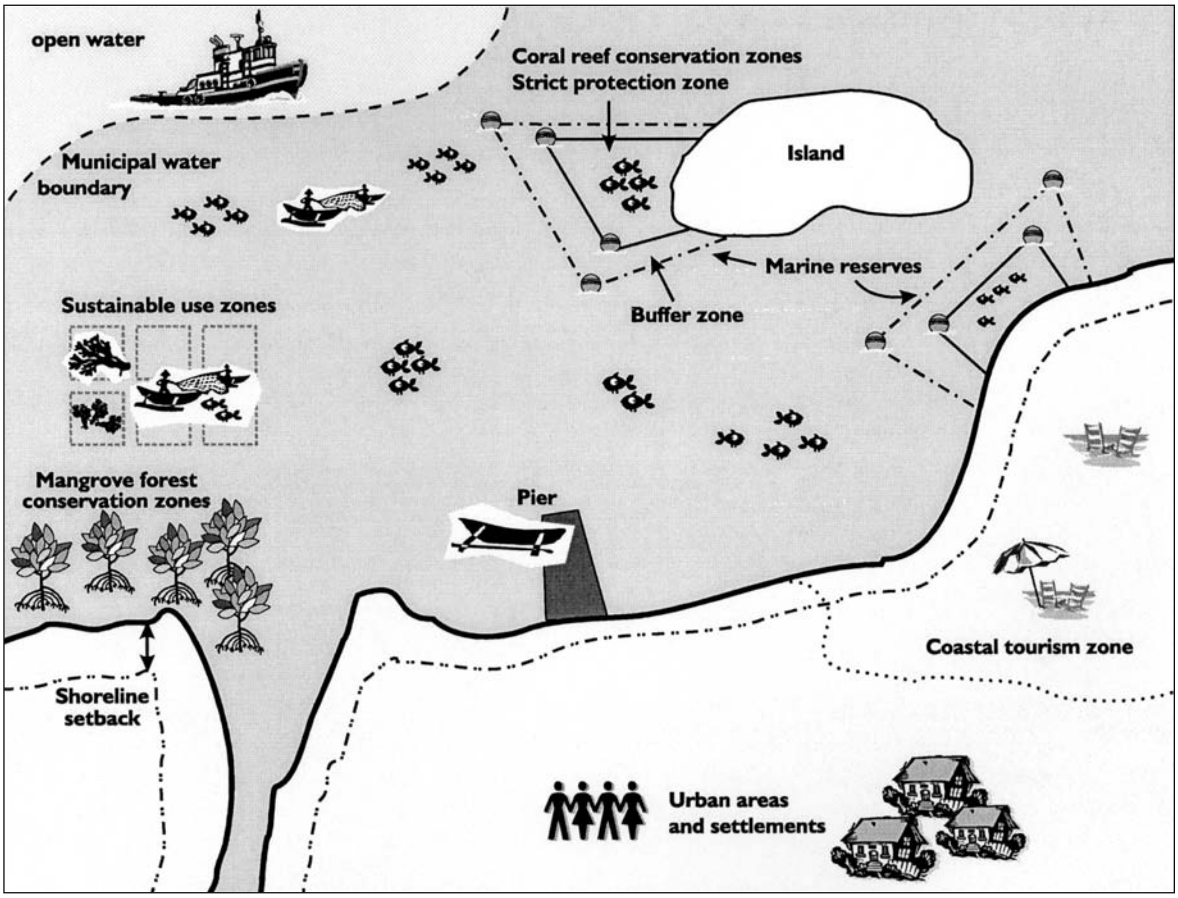


Figure 2. Planning and zoning of municipal water use in a typical Philippines bay or coastal area

- Certification of coastal management plans and their implementation through local government units (Courtney and White 2000).

- Periodic monitoring of coral reef biophysical, socioeconomic and governance impacts and context through local participatory means that raises awareness about the situation among local resource users and also gathers essential information for management and refinement of plans and actions (Uychiaoco et al. 2001). A typical planning cycle that incorporates the results of monitoring for management is shown in Figure 3.

Education is also part of the CRM planning cycle illustrated in Figure 3.

Regulatory policies

Regulatory mechanisms are many, and yet few are successful at achieving their intended result. This is probably because most regulations are implemented without the prerequisite education and consensus-building processes that will help ensure compliance. Regulatory policies almost always limit access and use in some form but they must be locally acceptable to be effective. Typical regulations used to help protect coral reefs are:

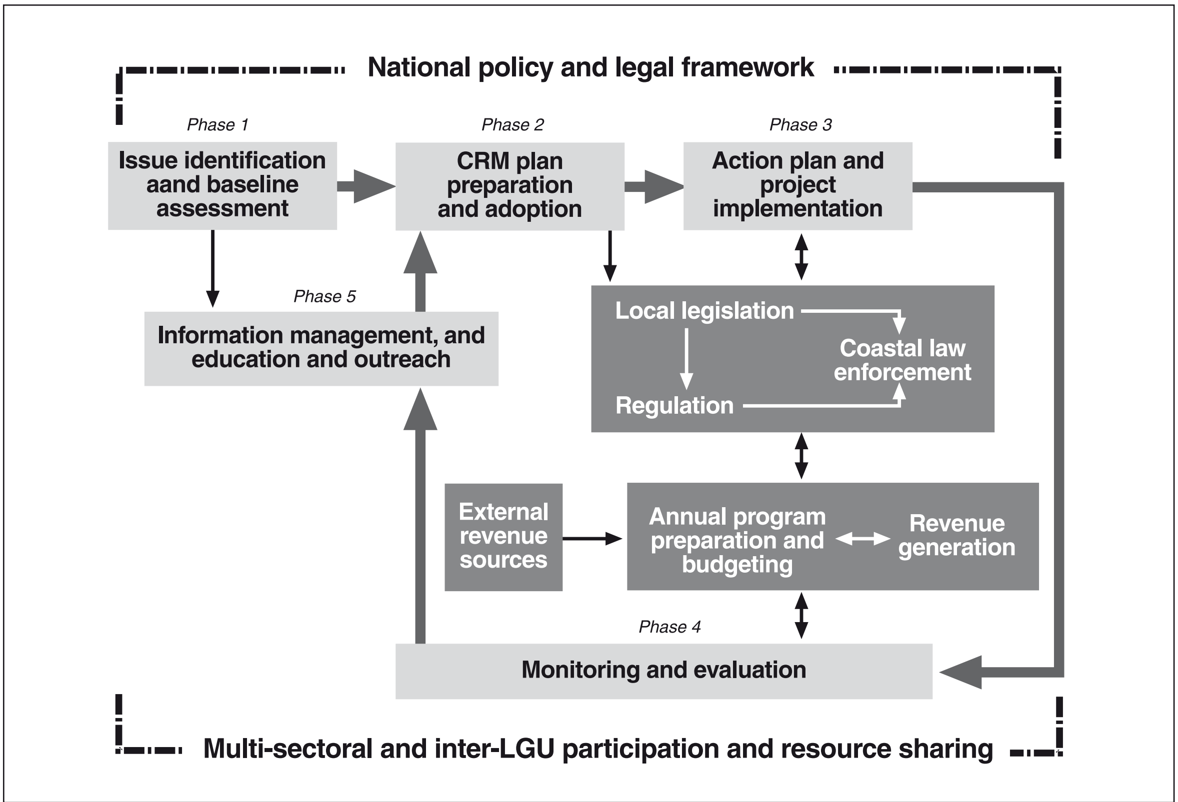


Figure 3. Coastal resource management planning and implementation cycle for a local government unit

Education is needed to reinforce positive actions at all levels and among all stakeholders. Education is a tool that must fit into the local context and that is more effective if driven by actual experience rather than by theory or ideas that are not easily comprehended by those expected to change their patterns of behavior (Wells and White 1995). Education can also make use of information from resource economic valuation and benefit analysis to raise awareness about the inherent values of the reef resources or area of concern. The role of education is illustrated in Case study 1 below.

- Bans on resource use activities such as logging and on use of destructive fishing methods. Such bans are common and necessary yet they are often ineffective because of poor education and acceptance among the target audience (Pomeroy and Carlos 1997).

- Regulatory limits to access and use for fishers or visitors. These are proving to be effective if implemented through a MPA approach that is specific for small areas, as shown in the case of functional MPAs in the Philippines where various rules are accepted and followed.

- Use of catch quotas, size limits and seasons for fishing. These methods are generally not effective tools in developing countries because of the difficulty of implementation and enforcement (Pomeroy and Carlos 1997) in situations where there is no appropriate government bureaucracy. Even in places like the Great Barrier Reef or Florida there are still problems with monitoring compliance.

- Restrictions on fishing gear by type and place. These are often effective in the context of localized management implemented by local governments or through MPAs but are often difficult to monitor in large areas due to lack of government capacity. Private sector cooperation through the dive industry or local management organizations can enhance the enforcement of fishing restrictions.

Economic incentives

- Use of economic incentives and disincentives is a valuable tool in making MPAs effective and also attractive to users such as visitors or local fishers (Cesar 1996; Arin 1997; White and Trinidad 1998). In the local context, economic incentives must operate so that they directly reinforce conservation practices through the local resource users (Vogt 1997). The economic incentive should be linked directly to a resource user behavior pattern that requires changing or reinforcement so that the connection is very clear. Options for economic incentives include:

- Sustainable tourism – often a strong positive economic incentive for protecting coral reefs as long as the tourist is really interested in visiting healthy reefs (White et al. 2000). Setting up user fee systems can reinforce good behavior by placing value on the site of visitation and also provide revenue to manage a special area. Entry permits for boats can have the same positive effect and help control activities of the boat owners while in a limited access area.

- Community trust funds – may be more complicated to set up and manage but still have potential where the community has decided to manage an area and is able to collect user fees that are managed through a communal system. Such a community-based system is working in some areas where the community is well organized and there is no problem of too much government intervention.

- Compensation payments to local resource users – may help initiate a conservation program but might not be sustainable unless the compensation comes from revenue that is generated from sustainable tourism or another related source.

- Alternative livelihood projects for fishers dependent on reefs – often do not work as intended and many times end up assisting the wrong beneficiaries. Thus, all livelihood projects must be carefully planned and tested to ensure that they do indeed support better conservation by benefiting the targeted stakeholders of concern to reef management. Livelihoods that are working in the Philippines to support reef conservation are tourism-related or environmentally friendly forms of aquaculture that can be implemented without too much capital or training.

Economic disincentives can also have a beneficial effect on reef management if implemented consistently in the context of law enforcement. Even community-based management regimes use fines for offenders of marine sanctuaries or fishing gear rule infractions. Local governments in the Philippines are increasingly collecting fines for illegal fishing (Courtney et al. 2002).

Global/national management policies and their effectiveness

Governance policies

Policies that truly emanate from the global level are those embodied in the Earth Summit, Agenda 21, Chapter 17 that addresses the conservation needs of oceans and coasts. The overall thrust of Chapter 17 is to promote the integrated management of coastal areas and resources following the guiding principles of sustainable use and development (Cicin-Sain 1993). Most of the key principles and concepts of good coastal resource management are expressed in Chapter 17, but what is of relevance to this paper is how these policies affect coral reefs within the national and local context. Important governance policies and strategies at the global and/or national levels with practical implications for improved management and conservation include those listed in the following page.

- International agreements covering trans-national areas and creating international marine parks, such as the Turtle Islands National Park which is jointly implemented by Malaysia and the Philippines, or the proposed Spratly Islands International Marine Park in the South China Sea. There are few effectively managed areas that cross national borders but there is potential for such management regimes in future.

- National laws, guidelines and certification systems that establish and support integrated coastal management approaches, national marine parks or other similar management approaches. These are often essential ingredients in supporting effective local management. The ability to transpose national legal support into effective local action is still lacking in most countries, although good examples exist in Australia, Indonesia, Malaysia, Thailand and the Philippines in a few well-known and high priority sites. A national CRM certification system is now being tested in the Philippines (Courtney et al. 2002).

- International and national training programs in ICM, MPA management, monitoring and evaluation or other technical and governance techniques. Such programs are important in building capacity in the government and private sector for improved CRM. An important aspect of training is dissemination of standardized management and evaluation approaches, rating systems for governance in MPAs or CRM programs, criteria for site selection of MPAs, and methods used for biophysical, socioeconomic and governance monitoring. At present, in most countries, such standards are lacking and training is being done using non-standard methods. This makes information sharing difficult and ineffective.

- Access and management rights. These policy tools are affected by national policies controlling the devolution of authority. In some countries, traditional use rights are awarded to indigenous communities for shoreline and marine areas. This does not always mean improved management but it does offer some local accountability for management and is effective in some Pacific island countries (Bettencourt and Gillet 2001; Hviding and Baines 1992; Hviding 1991).

- National education programs for coral reef conservation and management. These exist in varying capacities in many countries. The extent to which they have a lasting and positive impact depends on the degree to which they are integrated into school curricula and national media outlets. All successful coral management programs have strong, ongoing education components. Certainly, the general awareness about the importance of coral reefs is much higher now than it was a few years ago; much of this can be attributed to the dissemination of information on the relative economic value of reefs to policy-makers, government agencies and the general public (Courtney et al. 2000).

Regulatory policies

Global and national regulatory policies are primarily reflected in, amongst other things, international trade and pollution control agreements as well as in national laws that regulate trade and use of species, use of fishing methods, laws controlling landuse and land-based pollution. One trade agreement that is relatively effective is the inclusion of corals in Appendix 3 of the Convention on International Trade in Endangered Species (CITES) under which shipment of corals is inhibited internationally. Yet, the best enforcement comes when national laws prevent both export and import of corals directly so that national customs officials are more vigilant. Having clear regulatory policies and laws at the national level makes it easier for effective enforcement at the local level. An example of an unclear national law is when the law states that all "active fishing gears" are prohibited from use in municipal coastal waters (including all coral reef areas) but fails to define "active fishing gears" or leaves the definition to the discretion of local governments, as in the Philippines. Unclear laws usually lead to poor or no enforcement.

Economic policies

An important international and national economic policy that can assist directly with reef conservation is the promotion of sustainable tourism. Tourism as an economic force cannot be disputed and, when harnessed to support conservation in the right manner, it can be beneficial, especially if it is linked to effective local management policies that ensure distribution of benefits among coastal resource stakeholders.

National tourism promotion may benefit well-managed national marine parks but might be detrimental to local MPAs if the local authorities and communities cannot manage the influx of tourists and derive economic benefits from them in an equitable manner (White et al. 2000). Other international or national economic policy incentives or disincentives may include:

- Pollution taxes by which polluters pay either for emissions to marine waters or for specific damages to coastal waters and reefs. This mechanism is difficult to implement in developing countries and is probably not very effective in terms of reef conservation anywhere except maybe in Australia and the United States where ships dumping wastes or directly breaking the reefs have been fined under the law.

- Conservation tax write-offs and market entry fees. These mechanisms are used in developed countries in certain circumstances but their effectiveness may be difficult to measure and they may not work in developing countries.

- Debt-for-nature swaps and incentives for investments that support conservation. Such measures have been used to generate revenue for conservation in developing countries where the government allows and encourages retirement of public or private debt, or has progressive investment policies. The combination of factors and cooperation to make such arrangements work in reality is rather complex and the overall use of these tools has not been great.

- Finally, at the truly global level, the need to cut carbon emissions is recognized but is making little headway in the international arena. Certainly the most promising solution here will be alternative energy sources that depend less on fossil fuels than at present.

Case study 1: Local government and community coral reef management in the Philippines

Owing to years of neglect and mismanagement, the condition of coral reefs and other coastal resources in the Philippines declined significantly until about 1985. Since then, over 430 MPAs have been established in the country (Baling 1995; Pajaro et al. 1999; White et al. 2001). Presently, the degradation of the reefs has slowed down and, although many are not well managed, the MPAs are having a positive effect and the level of awareness nationwide has improved. With the passage of the Local Government Code in 1991 and the 1998 Fisheries Code responsibility for managing municipal waters and their resources was devolved to local governments. However, local governments often lack technical capacity, funds, and economic justification to support investment in coastal resource management. Co-

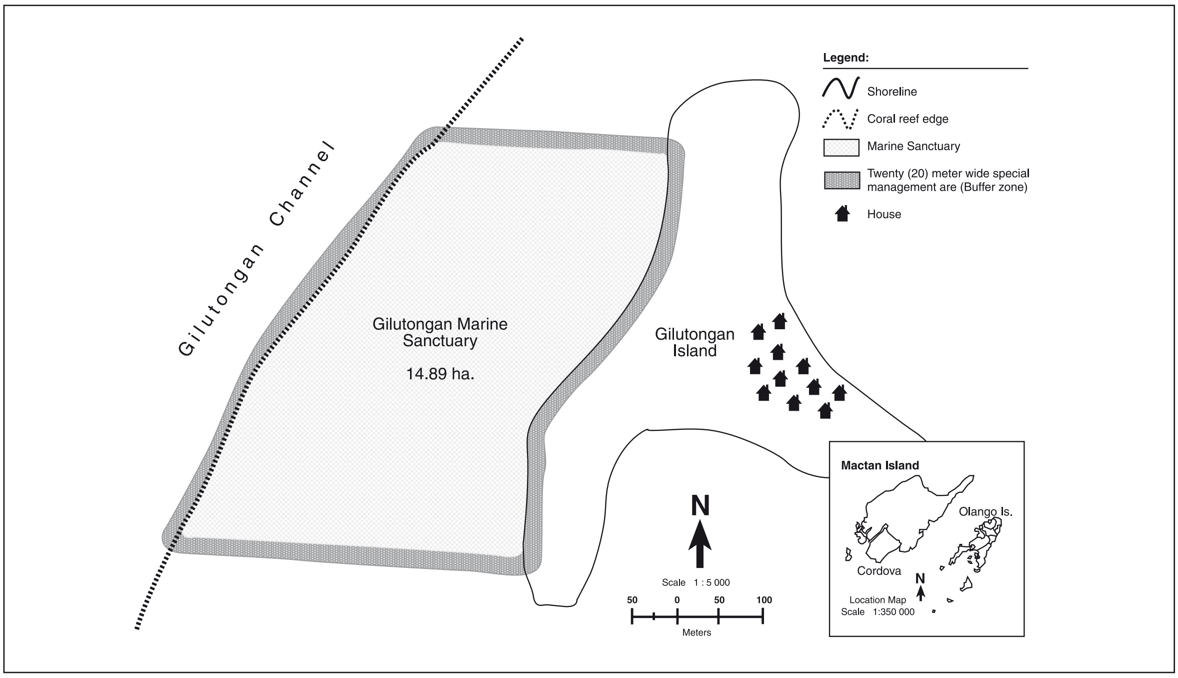
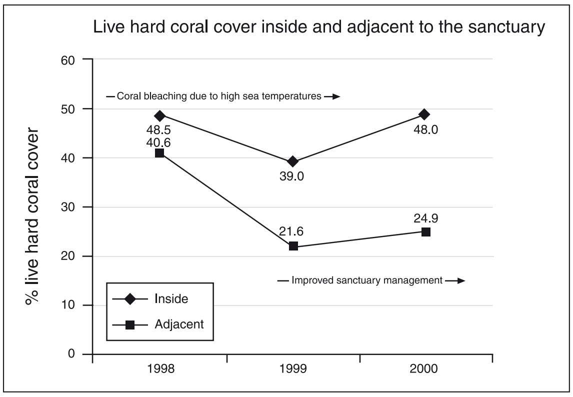


Figure 4. Gilutongan Island Marine Sanctuary, Cordova, Cebu, Philippines

management projects, such as the Coastal Resource Management Project (CRMP) in Cordova, Cebu, have helped to coordinate government and academic expertise to assist local communities manage their coastal resources better (Courtney and White 2000).

The boundaries of the Gilutongan Marine Sanctuary in Cordova were officially established by a municipal ordinance in 1994 (Figure 4). However, the sanctuary has only recently become effective with active involvement by the community, national and municipal governments, non-government organizations (NGOs) and academic institutions. The National Department of Environment and Natural Resources, the University of the Philippines, the Marine Science Institute and the University of San Carlos are monitoring the coral reef substrate and fish abundance, activities the community does not have the expertise to perform. However, because the management is community-based, the risk of local resource conflicts and non-compliance is reduced.

Early results have been positive. Fish abundance and diversity and live coral cover have improved markedly (Figure 5). Study tours from other coastal communities and tourism in general are growing as well. Revenues from the recreational diving industry are generating on average US$1 000 a month, of which 70 per cent is allocated to the municipality to support marine sanctuary management and 30 per cent is allocated to the community for special improvement projects (Ross et al. 2001).



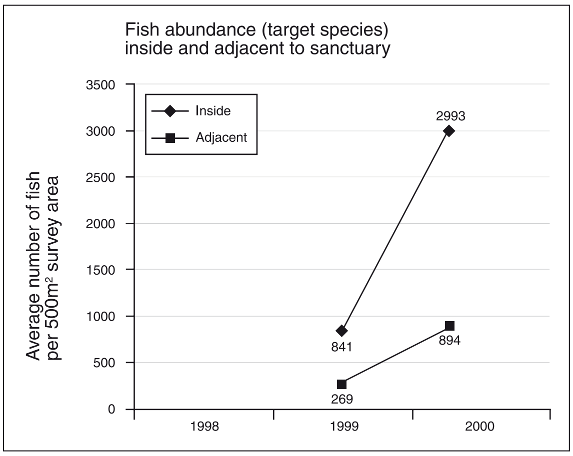


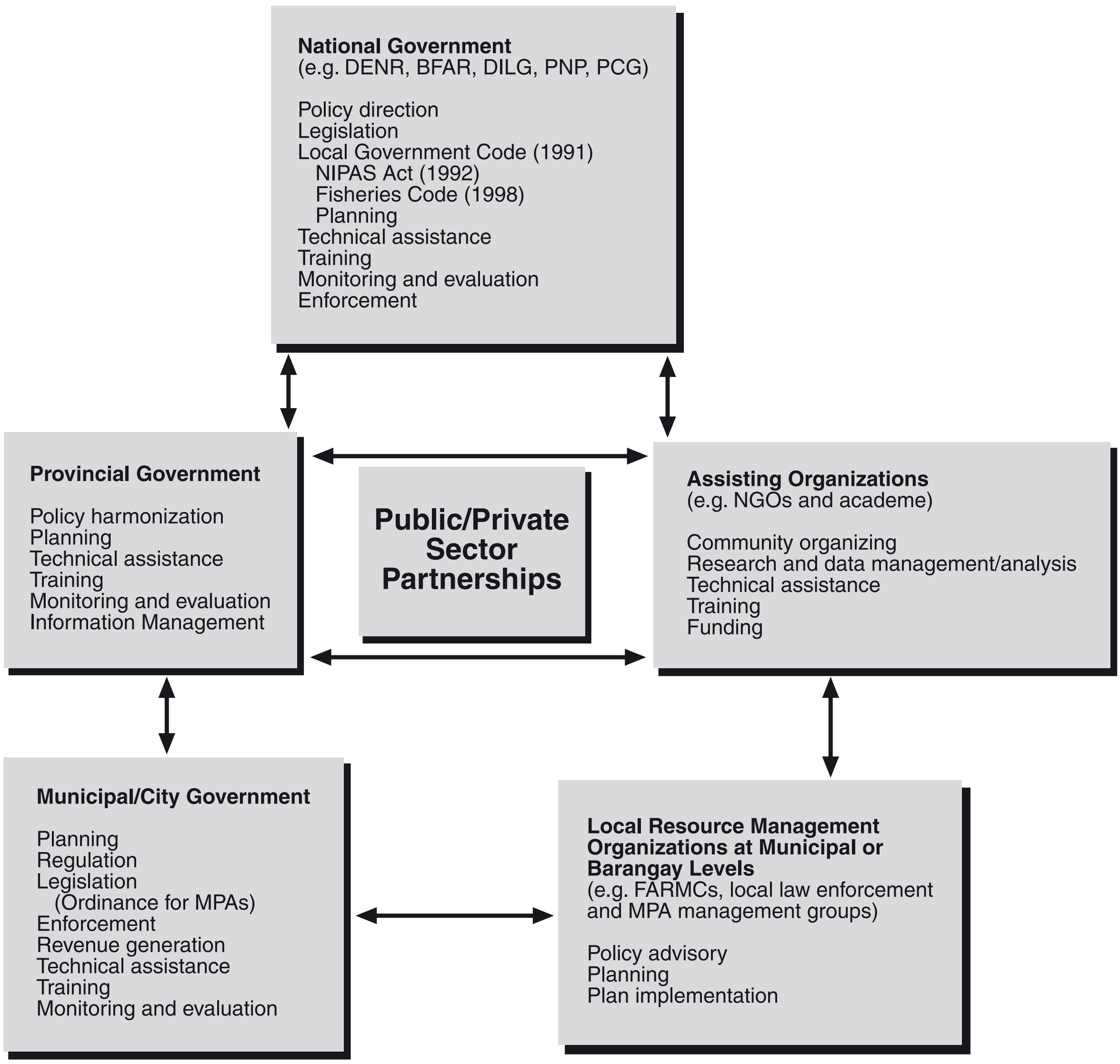
Figure 5. Change in coral cover and fish abundance in Gilutongan Island Sanctuary

CRMP has been working with municipalities and communities such as Cordova in other parts of the Philippines to build the capacity of local governments to deliver coastal resource management as a basic service. By the end of 2001, 70 municipal governments, covering more than 2 100 kilometers of shoreline, will have adopted a rigorous CRM system.

Precursors to Gilutongan Island Marine Sanctuary, Apo, Pamilacan and Balicasag Islands and others in the Central Visayas, Philippines, are also recognized as successful community-based resource management projects. In the late 1970s, blast and dynamite fishing, as well as other destructive fishing practices, threatened these and other reefs in the Central Visayas. Thanks to a community-based marine management initiative that controlled destructive fishing practices, put in place in the mid 1980s, these practices stopped (MCDP 1986). With financial assistance, Silliman University staff organized local people on these islands into marine management committees. These groups then set up marine reserves that included "no fishing" sanctuaries on one part of the reef. With the assistance of the municipal governments, residents have continued to prevent reef damage from fishers and divers both within and outside the sanctuaries (White 1988a; 1988b; 1989; 1996). A growing tourism industry catering to scuba divers is providing much needed revenue to local communities. In 1999, live coral cover and fish populations within the marine sanctuaries had increased substantially, along with fish yields from the island reefs (White et al. 1999; White and Vogt 2000).

Case study 2: National coral reef management in the Philippines

Policies supporting the three overall strategies prevalent in Southeast Asia – integrated coastal management, community-based coastal management and co-management – delegate the power to manage coastal resources to different groups. With top-down strategies, governments retain



BFAR	- Bureau of Fisheries and Aquatic Resources
DENR	- Department of Environment and Natural Resources
DILG	- Department of Interior and Local Government
FARMC	- Fisheries and Aquatic Resources Management Council
NIPAS	- National Integrated Protected Area System
NGO	- Non-government Organization
PCG	- Philippine Coast Guard
PNP	- Philippine National Police

Figure 6. Key institution roles and responsibilities for local level coastal management in the Philippines

most of the control. Following the trend of decentralization, especially in the Philippines, NGOs and local authorities have developed community-based management and co-management regimes. This devolution of power makes local communities, and municipal and city governments, crucial actors in the management of coastal resources (Figure 6).

The major policies that affect coral reef management are the Republic Act (RA) 8550 or the Philippines Fisheries Code of 1998 and RA 7160 or the Local Government Code. The relevant provisions of the Fisheries Code are:

a) A ban on coral exploitation and exportation. It is prohibited for any person or corporation to gather, possess, sell or export ordinary precious and semi-precious corals, whether raw or in processed form;

b) A ban on muro-ami, other methods and gear destructive to coral reefs and related marine habitat. It is unlawful to fish with a gear method that requires diving and other physical or mechanical acts that pound and destroy coral reefs, seagrass beds, and other marine life habitat;

c) The prohibition of fishing or taking of rare, threatened, or endangered species as listed in CITES (which includes species of corals);

d) The declaration of fishing reserves. Local Government Units (LGUs) are authorized to recommend to the Department of Agriculture (DA) portions of municipal waters that can be declared as fishery reserves; and

e) The establishment of fish refuges and sanctuaries. LGUs are authorized to establish these within their municipal waters.

Meanwhile, the Local Government Code establishes the jurisdiction of municipalities in the management of its municipal waters, where some coral reefs are found. The functions of LGUs relevant to coral reef management are:

a) Enforcement of all national laws on fishery and coral reef conservation including ordinances;

b) Legislation of ordinances that limit destructive activities on coral reefs, such as those associated with fishing (spear fishing by recreation divers) or tourism (anchoring, entrance fees in marine sanctuaries, etc.);

c) Inter-LGU collaboration which enhances implementation of integrated management;

d) Consultation of national government agencies with LGUs, NGOs and other stakeholders in relation to programs or projects which may cause pollution, climate change, depletion of non-renewable resources or any activities which would cause ecological imbalance;

e) Recognition of the roles of peoples' organizations and NGOs as the backbone of participatory planning; and

f) Power to generate their own sources of revenue, e.g. charging entrance fees for marine parks.

The National Integrated Protected Areas System (NIPAS) Act is also an important policy support for coral reef management. The NIPAS has included in its system 13 marine seascapes (Table 3) of notable biological and physical diversity. One of these seascapes is the Tubbataha Reef National Marine Park, which is also a World Heritage Site due to the unparalleled beauty and biodiversity of coral reefs in the area. The NIPAS further provides for a degree of interface with the LGUs through membership in the Protected Area Management Board (PAMB) and consultations before enlistment in the system. Although a progressive law, the NIPAS Act has had the effect of alienating some community groups from a previously successful management operation. The well-known Apo Island in the southern Philippines is a case in point. There, the successful community-based and local government-run marine reserve of the 1980s was declared a Protected Seascape under the NIPAS Act in 1996. Since 1996, the community has complained of problems of working within the national system and, in fact, the revenues collected from visitors to the island have largely been lost in the national treasury through the poor management of the DENR. This highlights the potential weakness of an apparently good national law for protected areas that in theory involves local government and communities in the planning and management process but in practice does not do so. Also, as can be seen from Table 3, management is not effective in most of the nationally protected seascapes, thus reinforcing the notion that national policies/laws are not effective without local mechanisms and accountability (NIPAP 1999; White et al. 2001).

The Philippines has various other environment and pollution prevention policies of importance to coral reefs, especially as the reefs function as recipients of silt and polluting materials. Such policies as they apply to shoreline development, forestry, and disposition of solid waste are all highly relevant to coral reef management but are woefully lacking in enforcement.

While it is clear that local level management of coral reefs is the mandate of the LGUs, the functional overlaps and interests of national agencies blur the issue. The Department of Agriculture-Bureau of Fisheries and Aquatic Resources (DA-BFAR) has general responsibility for the management of fishery management areas, while the Department of Environment and Natural Resources (DENR) has jurisdiction over the entire natural resources and environment

Table 3. Nationally proclaimed marine protected areas in the Philippines and their effectiveness[1] (DENR 2001)

Name of protected area	Date established	Area (hectares)[2]	Approximate reef area	Relative protection from protected area status[3]
Palaui Island Marine Reserve, Luzon	08-16-1994	7 415	<10%	❖
Batanes Protected Landscape and Seascape, Luzon	02-28-1994	213 578	<5%	❖
Masinloc and Oyon Bay Marine Reserve, Zambales	08-18-1993	7 568	<5%	❖
Tubbataha Reef National Marine Park, Sulu Sea, Palawan	08-11-1988	33 200	>10 000 ha	❖ ❖ ❖
Apo Reef Natural Park, Sulu Sea, Mindoro	02-20-1996	11 677	>3 000 ha	❖ ❖
Taklong Island National Marine Reserve	02-08-1990	1 143	<10%	❖
Sagay Protected Seascape, Negros Occidental	06-01-1995	28 300	<10%	❖
Apo Island Protected Landscape and Seascape, Negros Oriental	08-09-1996	691	=100 ha	❖ ❖ ❖
Guiuan Protected Landscape and Seascape, Samar	09-26-1994	60 448	<10%	❖
Turtle Island Heritage Protected Area, Tawi-Tawi	05-31-1996	1 740	<10%	❖ ❖
Pujada Bay Protected Landscape and Seascape, Mindanao	07-31-1994	21 200	<10%	❖
Sarangani Protected Seascape, Mindanao	03-05-1997	215 950	<5%	❖ ❖
Tañon Strait Protected Seascape, Negros/Cebu	05-28-1998	No data	<5%	❖

1 There are many more marine protected areas established by municipal or city ordinance that are not listed here. About 10 to 15 per cent of the local government MPAs are considered to be managed effectively.
2 Area includes all marine waters of protected areas, generally less than 10% is coral reef habitat.
3 ❖ Little or no management
❖ ❖ Management starting
❖ ❖ ❖ Effective management in place for several years

sector. A positive legal agreement that emerged despite this seeming confusion is the Joint Memorandum Order No. 2000-01 between DA-BFAR and DENR. The agreement, first and foremost, lays down procedures for cooperation and collaboration on matters that affect jurisdictional mandates of both agencies (DENR et al. 2001a).

In the Philippines, despite a strong legal and institutional framework for coral reef management, enforcement of the laws remains weak. Reasons range from mere lack of political will on the part of the enforcer, to total ignorance of the law or lack of appreciation of resource values on the part of stakeholders. Local governments complain that there is very little funding for enforcement and that hardware and personnel support from national government is minimal. Nevertheless, there are important policy shifts taking place for improving CRM in the country as indicated in Table 4.

In the Philippines, the future of coral reefs depends on the actions listed below.

- Implementing more effective MPAs and improving the quality of management of many existing but poorly managed MPAs under local and national governments;
- Promoting coastal resource management planning and implementation for all municipal and city governments that includes CRM best practices such as improved coastal law enforcement, zoning, MPAs, controls on shoreline development and collecting resource rents;
- Adopting a newly designed national policy framework for coastal management that streamlines the roles and responsibilities of various agencies that support local governments in the task of protecting coral reefs and other resources;
- Encouraging collection of resource rent in exchange for access to coral reefs and fisheries to obtain revenue for improved management and protection; and
- Continuing to educate the public and policy-makers about the importance of coral reefs in the local and national economy and about their high biodiversity values.

Table 4. Policy directions for improved local governance and coastal resource management in the Philippines (Courtney et al. 2001)

FROM	***TO***
Improved local governance (adapted from Ellison 1997)	
Public administration Centralized, uniform, "top down" service delivery Self-sufficiency Hierarchical control "Upward" accountability Standardized procedures Apolitical civil society Individual skill building	Public management Decentralized, diverse, localized service delivery Inter-linked sectors Empowerment "Outward" accountability Performance orientation Advocacy-oriented civil service Organizational competence
Improved coastal resource management (adapted from Courtney and White 2000)	
Agri-based fisheries development National government control and regulation Top-down planning by national government Input indicators used to monitor activities Single local government interventions Individual skill building in CRM	Coastal resource management and protection Local government delivery of CRM as a basic service Upward, participatory planning and co-management regimes Output indicators used to benchmark local government performance Inter-local government and multisectoral participation in co-management regimes Organizational capacity building in CRM for local government, resource management councils, NGOs, civil society

Institutional arrangements that work for coral reef management

There are many different examples of institutional arrangements for managing coral reefs around the world. The Philippines examples above highlight the roles of communities, and local and national governments in a varying mix that is biased towards local level control, even in national marine parks. In Table 5, examples from around the world are summarized to give a sense of what can work under different governments and in various situations. One pattern that emerges from this summary table is that local accountability must always be in place whether it is orchestrated from national headquarters or from a local government or community. Thus, national management regimes in developed countries may appear to be more hierarchical but, in reality, if they are effective in management, they may have devolved much of their authority and responsibility to local management units that reflect local community and cultural needs. Another trend that emerges from the management cases of Table 5 is that there is always some form of collaborative management present. This may be in the form of collaboration between local or national governments and stakeholder communities, or it may be collaboration between the private sector and communities and/or government.

Table 5. Selected coral reef management programs and their type of institutional support and role of community (modified from White et al. 1994)

Local Community and/or Local Government Management

Site name	Area	Organization responsible	Management role of community
FIJI			
1. Customary fishing rights areas	Inshore areas up to reef drop-off	Local communities with government Fisheries Division	Owners of fishing rights must grant permission for activities that might affect reefs; joint government and community program to stop dynamite fishing with increased prosecutions.
MOZAMBIQUE			
2. Bazaruto Archipelago Conservation Project	Reefs and other marine habitats of five islands	Local tourism organizations and villages, with assistance of World Wide Fund for Nature and South African Nature Foundation	Through custodianship of resources and a joint decision-making process, residents have established five reserves on fringing reefs in which fishing is prohibited and four in which spearing ad seine nets are prohibited but other artisanal methods are permitted.
PHILIPPINES			
3. Apo Island Municipal Marine Reserve (until 1996)	106 ha of fringing reef reserve surrounding the island to 60 m isobath	Marine Management Committee of residents, municipal government, and Silliman University	Marking and guarding of sanctuary and regulation of fishing practices and tourist activities around the island.

4. Balicasag Island Municipal Marine Reserve	31 ha of fringing reef reserve surrounding the small island to 20 m isobath	Marine Management Committee of residents, municipal government, and the Philippine Tourism Authority	Guarding of sanctuary and prevention of destructive fishing.
5. Mabini Municipal Marine Reserve	Coral reef and marine waters to 500 m offshore fringing 4 km of coastline, with three sanctuaries inside	Marine Management Committee of fishers and resort operators, municipal government	Surveillance of sanctuaries, installation of mooring buoys, and prevention of destructive fishing.
6. Pamilacan Island Municipal Marine Reserve	180 ha of fringing reef reserve surrounding the island to 20 m isobath	Marine Management Committee of residents and municipal government	Guarding of sanctuary and regulation of fishing activities.
7. San Salvador Island Municipal Marine Reserve, Zambales	Fringing reef surrounding 300 ha island, 125 ha reef sanctuary	Marine Management Committee of residents, municipal government and the Haribon Foundation	Surveillance of sanctuary and monitoring of fishing activities on remaining fish areas.
8. Sumilon Island Municipal Marine Park	25 ha island surrounded by 50 ha coral reef	Municipal government and resort company	Municipal employees watch the reef to prevent destructive fishing and collect fees from tourists; sanctuary imposed until 1984. Monitoring showed dramatic increases in fish diversity, abundance and yield up to 1984.
	SOLOMON ISLANDS		
9. Marovo Lagoon Customary Marie Tenure	700 km^2 of reefs and water enclosed by barrier reefs	Traditional chief oversees regulations; village communities control access to reef	Control access to reef resources and regulation of harvesting within community areas; may give fishing rights to outsiders under certain conditions.

National or State Government Management

Site name	Area	Organization responsible	Management role of community
	AUSTRALIA		
10. Great Barrier Reef Marine Park	350 000 km^2 with about 2 900 reefs, 300 coral cays, and 600 continental islands	Great Barrier Reef Marine Park Authority and Queensland National Parks and Wildlife Services	Community or park users assist in determining activities within park zones; implementation through education, public awareness and enforcement as needed.
	BELIZE		
11. Hol Chan Marine Reserve	Several small reef areas and sand cays	Fisheries Department	Fishing banned by government, and local fishers cooperate by not fishing within the reserve.
	EGYPT		
12. Ras Mohammed Marine Park	170 km coastline with fringing reefs and desert landscape	Department of National Parks, with assistance of European Economic Community project	Tour companies cooperate with government office to monitor diving activities and mooring of boats.
	INDONESIA		
13. Bali Barat National Marine Park, Bali	One small island and fringing reefs (sanctuary); fringing reefs and other marine ecosystems bordering mainland shore	Directorate of Nature Conservation within the Ministry of Forestry, park director, and staff	The park director works closely with local fishing communities in a cooperative manner to ensure compliance.
14. Bunaken National Marine Park, North Sulawesi	89 000 ha with five islands and two stretches of mainland shoreline with 5 000 ha of coral reefs and 1 800 ha of mangrove forest	Directorate of Nature Conservation within the Ministry of Forestry, park director, and staff	Several NGOs are beginning to work with the park management. Local participation is beginning through a planning process.
	MEXICO		
15. Sian Ka'an Biosphere Reserve, Yucatan	528 000 ha of rain forest, mangroves, reefs , and associated waters, bounded by Yucatan barrier reef	Government department in cooperation with the NGO Amigos de Sian Ka'an	Fishing cooperative for spiny lobster and Council of Representatives of people living in the reserve participate in management with the government.
16. Key Largo National Marine Sanctuary, Florida	259 km^2 of patch and bank reefs, sea grass beds, and adjacent waters	Florida Department of Natural Resources	Surveillance and education; spearfishing and trap fishing prohibited; mooring buoys installed.

17. Looe Key National Marine Sanctuary, Florida	18 km^2 of reefs, sea grass beds, and associated waters	Florida Department of Natural Resources	Surveillance and education; spearfishing and trap fishing prohibited; mooring buoys installed.
18. Marine Life Conservation Districts, Hawaii	Nine areas ranging in size from 11 to 150 ha of coral reef and marine water	State Division of Aquatic Resources	Dive tour operators cooperate with state to manage sites on a case-by-case basis; fishing and anchoring banned; recreation permitted.
19. Virgin Islands National Park (VINP) and Biosphere Reserve, Caribbean	6 127 ha, including 2 286 ha sea, 3 644 ha land. Park has fringing reefs, mangroves, sea grasses, and associated waters and beaches	National Park Service, Department of Interior, with Virgin Islands Resource Management Cooperative	Park Service is encouraging participation of fisher groups through traditional fishing and planning; and NGO, Friends of the VINP, serves as a liaison.

Collaborative Management

Site name	Area	Organization responsible	Management role of community
BRITISH VIRGIN ISLANDS			
20. RMS Rhone Marine Park	323 ha, including the wreck, island, and surrounding waters and reefs	National Parks Trust, with participation of Dive Operatives Association	Local dive operators involved in surveillance, monitoring, education, and installation of mooring buoys.
HAITI			
21. Les Arcadins Marine Park	Islands with fringing coral reefs on west coast north of Portau-Prince	Government in cooperation with World Wildlife Fund	Fisher cooperatives, the Haiti Hotel Association, and local dive club, with assistance of World Wildlife Fund-U.S., are active in regulating fishing activities in the park with the implementation of no-fishing areas.
JAMAICA			
22. Montego Bay Marine Park	13 km^2 includes extensive coral reefs, sea grass beds, and mangroves	National government agency, with active assistance of NGOs	Dive operators have trained wardens; Rotary Club has raised funds; schools are involved in publicity and awareness-raising; local fishing cooperatives assist with fishing regulation and area-use monitoring; mooring buoys installed.
NETHERLANDS ANTILLES			
23. Bonaire Marine Park	Coral reef and marine habitat surrounding the island to 60 m isobath	An NGO, Bonaire National Parks Foundation (STINAPA), with local government support and assistance of local community groups	STINAPA, hotels, dive organizations, and the government are represented on the management committee; partially zoned with two scientific reserves.
24. Saba Marine Park	Entire nearshore environment of the island covering 870 ha	Saba Conservation Foundation with local government and dive operators	Zoned for diving, anchoring, and fishing; mooring buoys installed; permit system for dive operators; one-quarter of park closed to fishing with cooperation of fishers.
MALDIVES			
25. Maldives Resort Islands	Fringing coral reefs, beaches, islands, and surrounding marine waters zoned for tourism	Department of Fisheries and national resort organization	Resort and dive operators actively monitor use of reefs on their islands and dive sites frequented by their boats, in collaboration with Department of Fisheries.
MICRONESIA (Federated States)			
26. Kosrae Island	Fringing coral reefs, mangroves, and beaches bordering island	Island government and communities	Trochus shell sanctuaries are being maintained by communities where no collection is permitted; habitat protection is generally promoted, and fishing by outsiders is discouraged; locally managed tourism is being planned.
PHILIPPINES			
27. Tubbataha National Marine Park, Sulu Sea	32 200 ha, two atolls with lagoons, and fringing coral reefs	Protected Area Management Board (PAMB) of National and Local Governments, NGOs and stakeholder	The World Wildlife Fund for Nature actively supports, manages, and patrols to prevent destructive fishing, conducts education programs, and makes liaisons with dive operators and the Philippine navy under direction of the PAMB.

ST. LUCIA			
28. Soufriere	Fringing coral reefs along about 10 km of coastline on the west coast of St. Lucia	Department of Fisheries and dive operators	Dive companies monitor the conditional of the reefs and maintain mooring buoys, in coordination with government and the Caribbean Natural Resources Institute.

Note: Organization responsible refers to the local (community or government) entity, state or national government agency, or NGO responsible for management of the site or program. Management role of community varies from one program to another because of the need for brevity and the difficulty in obtaining complete sets of data for each program. Community, as used here, refers to local residents, resource users, and tour or dive operators, as appropriate for the site. All the sites noted are relatively successful. Indicators of success are given in a similar table in White et al. (1994).

References used in this table:

Anon 1991
Arquiza and White 1999
Buhat 1994
Carillo and Martinez 1989
Causey 1990
Christie et al. 1990
Christie et al. 1994
Christie et al. 1999
Clark et al. 1989
Ferrer et al. 1996
Geoghean et al. 1991
Hviding 1990; 1991
Hviding and Baines 1992
Katon et al. 1997
Katon et al. 1999
Kelleher 1991
Miller 1986
Post and Van't Hof 1992
Russ and Alcala 1996
Savina and White 1986a; 1986b
Smith and Van't Hof 1991
Smith and Water 1991
Toch 1990
Towle and Rogers 1989
Walker 1992
White 1984
White 1987
White and Savina 1987a; 1987b
White 1988a; 1988b
White 1989
White and Palaganas 1991
White 1992
White and Calumpong 1992
White et al. 1999
White et al. 2000

Critical success factors and policy priorities for sustainable management of coral reefs

Policies and strategies that are frequently used and known to be successful in documented marine management areas are highlighted in Table 6. This analysis helps us prioritize those policies and strategies that, based on experience, deserve the most attention. Those that show up most frequently (in 40 per cent or more cases) as critical success factors in MPAs or in other forms of management areas are listed below in the order of frequency of occurrence in Table 6.

Governance
1. Education support and programs
2. Supportive national policies/laws
3. Periodic monitoring activities
4. Technical planning for biophysical effectiveness and geography
5. Extant national marine protected area mandate
6. Local management or stewardship council
7. Training programs on coastal management
8. National monitoring or rating standards
9. National site selection standards
10. National management standards
11. Valuation tools used to raise awareness or make decisions
12. Information network available
13. Local government or community-based MPA
14. MPA network exists in a supportive context

Regulatory
1. National laws ban or control destructive activities
2. Local laws ban or control destructive activities
3. Local fishing gear restrictions in place
4. Local restricted access in place
5. Local visitor rules applied

Economic
1. Sustainable tourism a theme or policy in area
2. Visitor fees are collected with positive results
3. Boat permit used and effective
4. Alternative livelihood present and used successfully

When reviewing the matrix of Table 6, it is noted that certain policies/strategies marked in black are key supporting factors in many management areas. This does not imply that the others marked in gray, or those less frequent in the table are not important as some, such as national laws that are always present but which may not make the difference in successful management, will automatically be important supporting factors. Some policy/strategy approaches are only starting to be tested and will not show up in this type of analysis, which depends on experience and results over time. An approach such as "CRM certification", being tested in the Philippines, ranks low in the analysis because it is new and not used in other countries.

Table 6. Policies and strategies used with success in marine management areas

Collaborative Management (National/Local Collaboration)

		1 RMS Rhone, British Virgin Is.	2 Les Arcadins, Haiti	3 Komodo, Indonesia	4 Pulau Seribu, Jakarta Bay	5 Montego Bay, Jamaica	6 Bonaire, Netherlands Antilles	7 Saba, Netherlands Antilles	8 Maldives Resort Islands, Maldives	9 Kosrae Island, Micronesia	10 Apo Island, Negros, P. (post 1996)	11 Apo Reef, Mindoro, P.	12 El Nido, Bacuit Bay, P.	13 Tubbataha Reefs, P.	14 Soufriere, St. Lucia	Relative Frequency of policy/strategy in all 39 cases (%)
Summary	Relative success of mgt./protection	3	2	2	1	1	3	3	3	2	3	1	1	3	2	
	No. of supporting policy regimes	14	9	16	12	16	13	14	25	11	30	17	21	29	15	
Economic	Carbon emission tax								▒					▒		8
	Debt for nature swap													▒		8
	Ecolabeling for practice															3
	Price incentive for practice			▒												5
	Tax write-off													▒		5
	Pollution tax															0
	Fines										▒			▒		26
	Alternative livelihood		▒	▒				▒	▒	▒	▒	▒		▒		46
	Compensation payment			▒		▒					▒	▒		▒		21
	Trust fund					▒							▒	▒		10
	Boat permit	▒					▒	▒	▒		▒			▒	▒	51
	Visitor fee	▒		▒		■	▒	▒	▒		■	▒	▒	■	▒	69
	Sustainable tourism	▒	▒	▒			■	■	■	▒	▒	▒	▒	▒	▒	77
Regulations	Population mgt.															3
	Local visitor rules	▒			▒			▒			■		▒	▒	■	49
	Local fishing gear restrictions		▒	▒		▒					▒		▒	▒		62
	Local quotas									■						8
	Traditional restricted access								▒							5
	National privatization				■				▒		▒					21
	Local restricted access		■							▒	▒		▒		▒	59
	Pollution laws				▒	▒			▒		▒		▒	▒		28
	Import/export laws			▒					▒					▒		15
	National bans	▒	▒	▒	▒	▒	▒	▒	▒		▒	▒	▒		▒	85
	Local bans		▒					▒		▒	▒		▒		▒	67
Governance	Penalties										▒			▒		36
	Valuation tools used	▒		▒		▒	▒	▒	▒		▒	▒	■	▒		44
	Education program	▒	■	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	87
	Lease agreement/mgt. right	■			▒				▒							23
	National monitoring standard								■		▒	▒	▒	▒		54
	National site selection standard			▒	▒		▒		▒		▒	■	▒	▒		49
	National mgt. standard				▒		▒		▒		▒	▒	▒	▒		46
	Technical planning	▒		▒	▒	▒			▒	▒	▒	▒	▒	■	▒	79
	Training program		▒		▒	▒			▒		▒		▒	▒		54
	Information network	▒				▒	▒	▒	▒		▒				▒	41
	Periodic monitoring	▒		■		▒	▒	■	■	▒	▒	▒	▒	■	▒	82
	Local mgt council	■	▒			■	■				■	■	▒	▒	■	59
	Certification of ICM										▒					5
	Traditional regime									■						10
	Local ICM program					▒					▒				▒	28
	National ICM program								■							5
	MPA Network								▒		▒	▒	▒	▒		41
	Local MPA							▒		▒	▒					41
	National MPA	▒	▒	▒	▒	▒	▒	▒	▒		▒	▒	▒	▒	▒	67
	International MPA													▒		8
	National policies/laws	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	85
	International policies			▒					▒			▒		▒		15

Legend:

Relative success of mgt.: **3** Effective management in place for several years
2 Management starting or only moderately effective
1 Little or no management

ICM Integrated Coastal Management
MPA Marine Protected Area
P. Philippines

Note: This table is based on information available which is not consistent for each site analyzed. Thus, specific details in each site can be improved with better knowledge and information of each site. The bigger trends are the important result of this matrix and not the individual details.

▒	Gray box indicates some level of importance in the management of an area
■	Key policy/strategy with a major influence on success of area

Recommendations made by Burke et al. (2001) highlight the essential need for accurate information and effective management strategies in reef conservation. They maintain that effective resources management requires good information on the status of resources and the factors contributing to change. This information is needed to guide management at local and national levels. Such information and planning can be utilized through ICM or CRM programs that primarily work through co-management of community management regimes involving government and community level groups. Activities that are considered a high priority by Burke et al. (2001) to improve the status of coral reefs in Southeast Asia include efforts to:

- Improve mapping, monitoring and networking of information on coral reefs to support better management
- Halt the use of destructive fishing practices
- Reduce over-fishing
- Regulate the international trade in live reef organisms
- Encourage collaborative management of coastal and fisheries resources
- Improve the management of existing MPAs
- Expand the protected areas networks
- Develop sustainable tourism
- Adopt policies to reduce greenhouse gas emissions and climate change
- Raise public awareness

A factor often overlooked in coral reef management is the need to minimize the impacts of shoreline development and terrestrial pollution. Many significant reefs are found close to the coast, sometimes just a few meters from the shoreline. These reefs are directly affected by rapid population growth and increasing demand for industry, tourism, housing, harbors and ports etc., resulting in extensive coastal development. Furthermore, maintaining the aesthetic value of the coast, including clean beaches and water, and unspoiled landscapes, will become increasingly important if coral reefs themselves become less attractive to tourists. Addressing these issues requires careful attention to planning and regulation of coastal development and waste disposal through ICM and/or community-based resource management programs. Key issues in the protection of reefs from the impacts of shoreline development include:

- Protection and management of watersheds
- Planning and managing shoreline areas and uses
- Providing for sewage and other waste treatment
- Promoting environmentally sensitive building practices
- Promoting environmentally sensitive recreation activities

The list could go on but the key issues and some of their solutions have been highlighted. In summary, 25 years of community and cooperative-based coastal conservation through various forms of MPAs and strategies in the Philippines and other countries have shown that effective coral reef management is more than a problem of simple environmental education or law enforcement. Approaches that mobilize those people who use the resources daily are necessary to ensure wide participation and potentially long-lasting results (Wells and White 1995). Strictly legal approaches have had few successes. Equally, good environmental surveys and information have not been sufficient to bring about rational use of marine resources without being fully integrated into the long-term process of integrated planning and implementation within the context of well-articulated MPAs or other marine management areas. Combining community participation, regulations, environmental education, economic incentives, and legal mandates in a manner appropriate for a particular site together with long-term institutional support from government, non-government groups, academe, or other institutions offers some possibility of success (White et al. 2001).

Acknowledgments

This review has benefited from work in various field sites and was made possible by a long-term association with several Philippine institutions and persons: Dr Angel Alcala, Dr Hilconida Calumpong, Ms Felina Tiempo, Ms Ester Delfin and Ms Louella Dolar of Silliman University; Dr Edgardo Gomez, Dr Porfirio Aliño and Dr Andre Uychiaoco of the University of the Philippines-Marine Science Institute (UP-MSI); Dr Liana McManus and Dr John McManus (University of Florida); Marivic Pajaro of the Haribon Foundation, and Dr G. Russ of James Cook University in Australia; and Dr Patrick Christie (University of Washington). Earthwatch Institute supported research expeditions in 1992, 1993, 1995, 1997, 1999 and 2001. Evangeline White and Leslie Tinapay assisted in the production. The Coastal Resource Management Project of USAID implemented by Tetra Tech EM Inc., along with the Coastal Conservation and Education Foundation, Inc. have provided the space, time, and materials to prepare this paper. We wish to thank the WorldFish Center for the invitation to present this paper.

References

Anon. 1991. Editorial, Crown of Thorns Newsletter 31:1-3. Marine Research Section, Ministry of Fisheries and Agriculture, Republic of Maldives.

Arin, T. 1997. Survey on diver valuation of coral reefs using the contingent valuation method. Coastal Resource Management Project, Document No. 7-CRM/1997, 12 p.

Arquiza, Y. and A.T. White. 1999. Tales from Tubbataha, natural history, resource use, and conservation of the Tubbataha Reefs, Palawan, Philippines. (Rev. ed.) Bookmark and Sulu Fund for Marine Conservation Foundation, Inc., Manila, Philippines, 140 p.

Baling, N. 1995. Philippine marine protected area management. A country paper presented at the Review of Protected Areas of the Indo-Malayan Realm Regional Workshop, 23-25 January 1995, Bogor, Indonesia.

Barber, C.V. and V.R. Pratt. 1997. Sullied seas strategies for combating cyanide fishing in Southeast Asia and beyond. World Resources Institute, International Marinelife Alliance, Washington D.C., U.S.A.

Bettencourt, S. and R. Gillett. 2001. Learning from communities: coastal resource management in the Pacific Islands. Paper presented to the 9th International Coral Reef Symposium, October 2000, Bali, Indonesia.

Bryant, D., L. Burke, J. McManus and M. Spalding. 1998. Reefs at risk: a map-based indicator of threats to the world's coral reefs. World Resources Institute, Washington D.C., U.S.A., 56 p.

Burke, L., E. Selig and M. Spalding. 2001. Reefs at risk in Southeast Asia. World Resources Institute, Washington D.C., U.S.A.

Buhat, D. 1994. Community-based coral reef and fisheries management, San Salvador Island, Philippines, p. 33-49. *In* A. White, L. Hale, Y. Renard and L. Cortesi (eds). Collaborative and community-based management of coral reefs. Kumarian Press, West Hartford, Connecticut, U.S.A.

Calumpong, H.P. 1996. The Central Visayas regional project lessons learned. Tambuli 1:12-17.

Carillo-Barrios-Gomez, E., and H. Herrmann-Martinez. 1989. A new biosphere reserve model in Mexico. *In* W.P. Gregg, S. Krugman, and J.D. Wood (eds). Proceedings of a Symposium on Biosphere Reserves. Fourth World Wilderness Congress, 1987, Colorado, U.S.A.

Causey, B. 1990. Experience from a national marine sanctuary in the United States, p. 37-44. *In* Proceedings of International Coastal Resource Management Workshop, Belize.

Cesar, H. 1996. The economic value of Indonesian coral reefs. Environmental Division, World Bank, Washington D.C., U.S.A., 9 p.

Christie, P., A.T. White and D. Buhat. 1990. San Salvador Island marine conservation project: Some lessons in community-based resource management. Tropical Coastal Area Management (ICLARM, Manila) 5 (1/2): 7-12.

Christie, P., A.T. White and D. Buhat. 1994. Community-based coral reef management on San Salvador Island, Philippines. Society and Natural Resources 7: 103-117.

Christie, P. and A.T. White. 1997. Trends in development of coastal area management in tropical countries: From central to community orientation. Coastal Management 25: 155-181.

Christie, P., D. Buhat, L.R. Garces and A.T. White. 1999. The challenges and rewards of community-based coastal resources management: San Salvador Island, Philippines. Sunny Press, New York, U.S.A.

Chua, T.E. and L.F. Scura (eds.) 1992. Integrative framework and methods for coastal area management. ICLARM Conference Proceedings 37.

Cicin-Sain, B. 1993. Sustainable development and integrated coastal management. Ocean and Coastal Management 21:11-43.

Clark, J.R., B. Causey and J.A. Bohnsack. 1989. Benefits from coral reef protection: Looe Key Reef, Florida, p. 3076-86. *In* Proceedings of Coastal Zone 1989, Charleston, N.C. American Society of Civil Engineers, New York, U.S.A.

Courtney, C.A. and A.T. White. 2000. Integrated coastal management in the Philippines: Testing new paradigms. Coastal Management 28(1):39-53.

Courtney, C.A., A.T. White and E. Anglo. 2000. Philippine case study: managing coastal resources – drawing lessons and directions from the Philippine experience. Sustainable Development Report, Asian Development Bank, Manila, Philippines, 115 p.

Courtney, C.A., A.T. White and E.T. Deguit. 2002. Building Philippine local government capacity for coastal resource management: methods, progress and trends. Coastal Management 30:45-63.

Department of Environment and Natural Resources. 2001. Country report on coral reef status to the International Coral Reef Initiative Workshop. DENR. April, Mactan, Cebu City, Philippines.

Department of Environment and Natural Resources, Bureau of Fisheries and Aquatic Resources of the Department of Agriculture, and Department of the Interior and Local Government. 2001a. Legal and jurisdictional guidebook for coastal resource management in the Philippines. Coastal Resource Management Project of the Department of Environment and Natural Resources, Cebu City, Philippines.

________ 2001b. Managing coastal habitat and marine protected areas. Coastal Resource Management Project of the Department of Environment and Natural Resources, Cebu City, Philippines.

Ferrer, E.M., L. Polotan-De la Cruz and M. Agoncillo-Domingo. 1996. Seeds of hope: A collection of case studies on community-based coastal resources management in the Philippines. College of Social Work and Community Development, University of the Philippines, Diliman, Quezon City, Philippines, 223 p.

Geoghegan, T., Y. Renard and A. Smith. 1991. Community participation in protected area management: some case studies from the Caribbean. Paper presented at the Regional Symposium on Public and Private Cooperation on National Park Development, August 1991, Tortola, British Virgin Islands.

Gustavson, K. and R.M. Huber. 2001. Capturing coral reef benefit values: Financing marine environment conservation in Montego Bay, Jamaica. Paper presented to the 9th International Coral Reef Symposium, October 2000, Bali, Indonesia.

Hatziolos, M.E., A.J. Hooten and M. Fodor (eds). 1998. Coral reefs: Challenges and opportunities for sustainable management. *In* Proceedings of an Associated Event of the Fifth Annual World Bank Conference on Environmentally and Socially Sustainable Development. Washington, D.C., U.S.A.

Huber, R.M. 2001. Ecological economic decision support modeling for the integrated coastal zone management of coral reefs in the developing tropics. Paper presented to the 9th International Coral Reef Symposium, October 2000, Bali, Indonesia.

Hviding, E. 1991. Traditional institutions and their role in contemporary coastal resource management in the Pacific Islands. NAGA, the ICLARM Quarterly 14 (4): 3-6.

________. 1990. Keeping the sea: Aspects of marine tenure in Marovo Lagoon, Solomon Island. *In* K. Ruddle and R.E. Johannes (eds). Traditional Marine Resource Management in the Pacific Basin: An Anthology. Jakarta, Indonesia: UNESCO/ROSTEA.

Hviding, E. and G.B.K. Baines. 1992. Fisheries Management in the Pacific: tradition and the challenges of development in Marovo, Solomon Island. Discussion Paper 32. United Nations Research Institute for Social Development, Geneva, Switzerland.

Katon, B.B., R.S. Pomeroy, A. Salamanca and L. Garces. 1997. The marine conservation project for San Salvador: A case study of fisheries co-management in the Philippines. Working Paper No. 23, Fisheries Co-Management Research Project, International Center for Living Aquatic Resources Management, Manila, Philippines.

________. 1999. Fisheries management of San Salvador Island: A shared responsibility. Society and Natural Resources 12:777-795.

Kelleher, G. 1991. The Great Barrier Reef Marine Park Authority: its role in the use and care of the Great Barrier Reef Marine Park. *In* M. Gourlay (ed.). Proceedings of Engineering in Coral Reef Regions Conference, November 1990, Townsville, Australia.

Kuperan, K., N.M.R. Abdullah, R.S. Pomeroy, E.L. Genio and A.M. Salamanca. 1999. Measuring transaction costs of fisheries co-management in San Salvador Island, Philippines. NAGA, The ICLARM Quarterly 22(4):45-48.

Marine Conservation and Development Program (MCDP). 1986. Final report and evaluation for the marine conservation and development program of Silliman University. The Asia Foundation and Silliman University, Dumaguete, Philippines.

Mascia, M.B. 2001. Designing effective coral reef marine protected areas: A synthesis report based on presentations at the 9th International Coral Reef Symposium, October 2000, Bali, Indonesia. Special Report to: IUCN, World Commission on Protected Areas-Marine. April 2001.

Miller, D.L. 1986. Technology, territoriality and ecology: the evolution of Mexico's Caribbean spiny lobster fishery. Workshop on Ecological Management of Common Property Resources, Fourth International Congress of Ecology, Syracuse, New York, U.S.A.

Murray, S.N., R.F. Ambrose, J.A. Bohnsack, L.W. Botsford, M.H. Carr, G.E. Davis, P.K. Dayton, D. Gotshall, D.R. Gunderson, M.A. Hizon, J. Lubchenco, M. Mangel, A. MacCall, D.A. McArdle, J.C. Ogden, J. Roughgarden, R.M. Starr, M.J. Tegner and M.M. Yoklavich. 1999. No-take reserve networks: Sustaining fishery populations and marine ecosystems. Fisheries 24 (11):11-25.

NIPAP. 1999. Annual report to the public 1998. National Integrated Protected Area Program – Department of Environment and Natural Resources, Manila, Philippines, 42 p.

Oracion, E.G. 2001. The trade-off of marine protected areas and tourism: The case of Apo Island, Philippines. Silliman University, Dumaguete City, Philippines.

Pajaro, M., F. Olano and B. San Juan. 1999. Documentation and review of marine protected areas in the Philippines: A preliminary report. Haribon Foundation, Manila, Philippines.

Pomeroy, R.S. and M.B. Carlos. 1997. Community-based coastal resource management in the Philippines: A review and evaluation of programs and projects, 1984-1994. Marine Policy 21(5):445-464.

Post, J. and T. van't Hof. 1992. The economic feasibility and ecological sustainability of marine protected areas: The case of Bonaire. *In* Fourth World Congress on National Parks and Protected Areas, Caracas, Mexico.

Ross, M.A., A.T. White, A.C. Sitoy and T. Menguito. 2001. Experience from improving management of an "urban" marine protected area: Gilutongan Marine Sanctuary, Philippines. *In* Proceedings of 9th International Coral Reef Symposium, October 2000, Bali, Indonesia.

Russ, G.R. and A.C. Alcala. 1996. Do marine reserves export adult fish biomass? Evidence from Apo Island, Central Philippines. Marine Ecology (Progressive Series) 132:1-9. Silliman University Marine Laboratory (SUML). Assessment of the Central Visayas Regional Project-I: Nearshore Fisheries Component, Vols. I and II. Silliman University, Dumaguete, Philippines.

Savina, G.C. and A.T. White. 1986a. Reef fish yields and non-reef catch of Pamilacan Island, Bohol, Philippines. *In* L. MacLean, L.B. Dizon and L.V. Hostillos (eds.) First Asian Fisheries Forum Manila, Asian Fisheries Society, Manila, Philippines.

________ 1986b. A tale of two islands: some lessons for marine resource management. Environmental Conservation 13(2):107-13.

Seenprachawong, U. 2001. An economic analysis of coral reef benefits from Phi Phi Islands, Thailand. *In* Proceedings of 9th International Coral Reef Symposium, October 2000, Bali, Indonesia.

Smith, A.H. and T. van't Hof. 1991. Coral reef monitoring for management of marine parks: cases from the

insular Caribbean. CANARI Communication No. 36. Vieux Forte: CANARI.
Smith, A.H. and R. Water. 1991. Co-management of the white sea urchin resource in St. Lucia. CANARI Communication No. 38. Vieux Forte: CANARI.
Spurgeon, J. 2000. Maximising opportunities for sustainable financing of coral reefs based on a "total economic value" approach. Paper presented to the 9th International Coral Reef Symposium, October 2000, Bali, Indonesia.
Toch, S.L. 1990. Integrating resource and community issues: an implementation strategy. Report to Virgin Islands National Park, St. John.
Towle, E.L. and C.S. Rogers. 1989. Models, methaphors, networks and insular biosphere reserves: The Virgin Islands case. Occasional Paper 50. Island Resources Foundation, St. Thomas, U.S. Virgin Islands.
Uychiaoco, A.J., S.J. Green, M.T. de la Cruz, P.A. Gaite, H.O. Arceo, P.M. Aliño and A.T.
White. 2001. Coral reef monitoring for management. University of the Philippines Marine Science Institute, United Nations Development Programme Global Environment Facility-Small Grants Program, Guiuan Development Foundation, Inc., Voluntary Service Overseas, University of the Philippines Center for Integrative and Development Studies, Coastal Resource Management Project, and Fisheries Resource Management Project, 110 p.
Walker, S. 1992. An attempt at financial self-sufficiency: the case of the Sava Marine Park. *In* Fourth World congress on National Parks and Protected Areas, Caracas, Mexico.
Wells, S. and A.T. White. 1995. Involving the community. *In* S. Gubbay (ed.). Marine protected areas: principles and techniques for management. Chapman and Hill, London, U.K.
White, A.T. 1984. Marine parks and reserves: management for Philippine, Indonesian and Malaysian coastal reef environments. University of Hawaii, Honolulu, U.S.A. Ph.D. dissertation.
White, A.T. 1987. Philippine marine park pilot site: benefits and management conflicts. Environmental Conservation 14(1):355-359.
White, A.T. and G.C. Savina. 1987a. Community-based marine reserves: a Philippine first, p. 2022-36. *In* Proceedings of Coastal Zone 1987, Seattle, Washington, U.S.A. American Society of Civil Engineers.
––––––––– 1987b. Reef fish yield and non-reef catch of Apo Island, Negros, Philippines. Asian Marine Biology 4:67-76.
White, A.T. 1988a. Marine parks and reserves: management for coastal environments in Southeast Asia. ICLARM Education Series No. 2.International Center for Living Aquatic Resources Management, Manila, Philippines, 36 p.
––––––––– 1988b. The effect of community-managed marine reserves in the Philippines on their associated coral reef fish populations. Asian Fisheries Science 1:27-42.
White, A.T. 1989. Two community-based marine reserves: lessons for coastal management, p. 85-96. *In* T.E. Chua and D. Pauly (eds). Coastal management strategies and case studies. ICLARM Conference Proceedings 19, 254 p.
White, A.T. and V. Palaganas. 1991. Philippine Tubbataha Reef National Marine Park: status, management issues, and proposed plan. Environmental Conservation 19 (2):148-57.
White, A.T. 1992. Impacts of the USAID Natural Resources Management Project on Environment and Management of Bunaken National Marine Park. Jakarta, Indonesia: WWF, Nature Conservancy, and World Resources Institute. Unpublished.
White, A.T. and H. Calumpong. 1992. Saving Tubbataha reef, monitoring marine reserves in the Central Visayas. Summary Field Report, Earthwatch Expedition, Philippines. April-May 1992. Unpublished.
White, A.T., L.Z. Hale, Y. Renard and L. Cortesi (eds). 1994. Collaborative and community-based management of coral reefs. Kumarian Press, Hartford, Connecticut, U.S.A. 130 p.
White, A.T. 1996. Philippines: Community management of coral reef resources, p. 561-567. *In* J. Clark (ed.). Coastal zone management handbook. CRC Lewis Publishers.
White, A.T. and A. Cruz-Trinidad. 1998. The values of Philippine coastal resources: why protection and management are critical. Coastal Resource Management Project, Cebu City, Philippines, 96 p.
White, A.T., P. Christie, M.F. Divinagracia, J. Apurado, A. Alvarado and E. White. 1999. Summary field report: Coral reef surveys for conservation in Southwest Bohol, Earthwatch Expedition to the Philippines. Coastal Resource Management Project, Sulu Fund and Earthwatch Institute, Cebu City, Philippines, 79 p.
White, A.T., C.A. Courtney, M.C. Meyer, A. Alvarado, E. White, J. Apurado and P. Christie. 2000. Summary field report: Coral reef monitoring expedition to Tubbataha Reef National Marine Park, Sulu Sea, Philippines, 21-30 May 2000. Coastal Resource Management Project and the Sulu Fund for Marine Conservation Foundation, Inc., Cebu City, Philippines, 79 p.
White, A.T and H.P. Vogt. 2000. Philippine coral reefs under threat: Lessons learned after 25 years of community-based reef conservation. Marine Pollution Bulletin 40:537-550.
White, A.T., H.P. Vogt and T. Arin. 2000. Philippine coral reefs under threat: The economic losses caused by reef destruction. Marine Pollution Bulletin 40(7):598-605.
White, A.T., A. Salamanca and C.A. Courtney. 2002. Experience with marine protected area planning and management in the Philippines. Coastal Management 30:1-26.

Policy Issues and Caribbean Coral Reefs: Surfing in the Perfect Storm[1]

Boris Fabres

Abstract

Coral reefs provide a variety of services to the continental and island people of the Caribbean. They provide, for example, coastline protection, fish harvests, and, more recently, increased tourism. But reefs have also suffered a long history of associated destruction, resulting from, amongst other things, over-fishing, deteriorating environmental conditions (arising from both local and remote societal stresses), factors linked to globalization (trade fixated on generating foreign exchange through fish exports and coastal tourism), and natural factors such as hurricanes. While similar pressures are occurring globally, the relative scale and accelerating convergence of these major factors, which make "The Perfect Storm", are unprecedented for the Caribbean, and the small island developing states (SIDS), in particular.

Stakeholders (i.e. coastal communities and governmental and inter-governmental agencies), traditionally entrusted as custodians, are fragmented and uncompetitive compared with proponents articulating a "use-first" approach. Conservation initiatives have been uncoordinated, information management and exchange are poor, and non-governmental interventions remain relatively under-developed. Country capacities are also swamped by a multitude of less than coherent agreements, conventions, "soft law", and national and other programs. Generating change and improvements through formal policy development (which presumes a high level of rational management), or through loosely devolved community action, has not been and is unlikely to prove effective. However, an adequate basis on which to initiate interventions does exist. On this basis must be built strategies and reforms that will lead to the development and communication of a clear, informed vision; changes in national structures of governance (including change in institutional, legal and policy components); equitable and participatory mechanisms; sharing of experiences (that take advantage of modern and traditional means); and development of livelihood options in order to reduce impacts while addressing valid societal and security needs.

Introduction

Traditionally, the Caribbean has been seen as the group of English-speaking islands (mostly, small island developing states – SIDS) in the western central Atlantic Ocean. Geographically, politically, and out of a necessity to ensure effective aquatic resource management, however, the concept of a "Wider Caribbean Region" has emerged. (This region is recognized as such by the United Nations Environment Programme, UNEP.) The wider Caribbean region reaches from the southeastern USA to the Guyana region of South America and represents over forty discrete political entities and countries with a rich diversity of heritage, culture, language, societal structure, and economic capacity. Even within the island chain, a rich historical diversity exists and is reflected in linguistic and cultural features that challenge systems of government, policy development, and regional integration. Over 230 million people are estimated to live in the Caribbean basin, with over 50 million of these in coastal areas (Schumacher et al. 1996).

Regional use of coastal aquatic resources, in particular coral reefs, has in the past been largely limited to fisheries and, more recently, to coastal and ecotourism. However, despite its historical roots in indigenous, small-scale and subsistence levels, fisheries received little attention during the colonial period compared with agriculture,

[1] WorldFish Center Contribution No. 1722

forestry, or mining. Trade in fishery products was largely biased towards imports from metropolitan countries. Post-colonial interventions in the Caribbean generally encouraged open-access fisheries with stress on state-subsidized mechanization and industrialization, joint-venture operations, and greater interest in fish exports, particularly of high-priced species. Coastal tourism continued to play a modest role, except in some island states (for example, Antigua and Barbuda, St. Lucia, the Bahamas, Barbados, the Netherlands Antilles, and Jamaica), where it emerged as a leading contributor to the gross domestic product (GDP) and employment. In most cases, however, economic development remained largely land-based with negative externalities for coastal aquatic resources (e.g. pollution, sedimentation, and habitat destruction) remaining unquantified or largely ignored.

A number of coinciding international economic and political changes resulted in mixed returns for Caribbean countries in terms of the restoration and conservation of the natural resources. The 1980s and 1990s saw a period of externally derived macro-economic structural adjustments and sectoral re-organization of national Caribbean economies. Additionally, during the period 1991-97, Caribbean islands in particular experienced drastic reductions in overseas development assistance (from US$688 million to only US$212 million) and financing (from US$710 million to less than US$17 million). Conversely, between 1990 and 1997, foreign direct investment increased from US$154 million to over US$1 billion, with 77 per cent going to just three countries (Brunton 2000). Associated globalization initiatives linked to trade, investment and market access resulted in re-focusing of economies in response to international investment priorities. In aquatic-related sectors they further stimulated fish exports, with accompanying changes in internal marketing and distribution systems, upward pressures on domestic prices of fish, and changing consumption patterns. They also linked national fisheries management policies and programs into a regional and international framework. A number of international and regional, environmental and fisheries-related agreements, conventions, and soft laws aimed at providing the framework for comprehensive conservation and management also evolved in this period. More continue to be developed, with existing ones developing specific protocols and/or promoting specific actions, for example, ecosystem-based management. These have placed significant administrative and scientific demands on Caribbean countries (Chakalall and Gumy 2001).

In related developments, regional tourism, especially coastal tourism (involving hotels, cruise lines and diving), significantly increased. A regional marketing emphasis and a generic promotion of "Sea, Sand, Sun", leading to a concentration of tourist facilities and activities in the coastal zone, have made this sector a significant economic contributor, especially in island states. It is now identified (UNEP/CEP 1997) as the sector of the regional economy that makes the greatest use of coastal and marine resources. Tourism statistics generated by various studies are somewhat variable (due to geographical interpretations of the Caribbean, difficulties in interpretation of travel objectives and durations, and varying access to private sector data). However, existing data indicate tourism's significant importance. Tourism-related employment has been estimated at between 500 000 and 2.9 million people (the latter figure representing 25 per cent of the work-force), with 18.8 to 35.5 million tourists annually (Burke et al. 2000; UNEP 1999). In 1998, gross revenue to the region was estimated at US$28 billion (Burke et al. 2000). Contributions to GDP were estimated at between 3.3 per cent and 46.2 per cent for island states; and between 0.9 per cent and 7.7 per cent for continental states (Association of Caribbean States Website: http://www.acs-aec.org). The region is estimated to attract approximately 57 per cent of international scuba diving tours (with such tours forecast to generate US$1.5 billion by 2005), and approximately 50 per cent of the world's cruise ship berths (C/LAA 1997) associated with up to 13.4 million cruise liner visitors annually (UNEP 1999).

In comparison, available data for fisheries in the island states indicate sectoral employment of 130 000 persons (1.8 per cent of the work-force), US$150 million in annual export earnings, and a contribution (not including the fish processing sector) of 0.3 to 8.0 per cent to countries' GDPs (Hamilton and Associates 2001).

A historical perspective

The historical use of Caribbean coral reef resources has been well documented (Jackson 1997 and 2001; Jackson et al. 2001; Wing and

Reitz 1982; and Wing and Wing 2001). The archaeological record demonstrates that, in the pre-colonial period, such coastal resources were among the primary protein sources for island inhabitants, particularly in small islands. Even then, there was evidence of over-fishing of large specimens of some reef species, manifested by decreases in the average weight of the fish caught, in mean trophic levels, in reef fish biomass and in species compositions (Wing and Reitz 1982; Wing and Wing 2001). By about 1 800 in the central and northern Caribbean, and by 1 900 in other parts of the Caribbean, turtle populations had been decimated. This contributed to a combination of seagrass overgrowth and disease, increasing densities of lower level herbivores (e.g. the Black Sea Urchin *Diadema antillarum*), and increasing susceptibility to disease, all of which contributed to ecosystem changes to coral reefs.

Socially, Price (1966) argues that fishing provided colonized populations with a means to escape the plantation system and slavery, to increase their status in society, and to develop a sense of independence. Additionally, with unregulated access, with little or no need for financial inputs compared with agriculture, and with little need for formal education compared with urban commerce, fishing as a means of livelihood also developed as an employment of last resort. Apart from fishing, coral reefs also provided other extractive functions. For example, reefs were mined as a source of building materials, with coral exports from the Caribbean to England documented over 200 years ago (Tattersfield 1998). The growth of colonial mono-crop agriculture (e.g. sugarcane, coffee, and cocoa), which was linked to deforestation, also contributed to degradation of coastal waters by way of increased freshwater runoff and sedimentation (Watts 1987). In some countries, such as Barbados and Antigua and Barbuda, removal of almost all forest cover had been completed 200-300 years ago (Watts 1993). At present, over 90 per cent of the original forest cover in the Caribbean has been lost (Brooks and Smith 2001). The biological and social bases for unsustainable use and degradation of Caribbean coral reefs were established centuries ago.

Status of Caribbean reefs

The Caribbean contains an estimated 9 per cent (23 000 km^2) of the global coral reef area (Spalding and Greenfeel 1997). The benefits of these reefs are enjoyed across sectors, and the goods, ecological services and functions provided are consistent with similar contributions globally. They are food products, raw materials (mining and medicinal), physical shoreline protection and accretion, ecosystem and biogeochemical maintenance, cultural and heritage services, and recreation and tourism opportunities (Moberg and Folke 1999). The Caribbean Sea connects the island archipelago with continental countries of North, Central and South America and has been defined as one large marine ecosystem bordering three others (Longhurst 1998). It is downstream from major continental river systems that generate over 20 per cent of global freshwater and 12 per cent of sediment outflows into the Atlantic Ocean, with the region also receiving major inflows of deep water from the Atlantic. Eight major river systems flowing into the basin drain catchment areas of approximately 7.5 million km^2, with the major river systems of northeast South America (Amazon, Orinoco, Magdalena) dominating surface conditions (Bidigare et al. 1993; Gallegos 1996; Muller-Karger et al. 1989). The region is also exposed to seasonal hurricane activity, with an increasing activity trend projected to persist for the next 10 to 40 years (Goldenberg et al. 2001), and to atmospheric dust storms originating in Africa. These dust storms annually transport across the Atlantic Ocean and deposit in the Caribbean basin hundreds of millions of tonnes of soil (Prospero and Nees 1986).

The Caribbean has been classified as one of the world's leading "biodiversity hotspots" in terms of the number of endemic species, and the exceptional loss of habitats, species extirpations and extinctions (Myers et al. 2000). Caribbean coral reefs and associated resources are particularly degraded. On a regional basis, 61 per cent of reefs have been classified as either high risk (29 per cent) or medium risk (32 per cent). For the Lesser Antilles the diagnosis is worse, with 80 per cent and 20 per cent classified as high risk and medium risk respectively (Bryant et al. 1998). Extensive areas are characterized by declining populations of reef-building corals, increasing abundance of fleshy algae and sponges, increasing bio-erosion rates, and, in heavily fished areas, finfish populations with reduced densities, smaller individuals and altered species compositions (Bouchon et al. 1987; Rogers 1985; Smith et al. 1997). Coral species that have dominated shallow reefs for over 500 000 years (e.g. *Acropora* spp.) have markedly declined since the 1980s (Jackson et al. 2001). Highest negative impacts are reported on reefs situated on narrow shelves adjacent to high population centers (Woodley et al. 1997), with reef fish in the Lesser Antilles island chain identified as "extremely over-exploited" (Mahon 1993). Other reef-associated resources, such as the spiny lobster (*Panulirus argus*) and queen conch (*Strombus gigas*), which are particularly in demand on export and tourism markets, are also under pressure in the region due to unsustainable fishing levels in many areas (FAO/WECAFC 2001; WECAFC 2001). Central American (continental) reefs are, however, reported to be in generally good condition compared with island systems (Cortes 1997).

Dramatic phase-shifts of dominant species have resulted in reefs normally dominated by corals losing coral cover and being dominated by macroalgal species. This phenomenon has been described in Jamaica from 1977 to 1993 where, at sampled sites, the coral cover across 250 km of coastline at 10 m depth declined from 52 per cent to 3 per cent, and fleshy macroalgae increased from 4 per cent to 92 per cent. Similar, but somewhat smaller, long-term and large-scale changes have been reported in Florida, USA, the Virgin Islands, the Netherlands Antilles, Lesser Antilles, and Panama. In the Bahamas, Ostrander et al. (2000) reported a similar rapid phase-shift over a period of three to four years. For remote reefs in Belize, McClanahan and Muthiga (1998) found the coral/algae ratio changed from 4 to 0.25 over 30 years. Of particular concern to reef habitat integrity is the relatively low species diversity of Caribbean hard corals. Few coral species (relative to the numbers in the Pacific Ocean) dominate; larval recruitment and recovery rates after massive adult mortality (such as that induced by hurricanes, disease or visitor damage) are low (Kojis and Quinn 1993; Sammarco 1985). Settlement and survival of coral recruits is further negatively affected by the expanded macroalgal cover, which prevents both coral recovery and herbivory (Hughes and Tanner 2000). Shifts also occurred in Caribbean reefs following events in the 1980s and 1990s whereby brooding corals came to dominate reefs that previously supported corals that reproduced by broadcasting. The restoration of such ecosystems to original states has been postulated by Knowlton (2001) and Scheffer et al. (2001) to require a combination of changes of biological, physical and chemical factors at more significant levels than those which initiated the negative changes.

On the basis of recent unprecedented marine epidemics, Harvell et al. (1999) have also characterized the Caribbean marine environment as a "disease hotspot". A global review of coral reef epizootiology by Green and Bruckner (2000) notes that a "disproportionate number of records, 66 per cent, describe observations of disease in 38 nations of the Wider Caribbean", with diseases recorded globally in 54 nations. Similar reviews (e.g. Antonius and Ballisteros 1998; Goreau et al. 1998) document the rapid spread of coral-associated diseases and their transmissibility in the Caribbean. Major events include widespread and rapid eradication from reefs of the algae-grazing Black Sea Urchin *Diadema antillarum* in 1983-84, with approximately 95 per cent mortality of the sea urchin (Lessios et al. 1984) enforcing the phase-shift to macroalgae reef domination. Sea urchin populations are only now slowly recovering, and in some areas they are being replaced by other species (Moses and Bonem 2001). The destruction in the 1980s of the main reef-building corals, such as *Acropora* spp. and *Monastrea* spp., reduced the former to scattered patches in many locations (Knowlton 2001). The infection and destruction of sea fans, *Gorgonia* spp. on reefs of Caribbean islands (i.e. the Bahamas, Jamaica, Puerto Rico, the British Virgin Islands, Cayman Islands, the Netherlands Antilles, Dominican Republic, the Lesser Antilles, and Trinidad and Tobago) and on continental reefs of Costa Rica, Panama and Colombia have been reported by Nagelkerken et al. (1997a; 1997b).

Priorities and issues for Caribbean coral reef management

In a compilation of priorities for research into Caribbean coral reef management, McManus (2001) lists 29 issues in four thematic areas. These areas are scientific needs for integrated coastal zone management; coral reef mapping and remote sensing; coral reef health and connectivity; and bleaching and diseases of coral reef organisms. Laydoo (1994) identified seven thematic areas for reef research in the Eastern Caribbean, noting the shortage of trained personnel as the main constraint to addressing the threats. GESAMP (2001) lists 20 factors, ranging in scale from local to global, which cause deterioration of the marine environment or which should be considered as threats, identifying within the wider Caribbean the two (land-based) priorities of inadequately treated domestic sewage and agricultural practices that result in pollution of the coastal zone. Hallock et al. (1993), Siung-Chang (1997), and UNEP/CEP (1994) link these factors to increasing nutrient-loading, eutrophication, sedimentation and pollutants in coastal areas of the Caribbean. Untreated sewage originating from hotels has been particularly identified in tourist-dependent economies as the major source of coastal pollution, with 75 to 90 per cent of hotels cited as inadequately treating wastewater (Island Resources Foundation 1996; UNEP/CEP 1997). The contribution of nutrient-loading to algal blooms and to eventual phase shifts on reefs that led to reduction of coral cover has been reported in a number of studies (e.g. Aronson and Precht 2000; Lapointe 1997).

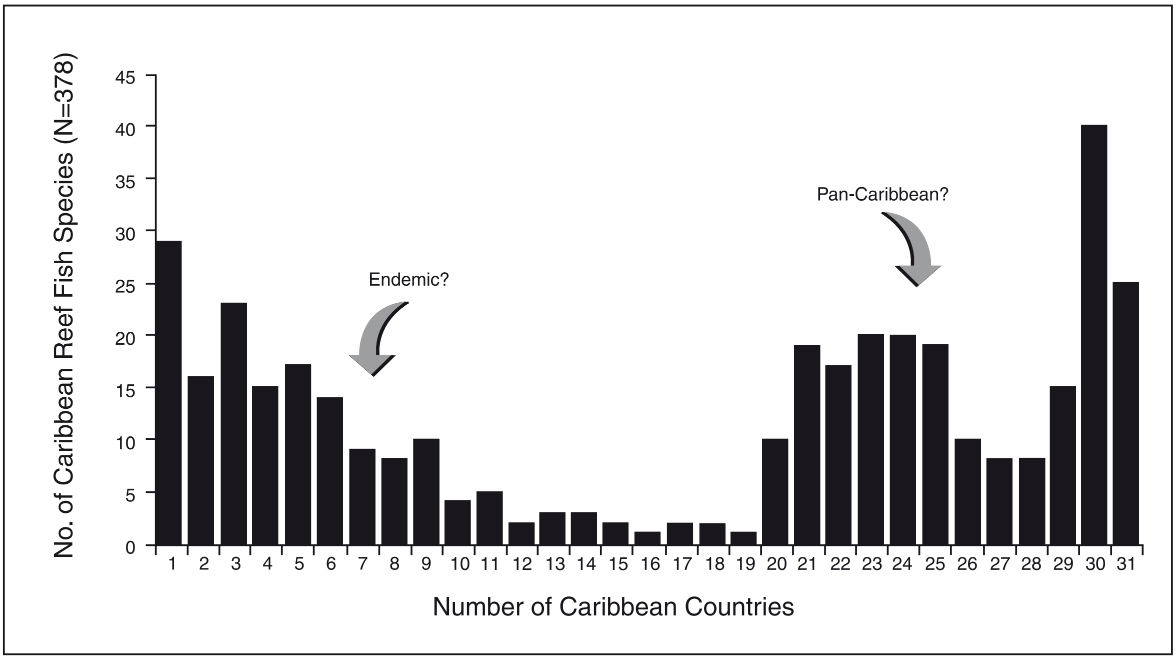
Reef damage, reef species changes and reduction of coral cover are also linked to local and foreign tourism and fishing, including snorkeling, diving, and related anchoring and grounding of vessels (Hawkins et al. 1999; UNEP 2001). On a larger geographic scale, perennial hurricane damage to Caribbean reefs also leads to reduced coral cover and species changes. Possible links between coral reef disease/mortality and the trans-Atlantic dust storms originating in Africa have been hypothesized by Ryan (2001), Schmidt (2001), Shinn (2001; 2000), and Shinn et al. (2000), based on the identification of pathogens known to cause Caribbean coral disease, peak storm activity related to diseases, and the rapid spread of diseases.

Smith et al. (1996) suggested sediment, discharged by rivers as a result of increased deforestation and agriculture and carrying the terrestrial pathogenic fungus *Aspergillus* spp., as the possible cause of coral disease and mortality in Caribbean sea fans (*Gorgonia* spp.). Similarly, Siung-Chang and Lum-Kong (2001) have identified river discharge as a carrier of the bacterium *Streptococcus iniae*, with possibly links to reef fish-kills in the southern Caribbean. Such impacts of river discharges are likely to increase as many Caribbean countries are downstream from the major river systems of northern South America, the countries of which are expanding agriculture, mining, and forestry operations (Bowles et al. 1998).

Over-fishing, particularly of herbivorous species, has been identified as a key controlling agent in Caribbean reefs (Aronson and Precht 2000; Eakin et al. 1997; Hughes 1994). This driving role of over-fishing, identified by Jackson et al. (2001) as the "primacy of over-fishing in human disturbance to marine ecosystems", can also contribute indirectly to eutrophication, disease outbreaks, and the establishment of alien species as native species that help to control them are reduced in number. With few exceptions, as harvesting technology becomes more effective, Caribbean coral reefs are, by most accounts, increasingly heavily fished or over-fished. The reefs remain largely open-access fisheries. In recent years, the additional pull of high prices in foreign fish markets (often encouraged by government subsidies or promotions) along with inadequate effective communication among those responsible for government sectoral policies (e.g. among trade, management and conservation agencies) have further increased fishing pressure on reef fish (Anon. 1998). In CARICOM (Caribbean Community and Common Market) countries, exports of fish and fish products from 1986 to 1998 increased from US$66 million to US$178 million (FAO 2000). A preliminary spatial analysis (Figure 1) of reef-associated fish in the Caribbean Sea from the WorldFish Center's global database FishBase (http: www.fishbase.org) indicates a high degree of endemism – five countries alone account for over 25 per cent of the species, with 29 species documented to occur only in one country. Continuation of unsustainable fishing patterns (particularly as many reef species are caught in a multi-species complex by fish-traps) and/or localized environmental degradation can realistically lead to extinctions.

In summary, therefore, the origins of the present state of Caribbean reefs can be traced to a number of factors:

1. A history of colonial (absentee) metropolitan interests promoting mono-crop agriculture at the expense of both terrestrial (forest/watershed) and coastal ecosystems.
2. A booming coastal-based tourist industry that, until recently, focused on short-term gain and ignored environmental impacts.
3. The economic geography of the Caribbean Sea as a major sea-lane, especially for merchant shipping and oil tankers, that has resulted in maritime pollution.
4. An increased orientation of regional economies towards fish exports in response to foreign demand for fish and fish products that increases pressure on Caribbean fish stocks.
5. The relatively low status and support for national environmental and fisheries administrations within governments, diminishing capacity for conservation leadership, incoherent national planning, and maintenance of open-access fisheries policies.



Summary Statistics

Estimated number of reef species : 378 (-10% of total species)
Range (species number/country) : 78 - 292
Threatened (IUCN Red List) : 17

Source: FishBase (www.fishbase.org)

Figure 1. Distribution of reef-associated fish species by Caribbean country

6. An, until recently, inadequate external agency, governmental or societal attention to the impacts on aquatic ecosystems of industrial, agricultural and fishery development.

These factors result partly from macro-economic adjustment programs, rising poverty and unemployment levels, and demands for immediate societal benefits (including subsidies and incentives) to cushion social impacts. An exacerbating factor has been the inadequate valuation of coastal ecosystems, in which market and consumption uses are considered, but non-market services and functions, along with inter-generational considerations, the social capital of coastal communities and societal values, are ignored. The continued application of traditional valuation approaches, and national accounts that do not incorporate negative externalities, leave aquatic ecosystem restoration issues disadvantaged, especially in comparison with other issues that are more convincingly articulated, marketed, and financed.

Despite this, Jameson et al. (1995) and Wilkinson et al. (1997) reported that the region places comparatively strong emphasis on coral reef conservation and management, associated with a significant research capability. Problems, however, exist with applications of the results of research. For example, the pioneering work of Munro from 1969 to 1973 on Jamaican coral reef fish (synthesized in Munro 1983), which essentially launched international tropical stock assessment, was never applied in management. Some subsequent, specific management-oriented activities (e.g. the regional coordination of research and management on spiny lobster (FAO/WECAFC, 2001), have, however, fared better. Except in specific cases, the relatively ineffective status of conservation and management agencies within national governments, and inadequate coordination with local non-governmental organizations and coastal communities, have constrained effective action. Even in successful cases, results tend not to be replicated to other sites.

Policy and beyond policy: The primacy of intervention

Interventions related to Caribbean aquatic resources have positive and negative aspects, both in content and in the focus of applications. Conservation-designed trade sanctions, fishing effort controls and quotas (e.g. those of the

International Commission for the Conservation of Atlantic Tunas (ICCAT) on large pelagic species; USA trade restrictions for shrimp and swordfish imports; and the Convention on International Trade in Endangered Species (CITES) quotas for queen conch) are increasing. It is likely that there will be attempts to extend this approach to reef fish and other internationally marketed species. Most Caribbean countries are signatory to, and have ratified, a large number of international and regional conventions and agreements. They have indicated support for similar non-legal instruments, and developed broad policies consistent with them. Within the region, however, use of perverse financial incentives and subsidies continue in fisheries, agriculture, and coastal and watershed industrial and tourism development.

National policy development itself is expressed through a myriad of pathways (Turner and Hulme 1997) – often reflecting national governance culture – with varying levels of formality and inter-agency support, and with practice often becoming *de facto*, legal or accepted policy. However, implementation of formal agreements has proved, to say the least, challenging, even in countries in the region with relatively high financial and human capacity. Nevertheless, framework initiatives continue. Examples are the recent adoption, based on a submission by Caribbean countries, by the United Nations General Assembly (Resolution 54/225) of a "Resolution to promote an integrated management approach to the Caribbean Sea area in the context of sustainable management", and a regional proposal to establish the Caribbean as a "Regional Sustainable Tourism Zone" (ASC 2001).

The many biophysical, societal, and governance phenomena (at local, national, regional and international levels) that have converged to contribute to the state of Caribbean coral reef resources are overwhelming, and need addressing at these scales. In general, degradation of reefs has occurred faster than restoration attempts, and it is clear that the crisis has not been adequately articulated, nor human capacity consolidated or targeted to address it. The challenges, particularly to SIDS, are immense. While more focused research, policy frameworks and development and legislation are needed, they are not the limiting factors; the region does not suffer from a lack of such tools. (In fact, a broad review of the literature indicates the opposite.) Nor does it suffer from a lack of case studies of successful (and unsuccessful) management experiences and reviews. The Caribbean experience does, however, point to a need for basic data and information consolidation and for exchange across language and sectoral barriers. A recent institutional review for Caribbean SIDS (ECLAC-CDCC/IDRC/UNEP 1997) points to fundamental problems in locating and exchanging data and information, and in the availability of skilled personnel in information management. In developing solutions for the conservation and management of Caribbean coral reefs, consideration should be given to customizing (i.e. developing Caribbean and reef site versions) and developing management interfaces and tools for the global databases/ information systems developed by WorldFish (i.e. ReefBase (Vergara et al. 2000; http://reefbase.org) and FishBase (Froese and Pauly 2000; http://fishbase.org).

The challenge of developing ways to restore Caribbean reefs lies not in attempts to short-circuit the traditional national (or regional) planning and policy process, but in incorporating them adaptively and progressively. The immediate target should be the restoration of coral cover, in particular in areas where loss has been related to the linked phenomena of algal over-growth and/ or over-fishing of reef fish. Additionally, as an end in itself and also as a motivator to facilitate societal support, valuation and multiple-use decision support studies should be undertaken. It is essential that stakeholder communities, civil society, and private enterprise be fully engaged, not only as essential partners and co-leaders, but also as supporters of governmental efforts, able to address historical and current governance constraints. Tools and mechanisms for such involvement are necessary. In particular, the welfare of communities whose livelihoods are presently dependent on reef systems needs to be assured. It is further suggested that, in order to gain acceptance, approaches be structured in a business plan framework rather than as a traditional research or resource management project.

Recognition of the scales of converging forces that affect Caribbean coral reefs requires regional and international collaboration. Given the need for experience-sharing and the practical limitations of any one location's or country's efforts, such collaboration is essential in all initiatives. Creative efforts to bridge the gap between the public and private sectors need to be adopted through civil contracts. The energies of volunteers, students and the vast potential of committed youth should be harnessed. Given the unprecedented rate of convergence of the causative factors of coral reef decline, and the experiences of previous initiatives, such non-traditional approaches must be emphasized and assume a central role.

References

Anon. 1998. London loves exotics. Fishing News International, March 1998, 16 p.

Aronson, R.B and W.F. Precht. 2000. Herbivory and algal dynamics on the coral reef at Discovery Bay, Jamaica. Limnol. Oceanogr. 45(1):251-255.

Antonius, A. and E. Ballisteros. 1998. Epizoism: A new threat to coral health in Caribbean reefs. Rev. Biol. Trop. 46(Suppl. 5):145-156.

ASC. 2001. Draft convention establishing the sustainable tourism zone of the Caribbean. Presented at the 7th Meeting of the Special Committee on Tourism, 1-2 June 2001, Panama City, Panama. Association of Caribbean States (ASC), 15 p.

Bidigare, R.R., M.E. Ondrusek and J.M. Brooks. 1993. Influence of the Orinoco River outflow on distributions of algal in the Caribbean Sea. J. Geophysical Res. 98(C2):2259-2269.

Bouchon, C., Y. Bouchon-Navaro, M. Louis and J. Laborel. 1987. Influence of the degradation of coral assemblages on the fish communities of Martinique (French West Indies). Proc. 38th Gulf and Caribbean Fisheries Institute, Trois-Ilet, Martinique, Nov. 1985:452-468.

Bowles, I.A., A.B. Rosenfeld, C.A. Sugal and R.A. Mittermeier. 1998. Natural resource extraction in the Latin American tropics: A recent wave of investment poses new challenges for biodiversity conservation. Policy Brief Number 1, Spring 1998. Conservation International, Washington, D.C., 12 p.

Brooks, T. and M.L. Smith. 2001. Caribbean catastrophes. Science 294:1469-1470.

Burke, L., Y. Kura, K. Kassem, C. Revenga, M. Spalding and D. McAllister. 2000. Pilot analysis of global ecosystems: Coastal ecosystems. World Resources Institute, Washington D.C., 77 p.

Brunton, D. 2000. Aid effectiveness in the Caribbean: Revisiting some old issues.

Caribbean Development Bank Staff Working Paper No. 3/00, May 2000:11 p.

Bryant, D., L. Burke, J. McManus and M. Spalding. 1998. Reefs at risk: A map–based indicator of threats to the world's coral reefs. WRI, ICLARM, WCMC, UNEP, 56 p.

Chakalall, B. and A. Gumy. 2001. Globalization and sustainable development in relation to fisheries in the Western central Atlantic region. *In* U. Tietze (ed.). Report of the regional workshop on the effects of globalization and deregulation on fisheries in the Caribbean. Castries, St. Lucia. FAO Fisheries Report 640.

C/LAA. 1997. Caribbean basin profile. Caribbean Publishing Company Ltd., Florida.

Cortes, J. 1997. Status of Caribbean coral reefs of Central America. Proc. 8th Int. Coral Reef Symposium, Panama City. 1:335-340.

Eakin, C. M., J.W. McManus, M.D. Spalding and S.C. Jameson. 1997. Coral reef status around the world: Where are we and where do we go from here? Proc. 8th Int. Coral Reef Symposium. Panama City. 1:277-282.

ECLAC-CDCC/IDRC/UNEP. 1997. Environmental information management in the Caribbean. Caribbean Ministerial Meeting on the implementation of the Programme of Action for Sustainable Development of SIDS, 10-14 Nov. 1997, Barbados.

FAO. 2000. The state of world fisheries and aquaculture 2000. FAO Fisheries Department, Food and Agriculture Organization of the United Nations, Rome, Italy, 142 p.

FAO/WECAFC. 2001. Report of the FAO/DANIDA/CFRAMP/WECAFC Regional workshops on the assessment of the Caribbean spiny lobster (*Panulirus argus*). 21 April-2 May 1997, Belize City, Belize, and 1-12 June 1998, Merida, Yucatan, Mexico. FAO Fisheries Report 619, 381 p.

Froese, R. and D. Pauly (eds). 2000. FishBase 2000: Concepts, design and data sources. ICLARM – The WorldFish Center, Penang, Malaysia, 344 p.

Gallegos, A. 1996. Descriptive physical oceanography of the Caribbean Sea. *In* G.A. Maul (ed.). Small islands: Marine science and sustainable development coastal and estuarine studies. Amer. Geophys. Union 51:36-55.

GESAMP (IMO/FAO/UNESCO-IOC/WMO/WHO/IAEA/UN/UNEP) Joint group of experts on the Scientific Aspects of Marine Environmental Protection) and Advisory Committee on Protection of the Sea. 2001. Protecting the oceans from land-based activities, land-based sources and activities affecting the quality and uses of the marine, coastal and associated freshwater environment. Rep. Stud. GESAMP No. 71, 162 p.

Goldenberg, S.B., C.W. Landsea, A. M. Mestas-Nuñez and W.M. Gray. 2001. The recent increase in Atlantic hurricane activity: Causes and implications. Science 293(5529):474-479.

Goreau, T.J. J. Cervino, M. Goreau, R. Hayes, L. Richardson, G. Smith, K. DeMeyer, I. Nagelkerken, J. Garzon-Ferrera, D. Gil, G. Garrison, E.H. Williams, L. Bunkley-Williams, C. Quirolo, K. Patterson, J.W. Porter, K. Porter. 1998. Rapid spread of diseases in Caribbean coral reefs. Rev. Biol. Trop. 46(Suppl. 5):157-171.

Green, E.P. and A.W. Bruckner. 2000. The significance of coral disease epizootiology for coral reef conservation. Biological Conservation 96(2000):347-361.

Hallock, P., F. Muller-Karger and J.C. Hales. 1993 Coral reef decline. National Geographic Research and Exploration 9(3):358-378.

Hamilton, T. and Associates. 2001. Fourth Edition. Draft final report on strategic plan for CRFM for the CARICOM fisheries unit. 19 October 2001, Kingston, Jamaica. 127 p.

Harvell, C.D., K. Kim, J.M. Burkholder, R.R. Colwell, P.R. Epstein, D.J. Grimes, E.E. Hofmann, E.K. Lipp, A.D.M.E. Osterhaus, R.M. Overstreet, J.W. Porter, G.W. Smith and G.R. Vasta. 1999. Emerging marine diseases – Climate links and anthropogenic factors. Science 285:1505-1510.

Hawkins, J.P., C.E. Roberts, T. van't Hof, K. de Meyer, J. Tratalos and C. Adams. 1999. Effects of recreational scuba diving on Caribbean coral and fish communities. Conservation Biology 13(4): 888-897.
Hughes, T.P. 1994. Catastrophes, phase shifts and large-scale degradation of a Caribbean reef. Science 265: 1547-1551.
Hughes, T.P. and J.E. Tanner. 2000. Recruitment failure, life histories and long-term decline of Caribbean Corals. Ecology 81(8):2250-2263.
Island Resources Foundation. 1996. Tourism and coastal resources degradation in the wider Caribbean: A study by Island Resources Foundation, St. Thomas, Virgin Islands December 1996, 48 p. http://www.irf.org/irtourdg.html
Jackson, J.B.C. 1997. Reefs since Columbus. Coral Reefs 16(Suppl.):S23-S32.
Jackson, J.B.C. 2001. What was natural in the coastal oceans? Proc. Natl. Acad. Sci. 98(10):5411-5418.
Jackson, J.B.C., M.X. Kirby, W.H. Berger, K.A. Bjorndal, L.W. Botsford, B.J. Bourque, R.H. Bradbury, R. Cooke, J. Erlandson, J.A. Estes, T.P. Hughes, S. Kidwell, C.B. Lange, H.S. Lenihan, J.M. Pandolfi, C.H. Peterson, R.S. Steneck, M.J. Tegner and R. Warner. 2001. Historical overfishing and the recent collapse of coastal ecosystems. Science 293:629-638.
Jameson, S.C., J.W. McManus and M.D. Spalding. 1995. State of the reefs: regional and global perspectives. ICRI Background Paper, May 1995, 45 p.
Knowlton, N. 2001. The future of coral reefs. Proceedings of the National Academy of Science 98(10):5419-5425.
Kojis, B.L. and N.J. Quinn. 1993. Biological limits to Caribbean reef recovery: A comparison with western South Pacific reefs. *In* R. Ginsburg, J. Bohnsack, A. Mayberg, P.W. Glynn, A. Szmant and P.K. Swart (eds). Global aspects of coral reefs: health, hazards, and history. University of Miami, Miami Florida, USA.
Lapointe, B.E. 1997. Nutrient thresholds for bottom-up control of macroalgal blooms on coral reefs in Jamaica and Southeast Florida. Limnol. Oceanogr. 42: 1191-1131.
Laydoo, R. 1994. The status of coral reef resource systems and current research needs in the Eastern Caribbean. *In* J.L. Munro and P.E. Munro (eds). The management of coral reef resource systems. ICLARM Conf. Proc. 44, 124 p.
Lessios, H.A., D.R. Robertson and J.D. Curt. 1984. Spread of *Diadema* mass mortality throughout the Caribbean. Science 226:335-337.
Longhurst, A.R. 1998. Ecological geography of the sea. Academic Press. San Diego, California, USA, 398 p.
Mahon, R. 1993. Lesser Antilles. *In* Marine fishery resources of the Antilles. FAO Fisheries Technical Paper 326:5-98.
McClanahan, T.R. and N.A. Muthiga. 1998. An ecological shift in a remote atoll of Belize over 25 years. Environmental Conservation 25:122-130.
McManus, J.W. (Compiler) 2001. Priorities for Caribbean coral reef research: Results from an international workshop held in Miami, 5-7 September 2001. www.ncoremiami.org
Moberg, F. and C. Folke. 1999. Ecological goods and services of coral reef ecosystems. Ecological Economics 29:215-233.
Moses, C.S. and R.M. Bonem. 2001. Recent population dynamics of *Diadema antillarum* and *Tripneustes ventricosus* along the north coast of Jamaica. W.I. Bull. Marine Science 68(2):327-336.
Müller-Karger, F., C.R. McClain, T.R. Fisher, W.E. Esais and R. Varela. 1989. Pigment observations in the Caribbean Sea: Observations from space. Prog. Oceanog. 23: 23-64.
Munro, J.L (ed.) 1983. Caribbean coral reef fishery resources. ICLARM Studies and Reviews 7. Manila, Philippines, 276 p.
Myers, N., R.A. Mittermeier, C.G. Mittermeier, G.A.B. da Fonseca and J. Kent. 2000. Biodiversity hotspots for conservation priorities. Nature 403:853-858.
Nagelkerken, I., K. Buchan, G.W. Smith, K. Bonair, P. Bush, J. Garzon-Ferreira, L. Botero, P. Gayle, C. Heberer, C. Pebrovic, L. Pors and P. Yoshioka. 1997a. Widespread disease in Caribbean sea fans: I. Spreading and general characteristics. Proc. 8th International Coral Reef Symposium, Panama City 1:679-682.
___________ 1997b. Widespread disease in Caribbean sea fans: II. Patterns of infection and tissue loss. Marine Ecology Progress Series 160:255-263.
Ostrander, G.K., K.M. Armstrong, E.T. Knobbe, D. Gerace and E.P. Scully. 2000. Rapid transition in the structure of a coral reef community: The effects of coral bleaching and physical disturbance. Proceedings of the National Academy of Science 97(10):5297-5302.
Price, R. 1966. Caribbean fishing and fishermen: A historical perspective. American Anthropologist 68: 1363-1383.
Prospero, J.M. and R.T. Nees. 1986. Impact of the North African drought and El Niño on mineral dust in the Barbados trade winds. Nature 320:735-738.
Rogers, C.S. 1985. Degradation of Caribbean and Western Atlantic coral reefs and decline of associated fisheries. Proc. 5th International Coral Reef Congress, 1985, Tahiti 6:491-496.
Ryan, J.C. 2001. The Caribbean gets dusted. Bioscience 51(5):334-338.
Sammarco, P.W. 1985. The Great Barrier Reef vs. the Caribbean: comparisons of grazers, coral recruitment patterns and reef recovery. Proc. 5th International Coral Reef Congress, 1985, Tahiti, 4:391-397.
Schmidt, L.J. 2001. When the dust settles. DAAC Alliance, http://earthobservatory.nasa.gov/Study/Dust/ (Downloaded 18 May 2001).
Schumacher, M., P. Hoagland and A. Gaines. 1996. Land-based marine pollution in the Caribbean: incentives and prospects for an effective regional protocol. Marine Policy 20(2):99-121.
Scheffer, M., S. Carpenter, J.A. Folke and B. Walker. 2001. Catastrophic shifts in ecosystems. Nature 413:591-596.
Shinn, E.A. 2001. Coral mortality and African dust. USGS Center for Coastal Geology FY 1998 Projects: Coral Mortality and African Dust. http://coastal.er.usgs.gov/african_dust/
Shinn, E.A. 2000. African dust causes widespread environmental distress. USGS Information Sheet, U.S. Department of the Interior, U.S. Geological Survey, 4 p.
Shinn, E.A., G.W. Smith, J.M. Prospero, P. Betzer, M.L. Hayes, V. Garrison and R.T. Barber. 2000. African dust and

the demise of Caribbean coral reefs. Geophysical Research Letters 27(19):3029-3032.
Siung-Chang, A. 1997. A review of marine pollution issues in the Caribbean. Environmental Geochemistry and Health 19:45-55.
Siung-Chang, A. and A. Lum-Kong. 2001. Possible link between reef-fish mortalities in the Southeast Caribbean and South American river discharge (July-October 1999). Bulletin of Marine Science 68(2): 343-349.
Smith, G.W., L.I. Ives, I.A. Nagelkerken and K.B. Ritchie. 1996. Caribbean sea fan mortalities. Nature 383:487.
Smith, A.H., S. Rogers and C. Bouchon. 1997. Status of Western Atlantic coral reefs in the Lesser Antilles. Proc. 8th Int. Coral Reef Symposium, Panama City 1: 351-356.
Spalding, M. D. and A. M. Greenfeel. 1997. New estimate of global and regional coral reef areas. Coral Reefs 16: 225-230.
Tattersfield, N. 1998. The forgotten trade: comprising the log of the *Daniel and Henry* of 1700 and accounts of the slave trade from the minor ports of England, 1698-1725. Random House Publishing.
Turner, M. and D. Hulme. 1997. Governance, administration and development: Making the State work. MacMillan Press Ltd.
UNEP. 2001. Coral reefs: An ecosystem under threat. Tourism impacts on coral reefs: the Caribbean example. UNEP Tourism Production and Consumption Unit. 4 p. http://www.uneptie.org/pc/tourism/sensitive/coral
UNEP. 1999. Assessment of land-based sources and activities affecting the marine, coastal and associated freshwater environment in the wider Caribbean Region. UNEP/GPA Coordination Office and Caribbean Environment Programme, UNEP Regional Seas Reports and Studies 172, 121 p.
UNEP/CEP. 1997. Coastal tourism in the wider Caribbean region: impacts and best management practices. CEP Technical Report 38, 84 p.
UNEP/CEP. 1994. Regional overview of land-based sources of pollution in the wider Caribbean region. CEP Technical Report 33, 36 p.
Vergara, S., J.W. McManus, K.N. Keisner-Reyes, L.A.B. Menez, R.Z. Funk, R.C. Evangelista, M. Noordeloos, A.M.B. Serrrana, M.F.S.J. Rull, V.L. Alarcon, A.B.T. Meneses and J. Glorioso. 2000. ReefBase 2000: improving policies for sustainable management of coral reefs, Ver. 2000, 164 p. + CD-ROM. ICLARM – The WorldFish Center, Penang, Malaysia.
Watts, D. 1993. Long-term environmental influences on development in islands of the Lesser Antilles. Scottish Geographical Magazine 109(3):133-141.
Watts, D. 1987. The West Indies: Patterns of development, culture, and environmental change since 1492. Cambridge University Press, England.
WECAFC. 2001. The status of fisheries resources in the Western Central Atlantic region. Western Central Atlantic Fisheries Commission 10th Session, WECAFC Lesser Antilles Fisheries Committee 7th Session, 24-27 October 2001, Bridgetown, Barbados. WECAFC/X/0/3 E, 14 p.
Wilkinson, C. R., S.J. Brinbridge and B. Salvat. 1997. Assessment of coral reef status using an anecdotal questionnaire: a tool for assessment and management. Proc. 8th Int. Coral Reef Symposium, Panama City 1:283-288.
Wing, E.S. and E.J. Reitz. 1982. Prehistoric fishing economies of the Caribbean. Journal of World Archaeology 5(2):13-32.
Wing, S.R. and E.S. Wing. 2001. Prehistoric fisheries in the Caribbean. Coral Reefs 20:1-8.
Woodley, J. D., J. De Meyar, P. Bus, G. Ebanks-Petrie, J. Garzon- Ferreira, E. Klein, L.P. Poors and C.M. Wilson. 1997. Status of coral reefs in the South Central Caribbean. Proc. 8th Int. Coral Reef Symposium, Panama City 1: 357-362.

Implementing Policy and Strategy for Coral Reef Rehabilitation and Management: Lessons Learnt from an Indonesian Effort

Mohammad Kasim Moosa

Abstract

Indonesia boasts the most diverse coral reef systems in the world and, with some 85.707 km^2 of coral, contains approximately one-eighth of the world's coral reefs. However, the quality of coral reefs in Indonesia is declining rapidly. Anthropogenic threats range from destructive fishing practices to pollution and from dredging to tourism-related damages. For the above reasons, there is an urgent need for rehabilitation and management designed to guarantee sustainable use of Indonesia's finite and valuable marine resources. The Coral Reef Rehabilitation and Management Program (COREMAP) was launched by the Indonesian government in 1998. The overall COREMAP goal is the protection, rehabilitation and sustainable use of coral reefs and associated ecosystem in Indonesia that will, in turn, enhance the welfare of coastal communities. This program is being implemented over a period of 15 years, and involves three phases The specific COREMAP Phase I (the subject of this paper) objective is to establish a viable framework for a national coral reef management system in Indonesia. The program strategy acknowledges that community-based management of coral reefs in Indonesia cannot be successful on a large scale without a supporting framework to contain external threats. This framework needs to include: (i) an effective national strategy for coral reef management; (ii) secure user rights for coastal communities; (iii) effective enforcement to protect communities against external threats; (iv) greater awareness among decision-makers of the threats facing the reefs; (v) effective monitoring systems; and (vi) strengthened management capacity. The COREMAP program addresses these aspects during the initiation phase. This paper describes the policy and strategy and explains the rationale behind their implementation.

Introduction

The Indonesian archipelago is the largest archipelago in the world. It stretches along the equator and is roughly 5 000 km long and 2 000 km wide. It consists of more than 17 000 islands with, altogether, about 81 000 km of coastline. Some of the large islands are Papua (Irian Jaya), Kalimantan, Sumatra, Sulawesi (Celebes), Java, Madura, Bali, and Nusa Tenggara (Lesser Sunda Islands). While the land area is only 1.94 million km^2, the archipelago sea area covers about 3.1 million km^2. Indonesia's 200-mile exclusive economic zone (EEZ) adds a further 2.7 million km^2 of sea area. Overall, the seas and coastal areas are the dominant physiographic features of Indonesia (Soegiarto and Polunin 1981).

Owing to the warm, humid tropical climate and high rainfall, the Indonesian archipelago is blessed with various ecosystems, which flourish along the coasts of the islands and island groups. These ecosystems are the most productive of the archipelago's ecosystems; but, unfortunately, they are also very sensitive and vulnerable to environmental changes and pressures arising from natural or human-induced processes. Coral reef ecosystems, distributed widely in the archipelago, are mainly in the form of fringing reefs. However, there are also limited barrier reefs and atolls.

Coral reefs are a unique and complex tropical shallow water ecosystem. Coral reefs function as living environments, provide physical protection for the ecosystems, are sources of numerous living resources, and are exquisite examples of natural beauty. As a living environment, coral reefs function as a habitat for numerous organisms. Many species are of economic importance. The interdependencies of these organisms with the environment, as well as with other organisms, make the web of life in the coral reef ecosystem one of the most complex on earth, comparable to the humid tropical forests.

Coral reef scientists have noted that Indonesia is the center of coral diversity. It has been reported that 75 genera and about 450 species of scleractinian corals have been recorded in Indonesian and surrounding waters (Borel-Best et al. 1989; Tomascik et al. 1997; Veron 1996).

There are various figures on the extent of coral reef in Indonesia, from a low estimate of 42 000 km^2 (Bryant et al. 1998) to 75 000 km^2 (Cesar 1996) and as high as 85 700 km^2 (Tomascik et al. 1997). COREMAP (Coral Reef Rehabilitation and Management Program) is tasked with providing information on the breadth of Indonesian coral reefs and its geographical distribution. The work is carried out by using remote sensing technology and is almost completed although it still needs an agreement from related technical agencies on some technical bases. It is hoped that, by the end of Phase I (extended to end 2003), the map will have been completed and agreement reached, so that more definite and reliable figures can be used to estimate the value of coral reefs resources.

For centuries, Indonesian coastal communities have benefited from the reefs, be it from renewable resources, such as the variety of reef dependent fish, mollusks, seaweeds and other living resources, or from the non-renewable ones, such as coral rocks, gravels, sand and seashells. More than 10 per cent of the Indonesian fisheries are related to coral reef fisheries. Unfortunately, however, uncontrollable increases in use cause over-fishing and damage to the ecosystem. In the last few decades, the coral reefs in Indonesia have experienced increased human-induced pressures, such as destructive fishing practices that use explosives and toxic chemicals and cause devastating and widespread destruction. Over-extraction of coral rocks, gravels and sand, as well as increasing land-based and marine-based pollution add to the serious disturbances to the coral reef ecosystem throughout the Indonesian archipelago. These human-induced pressures, combined with the natural disturbances such as volcanic activities, earthquakes, tidal waves (tsunami), cyclones, climate change and the outbreak of crown-of-thorns starfish (*Acanthaster planci*), are damaging many reefs in Indonesia. A 1996 economic analysis of Indonesian coral reefs (Cesar 1996) showed that the net cost to Indonesia of large-scale poison fishing amounted to US$48 million in a period of four years. The losses attributed to blast fishing in areas with tourism benefits are estimated at more than 50 times the benefit occurring to the blast fishing.

Suharsono (1998) reported that only about 6 per cent of coral reefs in Indonesia are in excellent condition (75 to 100 per cent coral cover). The rest are in various degrees of damage. Around 40 per cent is in poor condition (less than 25 per cent coral cover); 31 per cent is in moderate condition (26 to 50 per cent cover), and only about 23 per cent is in good condition (51 to 75 per cent cover). In 1998, in view of the critical level of coral reef degradation in Indonesia and the ecological and socioeconomic importance of this resource, the Indonesian government established a long-term action plan called COREMAP, which stands for the Coral Reef Rehabilitation and Management Program. It is supported by the World Bank, Global Environment Facility (GEF), Asian Development Bank (ADB), Australian Development Aid (AusAid), and other donor agencies and countries.

This program will be implemented over a period of 15 years, and involve three phases – Phase I, initiation phase - 3 years; Phase II, acceleration phase - 6 years; and Phase III, internalization phase - 6 years.

This paper deals with the implementation plan of Phase I of COREMAP. This implementation was to have occurred during the period 1998-2001, but was extended until the end of 2003 to provide additional time required for recruiting consultants and procuring equipment.

Background of the program

The Coral Reef Rehabilitation and Management Program (COREMAP) was established by the Government of Indonesia (GOI) to safeguard its coral reefs, the most extensive in the world. The COREMAP goal is the protection, rehabilitation and sustainable use of coral reefs and associated ecosystems in Indonesia. This, in turn, will enhance the welfare of coastal communities. The program's prime objective is to establish viable reef management systems in priority sites. These systems are to be operational, fully decentralized to the regional governments, and institutionalized.

The program at present works in 9 of Indonesia's 32 provinces, with pilot projects in 4 provinces (West Papua (formerly Irian Jaya), South Sulawesi, East Nusa Tenggara (Flores), and Riau).

The World Bank and GEF support of the program comes through a new adaptable program loan (APL) instrument, that provides a long-term commitment to the program subject to satisfactory performance of each phase as determined by benchmark indicators and independent evaluations. Other donors support the COREMAP through complementary parallel projects, following a common design framework.

The program strategy is based on the realization that community-based management (CBM) of coral reefs in Indonesia cannot be successful on a large scale without a supporting framework to deter external threats. This framework needs to include: (i) an effective national strategy for coral reef management; (ii) secure user rights for coastal communities; (iii) effective enforcement to protect communities against external threats; (iv) greater awareness amongst decision-makers of the threats facing the reefs; (v) effective monitoring systems; and (vi) strengthened management capacity. The COREMAP has made the strategic decision to address these aspects during the initiation phase, and to introduce interventions at the site level over a period of 15 years. Lessons learned from pilot locations are applied to a later, expanded acceleration phase. The program strategy therefore involves (a) program maturity, where the initial focus on a strong central project team and national components leads progressively to a decentralized program management at the district level; and (b) geographical expansion, from the initial four sites to priority coral reef sites in 10 provinces.

The setting of national policy and strategy

Policy

Sustainable coral reef management requires an integrated and solid basic framework to guide stakeholders. The framework needs to form the basis of the national policy, to be adopted and implemented by relevant government institutions, and supported by all levels of society. This framework is required because existing laws and regulations for the management of coral reefs in Indonesia are, as yet, insufficiently comprehensive for the management of natural resources.

The National Policy Concept for the Management of Coral Reef in Indonesia (the national policy) was developed in 2001 as a guideline to assist policy and decision-makers involved in coral reef management. There are three important issues requiring consideration – (1) increased coral reef degradation; (2) the need for economic development, specifically for coastal communities; and (3) the rights and responsibilities of the central government, regional governments and communities.

Formulation process

The formulation of the national policy concept involved a preparation stage, literature study, development analysis and conceptualization of the policy. Each stage comprised a number of activities, i.e. meetings, discussions, public consultation (national and regional), team meetings and workshops (national and regional). To consolidate the national policy concept, several meetings, discussions and workshops were held in Jakarta and in the regions (provinces and districts).

Aims, objectives and targets

The policy was designed:

- As a reference or input to assist government institutions and regional authorities prepare regulations;
- As guidelines and directions for the management of coral reefs; and
- As an academic document that can be used in formulating laws and regulations on coral reef management.

The specific aims of the national policy are:

1. To balance the use of the reefs, based on available scientific data and the carrying capacity of the environment;
2. To develop management systems that consider national economic priorities, the

local community and the conservation of coral reef resources;
3. To develop cooperative coral reef management systems involving all parties;
4. To implement formal and informal regulations; and
5. To create an incentive for equitable and balanced management.

It is recognized that successful coral reef management is a combination of science, law and administration relevant to the social, economic and political situation of a province or area and involving all stakeholders in its planning and implementation.

The targets for the policy are:

1. To increase stakeholders' awareness and participation in management of coral reefs;
2. To delegate authority for the management of coral reefs to regional government;
3. To encourage a cooperative approach among stakeholders in the management of coral reef ecosystems;
4. To reduce coral reef degradation;
5. To create a mechanism and framework for the management of scientific data concerning potential, utilization and carrying capacity of coral reef ecosystem; and
6. To implement community-based management in natural resource, especially coral reef management.

Basis of law

The source law for the national policy is the Indonesian Constitution 1945, specifically section 33, and other national laws and regulations, as well as various provincial and district regulations.

The challenge of coral reef management

Several studies on the use of coral reef resources have shown that the degradation of coral reefs is generally caused by either human activity (anthropogenic causes) or natural causes. Human activities causing the degradation of coral reefs include (1) coral mining and taking; (2) catching fish using destructive methods; (3) over-fishing; (4) water pollution; (5) coastal development; and (6) development of surrounding areas.

The degradation of coral reefs by natural causes is related to global warming, storms, earthquakes, floods, tidal waves (tsunamis) and other factors, e.g. El Nino, La Nina, etc.

All human-induced problems can be traced back to underlying factors that form the "root" of the problem. These are:

(1) Inconsistency in the application of policy;
(2) Insufficient management;
(3) Inadequate law and/or enforcement;
(4) Lack of awareness and knowledge about the importance and strategic value of coral reefs in various groups (i.e. politicians, entrepreneurs, the public);
(5) Poverty;
(6) Greed;
(7) Limited capacity and capability of management;
(8) Damaging nature of market demand/consumer behavior;
(9) Culture/customs/manners; and
(10) The status of coral reef areas open to the public.

Rationale for the national policy

National issues

Coral reefs become degraded as a result of changes in human activity and natural conditions. Such changes have resulted in reduced productivity of coral reef resources and reduced biological diversity. The reduced coral reef productivity aggravates the condition of the coastal communities that are dependent on these natural resources.

The government has been aware of and concerned about the condition of coral reefs for a long time. However, this awareness has not yet prevented the continuing degradation of the reefs.

One reason for this is that existing laws and regulations have not been consistently and continuously enforced. This failure has been exacerbated by the fact that the authority and responsibility of government institutions have been poorly defined.

Poor management of coral reefs by the Government is due to:

1. The lack of awareness of the value and the real economic benefits arising from coral reef ecosystems;
2. The weak horizontal and vertical coordinating capacity within and between government institutions;
3. Coral reefs having not yet become a priority issue in the political agenda of the nation's leaders;
4. The poor allocation of funds for managing coral reefs;
5. The poor lobbying skills of environmental groups interested in the conservation and management of coral reefs;
6. Programs that are dependent on one approach, namely the management of conservation areas (national parks, etc);
7. Inconsistent and weak law enforcement; and
8. Coastal communities having not yet been involved in the management of coral reefs.

Effective management of coral reefs in Indonesia thus requires:

1. Clear allocation of authority and jurisdiction among regional governments, provinces, districts or subdistricts/villages in accordance with Act No. 22/1999 t;
2. Clarification and improvement of the various laws and regulations that relate to the management of coral reef resources;
3. Improvement of interagency linkages;
4. Increased funding for coral reefs management;
5. Development of the capacity of personnel to enforce the law;
6. Improved monitoring and evaluation capacity of those involved in implementing coral reef management programs;
7. Commitment to implementing nationally ratified international laws that relate to natural resources management; and
8. Improved attitude towards the role and function of non-governmental organizations, higher education institutions, the local community, and the private sector, etc.

Regional issues

The introduction of Act 22/1999 by the regional government has created the opportunity for local communities to secure greater rights to manage natural resource, especially coral reefs, within their region. However, it should be realized that this has increased the responsibility of local communities. If communities claim and obtain rights to manage coral reef resources in their area, then they should also accept the obligation or responsibility to continuously manage these coral reefs. The responsibility given to communities means that they have an obligation to take on the burden of the sustainable use of the resource. Costs incurred include those associated with management, technical assistance, administration, law enforcement, monitoring resource quality, a likely decrease in the number of fishing units, reduction in fishing areas, reduced incomes at specific times, and the creation of alternative income generating opportunities, etc.

At the regional level, communities are empowered to formulate and plan the management of natural resources under Law No. 22/1999. Under this authority a community for a specific area/region has exclusive rights to the coral reef resources in their area. The definition of area is based on the guidelines under Law No. 22/1999 and several other regulations. Communities have the right to manage, with other parties (private sector), in such a way as to gain income in order to cover the costs incurred in sustainably using their resources. Some of the costs will be borne by the government. Despite this community empowerment, national and regional governments cannot avoid responsibility for coral reef management because some situations, such as uncontrolled population growth, technical issues, etc., will not be easily handled by the community and require government involvement.

Such involvement may include the creation and protection of the rights of a community to manage an area in order to provide a sense of ownership of and responsibility for these resources; the preparation of mechanisms to draw technical assistance and to stimulate innovations from within the community; the creation of schemes for the management of funds; and preparation and coordination of government agencies involved in supporting/helping community management.

It is noted that many coastal communities may have no interest in or capability to manage the reef resource. Rights need to be given only to those people who have shown interest in managing the coral reefs. In addition, governments should focus on assisting with laws and regulations for coastal communities that comprise a majority of poor fishers. Appropriate laws in such cases may include the prohibition of the use of non-traditional fishing gear within waters under the community's control.

The national policy should also consider the management of coral reefs as part of the broader coastal ecosystem that includes, for example, mangroves, seagrass beds, and other wetlands. Therefore, the policy should be designed to address two basic needs – the need to protect and conserve coral reef resources; and the need to manage coral reef resources nationally, to address conflict over its use, and to obtain a balance between use and conservation.

The policy must acknowledge the implications of Law No. 22 of 1999 concerning regional government. This law states that the jurisdiction of regional governments in the management of coastal and marine areas extends to 12 nautical miles. With decentralization, both planning and management are essential and must be implemented by regional governments. Problems or issues must be addressed and resolved through conflict resolution mechanisms involving the various primary stakeholders' interests and perceptions at the appropriate local and regional level.

Many of the scientific and technological principles underlying the management of coral reefs are readily available and easily learned. However, experience and knowledge from one site is often not easily applied to another site. The successful management of coastal resources has to be through the integration of science, policy, law and administration, taking into consideration the social, economic and political situation in each area.

The national policy must create conditions for voluntary partnership between all levels of government that play an important role in the management and conservation of the coral reef in their area. In the meantime, the national government needs to provide funds to organize and improve the administration of management programs that were formerly done at the provincial level. Provinces may receive funds from the national government to develop and implement management programs in accordance with the existing national regulations. The regulations should also refer to the international environment regulations.

As a broad outline, the national government role in the management of coral reefs should be to:

1. Assist in the arrangement of management programs at the regional level;
2. Ensure transparent and open management of assistance funds;
3. Evaluate the implementation of management programs according to appropriate standards;
4. Undertake research for which there is insufficient regional capacity;
5. Actively build the regional capability;
6. Campaign for the national interest in each region; and
7. Arrange and evaluate developments in each region.

Integration of the national policy

Because coral reef management cannot be separated from the management of the broader coastal ecosysytem, the national policy must adopt an integrated approach. In addition, the policy must be in line with national political development and implementation Act No. 22/ 1999 of the regional government. The policy presented a framework to assist the implementation of regional autonomy in the management of coral reef resources in every region.

The national policy is based on the following principles:

- A balance between use and conservation of coral reefs;
- Management conforming with the needs of local communities and national economic priorities;
- Reliance on the execution of formal and non-formal regulations to reach the objective of optimal coral reef management and use;
- Creation of incentives for continuous and fair management;
- The search for cooperative management approaches;
- Formulation of management programs based on available scientific data and the carrying capacity of the environment;
- Acknowledgement of traditional laws and community institutions regarding coral reef management;
- Strengthening of regional authorization in coral reef management in accordance with the spirit of regional autonomy.

These eight principles and the basis of decentralization, whether in planning or implementation, are of great importance and must be upheld. The background and issues, along with the differences in perception and interests, of the majority of stakeholders in each location must be taken into account so that suitable compromises are devised and adopted. It needs to be remembered that, while much scientific knowledge and many technological principles are relatively easy to obtain from various sources in this world, they cannot always be easily transferred from one locality to another.

The national policy aims to balance conservation and use, involving the integrated actions of central and regional governments, civil society, the private sector, higher education institutions and non-governmental organizations. This policy aims to both respond to and anticipate the various causes of the increasing degradation of coral reef ecosystems in Indonesia.

Strategy

In 1999-2000, the PMO-COREMAP in co-operation with the Marine and Coastal Resources Studies Center of IPB (PKPSL – IPB) prepared a Draft on National Policy and Strategy on the Management of Coral Reefs in Indonesia. The Draft was presented, discussed and improved through a series of seven provincial workshops (Makassar/South Celebes; Jayapura/Irian Jaya; Pekanbaru/Riau; Lombok/West Nusatenggara; Kupang/East Nusatenggara; Padang/West Sumatera and Manado/North Celebes) and culminated in a national workshop in Jakarta. The final draft that was fully endorsed by all stakeholders, was then submitted and accepted by PMO-COREMAP. Subsequently the draft was presented to the World Bank.

It was suggested by the World Bank that the policy be separated from the strategies and action plans, and be submitted to the Department of Marine Affairs and Fisheries (DKP), Dewan Maritim Indonesia, and other relevant Departments, for integration into the general policy on the development and management of the marine environment and fisheries.

It was further agreed that the "strategies and action plans" component be presented and discussed, with further inputs from all stakeholders being explored through a series of four district workshops and a national workshop.

The draft material to be discussed at the district level workshops was the edited and revised version of the strategies and action plans (PKSPL-IPB and COREMAP 2000), endorsed by all stakeholders in the series of seven provincial workshops and the national workshop mentioned above. The inputs and proposals from the four district workshops were duly integrated into the revised text of the draft and presented in the national workshop. In turn, the inputs and proposed improvements from the national workshop were integrated into the final version of the "Strategies and Action Plans on the Management of Coral Reefs in Indonesia".

In accordance with the national policy, the strategy and action plans do not specify activities. The detailed activities to be undertaken are selected by stakeholders in accordance with the specific situation, conditions and characteristics of each location. The document provides only guidelines or factors that should be considered if a region or area is planning to manage their coral reefs. Therefore, it should be considered as a living document that should be updated, or revised in accordance with the overall planning of local, regional and national developments.

Strategies and action plans

Strategy 1: ***Empowerment of coastal communities whose livelihoods are directly and indirectly dependent on the management of coral reef ecosystems***

Many coastal communities rely, either wholly or partly, on coral reef ecosystems for their livelihood. It is essential that these communities become involved in the management of the resources so that utilization is optimal, sustainable and equitable. Interest shown by the general public is a major factor in the success of coral reef management programs. Therefore, efforts to empower coastal communities should be directed towards increasing economic activities, management capability and the understanding of ecological functions. To be effective, the rights and obligations of the local communities in the management of ecosystem must be clarified.

Other income generating activities need to be developed to compensate those who are obliged to decrease their dependency on coral reefs. These activities must be developed in accordance with the ability of the local people and market demands.

Strategy 1 has five action plans: (i) development of sustainable options for income generating activities for coastal communities; (ii) development of appropriate and environmentally friendly technologies for coastal communities exploiting the coral reef ecosystem; (iii) enhancing the awareness of coastal communities and officials about their responsibilities in the management of coral reef ecosystems; (iv) delegation of rights, responsibility and legal status for the management of coral reef ecosystems to coastal communities; and (v) enhancing the participation of non-governmental organizations in programs empowering coastal communities.

Strategy 2: ***Reduce the rate of coral reef degradation***

A wide range of activities can have significant impacts on coral reef health. Some of these impacts are generated from within the community and can be reduced through improved technology, improved management, or through the implementation of different income generating activities. However, there are also a number of activities that occur outside the community and that have equally damaging effects. These might be related to poor agricultural practices in the coastal zone, industrial outputs upstream of a community, deforestation leading to siltation, etc.

Improved management could handle problems at the local, regional or national level. By connecting to the regional autonomy, this strategy could improve cooperation between national, provincial and regional governments to implement coral reef management.

Strategy 2 has six action plans: (i) development of specific management techniques or technical interventions, that conform to local conditions; (ii) formulation of appropriate criteria for evaluations undertaken in Environmental Impact Assessments (EIAs) of development projects that directly or indirectly influence coral reef ecosystems; (iii) preparation and dissemination of appropriate methods to enhance and strengthen voluntary compliance; (iv) development of conservation programs for coral reef ecosystems integrated with the economic needs of coastal communities (v) enhancement of the effectiveness of law enforcement for various activities causing degradation of coral reef ecosystems; and (vi) control and limitations on the trade of coral reef resources having commercial value, and prohibition of the trade of protected coral reef biota.

Strategy 3: ***Manage coral reefs based on ecosystem characteristics, utilization potential, legal status and the existing coastal community's wisdom***

The condition of coral reefs differs from one marine region to another. Therefore, no uniform management scheme can be implemented. Each and every type of coral reef cluster needs its specific management approach that has to be in accordance with its characteristics and the characteristics of human communities surrounding the ecosystem. It is essential to obtain a better understanding of the reef systems before management plans are developed and to continue research to inform the management process.

Strategy 3 has five action plans: (i) development of information and mapping system for the utilization and management of coral reef ecosystems; (ii) development of research and study agendas related to the rehabilitation and recovery of coral reefs and the sustainable utilization of coral reef resources by allowing local research institutions and universities to play an active role; (iii) classification and grouping of coral reef clusters into several types of management categories; (iv) development of demonstration or pilot programs for each type of management category; and (v) protection and conservation of invaluable coral reef ecosystems with respect to national, regional, and international considerations.

Strategy 4: ***Formulate and coordinate action programs incorporating government and local government agencies, the private sector, and other sectors in the community-based management of coral reef ecosystems***

The principle of autonomy and integrated management has to be translated into action plans, so that all stakeholders are given the opportunity to cooperate in the community-based management of coral reefs.

Strategy 4 has three action plans: (i) integration into the management and use of coral reef ecosystems of the government, regional government, private sector, non-governmental organizations, universities and local communities; (ii) provision of technical and financial assistance to strengthen the capability and capacity of community and regional governments to prepare coral reef management plans; and (iii) preparation of personnel and facilities required for the field monitoring, control, surveillance, and assessment of coral reef management involving all levels of communities.

Strategy 5: ***Develop and strengthen commitments, capacities and capabilities of all parties involved in the implementation of the management of coral reef ecosystems***

The management of coral reef ecosystem needs appropriate institutional support. Programs to increase the quantity and quality of human resources in these institutions are very important.

Clearly some institutions, both governmental and non-governmental, are more able to provide technical assistance to the communities than others. Therefore, the first part of the action plan must focus on a "needs assessment" for the key institutions that have been identified as being able to offer support.

In addition, there must be a targeted and coordinated approach amongst all parties delivering services in coral reef management. Such an approach avoids excessive duplication and allows a framework for knowledge-sharing. Much of this strategy is targeted at making improvements in the responses and support given by regional governments to coral reef management initiatives. The principles of coral reef management and regional autonomy have to be formulated into action programs providing opportunities for all parties involved in the management of coral reef ecosystem to cooperate. This cooperation makes it easier to establish and implement a community-based management system.

Strategy 5 has four action plans: (i) enhance the quantity and quality of human resources in relevant institutions through recruitment, training, and formal and informal education; (ii) strengthen the capability of local institutions to manage coral reef ecosystems; (iii) strengthen the capacity and capability of regional government in the management of coral reef ecosystem; and (iv) strengthen community commitment to the framework of managing coral reef ecosystems.

Strategy 6: ***Develop, safeguard and strengthen community support for managing coral reefs by increasing awareness of the community at all levels about the ecological and socioeconomic importance of coral reef ecosystems***

Community awareness about coral reefs is the main factor for the successful implementation of the management programs. Therefore, it is imperative that a priority be increasing public awareness of the importance of coral reefs for both livelihood and development in Indonesia.

Strategy 6 has four action plans: (i) dissemination of information on laws and regulations about the management of coral reef ecosystems; (ii) increased community participation in activities related to the management of coral reef ecosystems; (iii) promotion of coral reef management programs to the community at large; and (iv) increased political support for the promotion of the importance of sustainable coral reef management for Indonesian economic development.

Strategy 7: ***Improve various laws, regulations, and regulatory systems concerning the management of coral reef ecosystems and redefine development success criteria in order to reflect the need to conserve these ecosystems***

Various laws and regulations concerning aspects of the management of coral reef ecosystems need to be improved, especially from the point of view of law enforcement and the conformity of regulations in Indonesia with international environmental norms. On a national scale, how the law on regional autonomy relates to the management of marine areas containing coral reef ecosystem demands a judicial review. Finally, redefinition of development success criteria is imperative, since presently regional development success criteria are primarily focused on reaching economic targets.

Strategy 7 has two action plans: (i) improvement of various laws and regulations related to the management of coral reef ecosystems; and (ii) improvement and redefinition of various regional development success criteria by including various success indicators (such as economic efficiency; equity in the distribution of development products; and sustainability of the environmental functions of the resources.

Strategy 8: ***Increase and strengthen partnerships between the national government, regional government, the private sector, and the community in developing environmentally friendly economic activities in the framework of sustainable utilization of coral reef resources***

Enabling coastal communities to participate effectively in economic activities is the key to success in the management of coral reefs on a national scale. Expanding and facilitating the access of coastal communities to information, markets, capital and legal assistance can reduce the dependence of these communities on the destructive use of coral reef resources. Through technical assistance, the provision of services, and the introduction of programs incorporating partnership with various market agents, the lives of people in the communities can be improved.

Strategy 8 has two action plans: (i) provision of environmentally friendly technical and non-binding financial assistance by the government, regional government and the private sector to community groups involved in economic activities within coral reef ecosystems and their surroundings; and (ii) improvement of services provided by the government, regional government and the private sector to facilitate people's access to science and technology, capital, markets, management and information relevant to economic activities in coral reef ecosystems and their surroundings.

Strategy 9: ***Increase and reaffirm the commitment of government, regional government and communities to funding best practice management of coral reef ecosystems, and seek additional funding from domestic and foreign institutions***

The availability of funds for the management of coral reef ecosystems is a decisive factor in the successful implementation of various government and regional government programs. Thus, it is necessary to encourage national and regional governments to enter into a commitment to provide funds for the management of coral reef ecosystems. Finally, financial support should be sought from domestic and foreign institution.

Strategy 9 has three action plans: (i) provision of budgets for the management of coral reef ecosystems from the national development budget (APBN) and from the local development budget (APBD); (ii) acquisition of nonbinding foreign funding sources; and (iii) mobilization and use of community funds to manage coral reef ecosystems.

Lessons Learned

The lessons learned are still largely untried as most of the activities involve the establishment of only very basic infrastructure. Furthermore, the document has not yet been distributed to all of the potential stakeholders. To date, the main lesson learned relates to the need for patient advocacy if the Strategy and Action Plan is to be accepted by the community.

At first there seems to be problems at the district level. Some districts, even though lacking experience and human resources, had their own Action Plans. This meant that the Academic Draft of Government Regulation prepared by COREMAP-PMO and concerning fisheries resources conservation in Indonesian waters came close to being rejected. However, eventually, the draft, which was designed to be a guide for the preparation of regulations at all levels, was accepted and even appreciated.

Closing Remarks

The process of preparing the National Policy, Strategies and Action Plans on the Management of Coral Reefs in Indonesia was interactive and participatory and involved all stakeholders in coral reef ecosystems. The document presents a comprehensive approach to coral reef management.

The document contains only general guidance and factors that should be considered when a region or district plans to manage its coral reef ecosystem. It does not detail activities to be implemented. These detailed activities should be prepared and planned according to the priorities suggested by the local situation, coral reef condition, human resources and financial resources available. The document can also be used as an academic draft for preparing and improving rules and regulations and for preparing a program of sustainable coral reef management activities.

Under the agreement with the funding agency, the World Bank, the policy document is to be promoted to agencies which have activities or authority associated with marine resources. So far, it has been officially handed to some ministries, such as the Ministry of Marine Affairs and Fisheries (DKP), the State Ministry for Environment (Men LH), the Ministry of Forestry, the National Development and Planning Agency (Bappenas), and the provinces and districts of the COREMAP pilot sites. The Strategy and Action Plan will shortly be distributed by the Ministry of Marine Affairs and Fisheries.

References

Borel-Best, M., B. W. Hoeksema; W. Moka; H. Moll; Suharsono and I. N. Sutarna. 1989. Recent scleractinian coral species collected during the Snellius-II expedition in Eastern Indonesia. Netherlands Journal of Sea Research 23 (2):107-115.

Bryant, D., L. Burke, J. McManus, M. Spalding. 1998. Reefs at risk. World Resource Institute, ICLARM, UNEP.

Cesar, H. 1996. Economic analysis of Indonesian coral reef. Environment Department, World Bank, December 1996.

Soegiarto, A. and N. Polunin. 1981. The marine environment of Indonesia. Report prepared for the Government of Indonesia, IUCN/WWF.

Suharsono, 1998. Condition of coral reef resources in Indonesia. Jurnal Pesisir dan Lautan 1(2) :44-52.

Tomascik, T., A.J. Mah, A. Nontji and M. K. Moosa. 1997. The ecology of Indonesia Series Periplus Edition. Volume VIII. The ecology of Indonesian seas. Part One: vii – xiv, 1- 642.

Veron, J.E.N. 1996. Corals in space and time: Biogeography and evolution of Scleractinia. Australia Institute of Marine Science. Cape Ferguson, Townsville, Australia.

Coral Reef Monitoring for Climate Change Impact Assessment and Climate Change Adaptation Policy Development

Leslie John Walling and Marcia M. Creary-Chevannes

Abstract

Small Island and Low Lying Developing Sates of the Caribbean produce less than 1 per cent of the total global greenhouse gas emissions, but bear an overwhelmingly disproportionate level of risk associated with the impacts of climate change.

Coral reefs represent a coastal ecosystem of great economic and social importance to the countries of the Caribbean. As elsewhere, the coral reefs of the area are expected to have a low to moderate vulnerability to climate change, but are likely to experience extreme stresses from local land-based human activities, especially when these activities are combined with the pressures caused by climate change. As little can be done to mitigate the phenomenon of climate change in the short-term, adaptation measures represent the only realistic way of reducing the vulnerability of coral reefs to climate change. Adaptation policies provide policy frameworks within which meaningful strategies for sustainable coral reef management may be developed and implemented.

This paper looks at the implementation of the Global Environment Fund/World Bank sponsored Caribbean Planning for Adaptation to Global Climate Change (CPACC) project, under which 12 Caribbean countries are preparing to cope with the adverse aspects of climate change. It focuses on components of the project dedicated to coral reef monitoring and policy formulation.

The establishment of monitoring programs and the progress toward the preparation and adoption of national adaptation policies are documented. It is noted that the limited availability of human capacity for monitoring constitutes a widespread problem, requiring the development of innovative strategies to collect accurate environmental data on which to base policies. Extensive use of digital video technology is expected to help overcome the problem of data collection.

The fact that many of the adaptation measures also constitute sound coastal resource management practice means that the allocation of scarce resources to adaptation initiatives can be justified in terms of short-term planning and resource management benefits while also addressing the need to prepare for the more distant potential impacts of climate change and sea level rise.

Introduction

Like other small island developing states (SIDS),[1] the small and low-lying states of the Caribbean share a number of socioeconomic challenges. Among these challenges are heavy dependence upon narrow resource bases, susceptibility to the vagaries of international trade, lack of economies of scale, high transportation and communication costs, grave vulnerability to natural disasters,

[1] The United Nations Department of Economic and Social Affairs, which monitors the progress made in the implementation of the Barbados Programme of Action for the Sustainable Development of SIDS, currently lists 41 SIDS: Africa (Cape Verde, Comoros, Mauritius, Sao Tome and Principe, Seychelles); West Asia (Bahrain); Asia and the Pacific (Cook Islands, Fiji, Kiribati, Maldives, Marshall Islands, Micronesia, Nauru, Niue, Palau, Papua New Guinea, Samoa, Singapore, Solomon Islands, Tokelau, Tonga, Tuvalu, Vanuatu); Europe (Cyprus, Malta); Latin America and the Caribbean (Antigua and Barbuda, Aruba, the Bahamas, Barbados, Cuba, Dominica, the Dominican Republic, Grenada, Haiti, Jamaica, the Netherlands Antilles, Saint Lucia, Saint Kitts and Nevis, Saint Vincent and the Grenadines, Trinidad and Tobago, and the United States Virgin Islands).

scarce land resources, and ever-increasing pressures on coastal and marine environments and resources. These challenges are compounded by the limited availability of human capacity and of the means to manage and use natural resources on a sustainable basis.

The features that small island states have in common also serve to increase their vulnerability to the projected impacts of climate change. These features include, but are not limited to, small size; the fact that they are surrounded by large expanses of water and hence are relatively isolated; limited natural resources; extreme openness of economies that are highly sensitive to external shocks; large populations with high growth rates and densities; and limited funds, human resources, and skills (Nurse and Sem 2001).

SIDS in the Caribbean produce less than 1 per cent of the total global greenhouse gas emissions, but bear an overwhelmingly disproportionate level of risk of damage from the impacts of associated climate change due to their inherent vulnerability to natural disasters. The most recent assessment of the consequences of, and adaptation responses to, climate change identifies small island states as among the locations most vulnerable to the potential adverse effects of climate change and sea-level rise (IPCC 2001). The report describes model-projected scenarios for the Caribbean Sea based on a 1 per cent per year growth in greenhouse gas (GHG) concentrations after 1990, with the resulting GHG-induced positive radiative forcing and negative radiative forcing of sulphate aerosols. The projected scenarios for the Caribbean include:

- Sea-level rise of between 0.09 to 0.88 m between 1990 and 2100;
- Marginal decrease in diurnal temperatures as a result of the relatively more pronounced increase in minimum daily temperature than in maximum temperature over the regions where small island states are located;
- Projected area-average annual mean warming over the Atlantic Ocean and Caribbean Sea of approximately 2°C by the 2050s and 3°C by the 2080s;
- Fewer rainy days per year and an increase in the daily intensity of precipitation, resulting in a greater probability of more frequent drought and flood events;
- No significant change in hurricane frequency, but a possible increase of 10 to 20 per cent in hurricane intensity (Nurse and Sem 2001);
- Mean rainfall intensity up by 20 to 30 per cent;
- Temperature-induced bleaching that poses a distinct threat to the productivity and survival of coral reefs.

"Coral reefs are subject to a range of interacting influences and processes originating from marine, terrestrial and atmospheric sources operating over a wide range of spatial and temporal scales" (Boesch et al. 2000). The openness of coral reef communities makes them susceptible to activities that take place in different environments or at some distance, provided the reefs are linked in some way to that activity by physical and/or biological processes. Caribbean coral reefs are already under threat from a wide range of land-based development activities (Wilkinson 2000). The stresses from land-based human activity are a manifestation of the poor or misdirected planning and management of those activities. The over-exploitation of the reef resources, excessive domestic and agricultural pollution, increased sediment runoff from unregulated landuse practices, and habitat destruction are some of the anthropogenic factors contributing to the decline of coastal ecosystems. The implications of these planning and policy failures are compounded by the characteristic challenges facing SIDS (see above).

It is anticipated that development activities in the coastal zones of SIDS and low-lying coastal states will:

- Lead to a decrease in the ability of coastal systems to cope with natural variability;
- Adversely affect the natural capability of these systems to adapt to changes in the climate;
- Lead to increased risk of hazards that affect coastal populations, infrastructure, and investment (Bijlsma 1997).

Coral reefs are expected to have a low to moderate vulnerability to climate change, but are expected to experience extreme stresses from local land-based human activities (Maul 1993). Vulnerability to climate change is a function of both exposure to changes in the climate and ability to adapt to the impacts associated with that exposure. Since the climate change phenomenon will not respond in the short term to mitigation efforts (Nurse and Sem 2001), adaptation measures represent the only realistic way of reducing the vulnerability of coral reefs to the impacts of climate change.

Adaptation planning encompasses the concepts of "damage reduction" and "increased resilience" (IPCC 2001) and "vulnerability reduction" through changes in behavior and economic structure. The resilience of coral reef communities is being compromised by anthropogenic activities. This reduction in, or loss of, resilience represents a corresponding loss or reduction in adaptive capacity. Managing those factors that stress coral reefs and reduce their resilience therefore represents an adaptation strategy. Since measures to manage land-based impacts on coral reefs are desirable and beneficial, even in the absence of global climate change (GCC), the development of adaptation polices and strategies to reduce anthropogenic impacts on the Caribbean coral reefs represents a no-regrets, win-win strategy.

Strategies for the effective conservation and sustainable management of coral reefs cannot be successfully implemented in isolation from strategies to address other coastal resource management issues. There must, therefore, be an integrated approach to coastal resource management within which the need for sustainable coral reef management can be nested. This approach has been labeled Integrated Coastal and Ocean Management. The Intergovernmental Panel on Climate Change (IPCC) and the United Nations Framework Convention on Climate Change (UNFCC) have identified it as the most important vehicle for adapting to GCC (Bijlsma 1997). Integrated Coastal and Ocean Management will address short-term, present-day needs (climate variability, uncoordinated coastal development, the need for sustainable coastal resource use, etc.) while providing a predictive tool with the capability to plan for and respond to medium- and long-term issues such as sea-level rise and climate change.

Many of the strategies that small island states might employ to adapt to climate change would be those that constitute sound environmental management and appropriate responses to current climate variability (Nurse and Sem 2001). Given this commonality and the gaps in existing polices for addressing climate variability and coastal resource management issues, it is likely that there will be adaptation strategies suited to addressing, immediately and with no regrets, both climate variability and climate change.

The Caribbean Planning for Adaptation to Global Climate Change (CPACC) project

In order to address the issue of climate change, a number of Caribbean Community (CARICOM) member countries and the Organization of American States (OAS) formulated the Caribbean Planning for Adaptation to Global Climate Change (CPACC) project. The project was initiated during the United Nations Global Conference on SIDS, held in 1994 in Barbados. Twelve CARICOM member states now participate in the implementation of the project, which is Global Environment Facility (GEF) supported by the World Bank as the GEF implementing agency and the OAS and the University of the West Indies Centre for Environment and Development (UWICED) as the executing agencies. The project was completed in December 2001. The successor project, Mainstreaming Adaptation to Climate Change (MACC) in the Caribbean, was initiated in April 2003 to build on the successes of the CPACC Project. The project's overall objective is to support Caribbean countries preparing to cope with the adverse effects of GCC, particularly sea-level rise, through vulnerability assessment, vulnerability reduction planning, and capacity building.

More specifically the CPACC aims to:

- Strengthen the regional capability for monitoring and analyzing climate and sea-level dynamics and trends, seeking to determine the immediate and potential impacts of GCC;
- Identify areas particularly vulnerable to the adverse effects of climate change and sea-level rise;
- Develop an integrated management and planning framework for cost-effective responses and adaptation to the impacts of GCC on coastal and marine areas;
- Enhance regional and national capabilities for preparing for GCC through institutional strengthening and human resource development; and
- Identify and assess policy options and instruments that may help the implementation of a long-term program of

adaptation to GCC in vulnerable coastal areas.

The project follows a regional approach to strengthen regional cooperation and regional institutions and to provide cost-effective means for planning, data collection and storage, and skills. The project activities focus on planning for minimizing risk from GCC in vulnerable areas, and include data collection and management of regional sea/climate data impact and vulnerability studies, and the assessment of policy options through a series of regional activities and pilot studies. These activities are being complemented by selective capacity-building activities aimed at creating or strengthening the local capacity required to prepare a long-term program to minimize the impacts of GCC.

Specific achievements of the project are discussed below:

1. **Establishment of a sea-level and climate monitoring system that contributes to global and regional assessment of the issues**

   Monitoring stations and related information networks installed in 12 countries have improved regional climate change monitoring and evaluation capacity. The data are primarily used to document sea-level rise and changes in sea surface temperature (SST), thus assisting in the global monitoring of the impacts of climate change. The contribution and placement of this Caribbean monitoring activity within the global monitoring efforts have been assessed. Additional applications in areas such as shipping, tourism and monitoring of extreme events are being promoted. The system will be upgraded and expanded under the successor project, Mainstreaming Adaptation to Climate Change (MACC) in the Caribbean.

2. **Improved access to and availability of data**

   The project has developed an extensive database for coastal zone management and climate change monitoring, accessible to a wide range of environment and development agencies in each country.

3. **Increased appreciation of climate change issues at the policy-making level**

   CPACC has made policy-makers, decision-makers, technical personnel and the wider public fully aware of climate change, and they have increased appreciation of the complexity of climate change issues. The project has enabled a more unified and better documented positioning of the region in relevant fora.

4. **Expanded vulnerability assessment**

   Pilot vulnerability studies have increased understanding of vulnerability assessment tools and methods and helped raise awareness of the most physically vulnerable sectors in the Caribbean sub-region.

5. **Establishment of coral reef monitoring protocols**

   Coral reefs have proven to be key indicators of climate change. CPACC data are used to help document the pace of coral bleaching and impacts on coral reefs caused by changes in SST. As with SST and sea-level change, CPACC coral reef monitoring activities are being linked to global networks.

6. **Creation of a network for regional harmonization**

   Through collaboration with a number of agencies,[2] CPACC is introducing climate change to these agencies' agendas, and is establishing linkages between climate change and other programs.

   At the national level, National Implementation Coordinating Units (NICUs) have been established. These NICUs include representatives from several government agencies and, in some cases, representatives from the private sector and non-governmental organizations. In many respects, the CPACC

[2] For example, the Caribbean Tourism Organization (CTO), the Caribbean Alliance for Sustainable Tourism (CAST), the Centre for Resource Management and Environmental Studies (CERMES) of the University of the West Indies, the Caribbean Energy Information System (CEIS), the Caribbean Development Bank (CDB), the Caribbean Conservation Association (CCA), the Caribbean Environmental Health Institute (CEHI), the Caribbean Disaster and Emergency Response Agency (CDERA), and private sector interests such as Petrotrin of Trinidad and Tobago as well as the insurance and banking sector.

project is responding to the prescriptions for regional action on climate change and sea-level rise contained in the Barbados Programme of Action.[3]

A Regional Project Implementation Unit (RPIU), established under the aegis of UWICED, was responsible for the implementation of the project as a regional coordinating and implementing mechanism.

Component 5: Coral reef monitoring for climate change impacts (C5)

The overall objective of C5 is to assist CPACC countries establish long-term coral reef monitoring programs which will, over time, show the impacts of climate change factors such as temperature stress, sea-level rise and hurricanes. These monitoring programs will continue beyond the life of the CPACC project through support from the MACC project. The countries that have been selected for this pilot activity are the Bahamas, Belize and Jamaica. The lessons learned, skills, methods and protocols will be shared with the eight non-C5 countries through activities conducted under CPACC's successor, the Mainstreaming of Adaptation to Global Climate Change project.

The specific objectives of Component 5 are to:

I. Determine the most appropriate method for recognizing impacts of climate change on coral reefs, having regard to the need for long-term measurements;

II. Establish and maintain monitoring sites in the Bahamas, Belize and Jamaica to determine the potential impacts of climate change on coral reefs, including biological and physical indicators;

III. Establish mechanisms to ensure that coral reef monitoring continues beyond the life of the CPACC project;

IV. Strengthen existing institutions' (public, private, and NGO) activities in coral reef monitoring;

V. Increase awareness of the importance of coral reefs and the potential impacts of climate change;

VI. Ensure that the benefits and lessons learned are transferred to the other CPACC countries.

Method

The C5 site selection protocol (Woodley 1999) stipulates that at least three operational areas should be monitored in each of the pilot countries and these should be representative of least impacted, mildly impacted and severely impacted conditions. For the purpose of the study, "impact" was defined as land-based, anthropogenic impacts, transported to reefs by fluvial inputs, or actual physical impacts on reefs caused by activities within the marine environment. The monitoring sites selected for each country are outlined in Table 1.

Table 1. Sites selected for CAPCC monitoring in the pilot countries

Status of monitoring area	Pilot country		
	Bahamas	Belize	Jamaica
Least impacted	Exuma Cays Land and Sea Park	Glovers Reef Marine Reserve	Monkey Island, Portland
Mildly impacted	Manjack Cay, Great Abaco	South Water Cay Marine Reserve	"Gorgo City", Discovery Bay
Severely impacted	The Ridge, New Providence	Hol Chan Marine Reserve	Southeast Cay, Port Royal

Transects were located using the procedure outlined in the site selection protocol (Woodley 1999). A total of 20 transects, each 20 m in length, were monitored at all three monitoring sites established in every monitoring area.

Underwater digital video cameras were used to record the benthic cover of the coral reefs in each transect (Miller 2000). A software-assisted manual process was used to "capture" adjacent,

[3] The aims of this programme are to:

- Create and/or strengthen programmes and projects to monitor and improve predictive capacity for climate change, climate variability and sea-level rise, and to assess the impacts of climate change on marine resources, freshwater and agricultural production, including pests.
- Develop and/or strengthen mechanisms to facilitate the exchange of information and experiences among small island developing states, and to promote technology transfer and training in those states in response to climate change, including preparedness responses.
- Provide technical assistance for ratification or accession to the United Nations Framework Convention on Climate Change and assist those Parties that have ratified the Framework Convention in assuming their major responsibilities under it.
- Support national efforts aimed at developing strategies and measures on adaptation to climate change as well as the development of technical guidelines and methodologies to facilitate adequate adaptation to climate change.

non-overlapping images from the video footage of each transect.[4]

In 1999, temperature data loggers were deployed at monitoring sites in the Bahamas and Belize. The data loggers deployed at the Belize sites were lost in Hurricane Keith in 2000. Temperature data for the period December 1999 to June 2000 were reviewed for incorporation into the Bahamas 2000 coral reef monitoring report.

Institutional arrangements

A lead government agency in each pilot country was responsible for planning, coordinating and executing the country's annual monitoring and data analysis program. The CPACC RPIU provided technical assistance and training to each lead agency.

During the March 1998 technical workshop for the implementation of C5, the representatives of each pilot country met to identify prospective operating areas for monitoring. The operating areas were selected to reflect a gradient of impacts resulting from anthropogenic activities. Selection criteria included the existence of institutional capacity to undertake monitoring activities in the operational areas. Consideration was also given to past and current coral reef research or monitoring in these areas, and the monitoring of complimentary parameters, such as water quality. The institutions identified were considered to be capable of undertaking coral reef monitoring and/or data analysis at the national or local levels (Table 2).

Between June and November 1998, the CPACC RPIU undertook institutional assessment missions to the Bahamas, Belize, and Jamaica. The missions assessed the interest and institutional capacity of the prospective institutions to undertake the tasks associated with monitoring, data processing and analysis. The findings, combined with assessments of logistic requirements and capacity factors undertaken by pilot country lead agencies, led to a revision of the lists of the operational areas for each pilot country (Table 3).

The national focal point in each pilot country, supported by the NICU, provided a general overview of the implementation of C5 activities and institutional support to the C5 lead agency(ies) when necessary. The C5 lead agency in each pilot country was responsible for identifying the human and material resources required to monitor the coral reefs, and process and analyze the resulting data.

Table 2. Proposed operating area sites and institutional support arrangements

Bahamas		Belize		Jamaica	
Operating area	Institution	Operating area	Institution	Operating area	Institution
New Providence – Rose Island	Fisheries Dept/ Dive Operators	Hol Chan	Fisheries Department	Negril	Negril Coral Reef Preservation Society
New Providence – Sea Viking	Fisheries Dept/ Dive Operators	Glovers Reef	Fisheries Department/ Environmental Non-Governmental Organization	Montego Bay	Montego Bay Marine Park
Lee Stocking Island	Fisheries Dept/ Dive Operators	Dangriga	Fisheries Department/ Coastal Zone Management Authority/Institute	Discovery Bay	UWI Discovery Bay Marine Laboratory
				Pedro Cays	Natural Resources Conservation Authority/ Jamaican Fisheries Department Coast Guard
				Port Antonio	Portland Environmental Protection Association

[4] An automated process, managed by the WinBatch for Windows batch-processing program, generated random dots in Microsoft Excel and superimposed them on the images. The benthic component under each random data point was identified and then information entered into Microsoft Excel spread sheets, which automatically tabulated and grouped the substrate categories and calculated the percentage cover and standard deviation. Provision was also made in the spreadsheet for recording the occurrence of bleached and diseased corals. Quality Assurance-Quality Control checks were carried out on the video tapes, processed images and resulting data (Creary 2001) to refine the monitoring and data analysis processes.

Table 3. Final selection of operational sites and institutional support arrangements

Pilot country	Lead agency	Supporting institutions	Operating areas
Bahamas	Fisheries Department	National focal point – Bahamas Environmental Societies Trust Commission OAS Country Office	Sea Viking, New Providence Walker's Cay, Abbaco
Belize	Coastal Zone Management Institute/Authority/ Fisheries Department	National focal point - Meteorological Service National Coral Reef Committee National Climate Change Committee OAS Country Office	Glovers Reef Hol Chan South Water Cay
Jamaica	Natural Resource Conservation Authority/Centre for Marine Sciences	National focal point – Ministry of Economic Development National Climate Change Committee UWI Discovery Bay Marine Laboratory, OAS Country Office	Discovery Bay Port Royal Cays Monkey Island, Portland

The Caribbean Coastal Data Centre (CCDC) of the Center for Marine Sciences (CMS) at UWI served as the technical support node and archiving center for the pilot countries. The C5 Coordinator at the CCDC provided technical support to the pilot country teams. The coordinator also liaised with consulting experts to develop and refine the protocols and provide training. The arrangements by which the CMS provided technical support to C5 were documented in a memorandum of understanding (MOU). The CMS CCDC also provides support for the Caribbean Coastal Marine Productivity (CARICOMP) Network Project and serves as the regional node for the Global Coral Reef Monitoring Network (UNESCO 1998).

Coral reef monitoring and the policy process

Three critically important questions should be asked when considering the role that coral reef monitoring data could play in national policy and planning processes. The questions are: (a) Do the monitoring data lend themselves to the generation of policy relevant information? (b) Are the data and/or information in a format that can support the decision-making process? (c) Is this information accessible?

To provide strategic input into the policy cycle, coral reef monitoring programs should:

- Establish the baseline against which the effectiveness of adaptation policy interventions can be measured;
- Provide the scientific basis that will be used in the identification of policy issues and the evaluation of appropriate policy options;
- Provide accurate and easily understood information to assist in public consultation programs and in the presentation of policy options to decision-makers (de Romilly 2001).

Coral reef data and the resulting information can provide support in the development, implementation and evaluation of sectoral adaptation policies for fisheries, marine protected areas, coastal resource management, tourism, and economic development. However, even where policy processes are established, capacity constraints may prevent the monitoring of coral reefs necessary to generate the information to support the policy process.

In the member countries of the Organization of Eastern Caribbean States (OECS), Fisheries Departments are responsible for coral reef monitoring. The Fisheries Departments focus, primarily and understandably, on fisheries related issues, but also on tourism and conservation issues (Murray 2001). CANARI (2000) attributed their limited involvement in reef monitoring to a narrowing of the focus of fisheries administrations to issues of production and processing. Some obstacles to their involvement in coral reef monitoring include a shortage of personnel and financial constraints. A lack of personnel was cited as a constraint by every OECS fisheries administration (CANARI 2000). A less obvious obstacle to the sustained involvement of Fisheries Departments in coral reef monitoring is the perception that coral reef monitoring is a highly technical activity requiring extensive skills, equipment and other resources (CANARI 2000).

In 1999, the status of coastal resource data holdings in the 12 countries participating in the CPACC project was assessed. It was found that, in the 10 countries that responded,[5] coral reef data are used by national governments in the planning process. Seven of the 10 respondents indicated that a shortage of personnel was a problem encountered in the collection of coral reef data.

The survey also showed that the main uses to which the data were put were research, teaching, environmental planning and the monitoring of trends. Further research is required to determine exactly which government agencies collect and use coral reef data and the purposes for which these data are used.

CPACC Component 4: Formulation of a policy framework for integrated adaptation planning and management (C4)

CPACC C4 was designed to assist the 12 participating Caribbean states with the formulation of:

(a) A national climate change adaptation policy and an implementation plan; and

(b) A regional climate change adaptation policy and an implementation plan.

It was anticipated that the implementation of a national plan in each of the 12 CARICOM countries would establish mechanisms to guide national processes for addressing the short-term, medium-term and long-term effects of GCC. The adaptation policies would reflect the unique circumstances of each country, providing integrated approaches to adaptation planning and management at the national and regional levels, and would not be limited to dealing with the impacts of sea-level rise on coastal environments.

A seven-stage process of consultation, document preparation, and review was developed to guide participating countries in writing their respective adaptation policies (Table 4).

CPACC RPIU facilitated the drafting and consultation process in the 12 participating countries. In-country coordination was undertaken by the national focal points of the national climate change committees.

All 12 countries completed the first five stages of the process. St. Lucia has completed the entire process having obtained Cabinet approval for its national climate change adaptation policy and implementation plan. Belize has submitted its adaptation policy to its Cabinet and is awaiting final approval. Draft adaptation policies have been developed in Dominica, Guyana, Barbados, Antigua and Barbuda, Trinidad and Tobago, and, in some instances, have already been reviewed by local Cabinet sub-committees. Once approved by Cabinet, it is expected that these adaptation policies will initiate a series of five-year national programs and strategies aimed at reducing vulnerability to existing climate extremes, and thereby help to manage anticipated impacts from climate change.

It is intended that, by the end of December 2001, all CPACC participating countries will have submitted policy documents to their respective Cabinets for final approval. The CPACC project ends in December 2001, and a follow-up project has been designed to implement Stage 2 adaptation activities, as defined by guidance from the Conference of Parties on Adaptation.

Saint Lucia's policy paper is a comprehensive document, the goals of which speak to the avoidance of, reduction of, or adaptation to negative climate change impacts on a range of sectoral interests and natural resources. It clearly defines the level and nature of the Government's commitment to its obligations under international conventions, and to the recently enacted climate change adaptation policy.

Policy directives regarding coastal and marine resources address the issues of monitoring, resource assessment, coastal land protection, the enhancement of ecosystem resilience, ecosystem restoration, the development of a national landuse and management plan, the promotion of different fishery and resource use activities, and the fostering of increased public awareness of climate change impacts.

The National Climate Change Strategy is a direct derivative of the Climate Change Policy, each sub-component of the strategy corresponding to a subject area under the policy directives provided in the policy (Table 4).

Discussion

The CPACC project has succeeded in establishing a process that has led to the approval by Cabinet of a national adaptation policy in St. Lucia, and the submission of a policy to Cabinet for approval

[5] The coastal characteristics of Guyana do not permit the growth of coral reefs. No response to the survey was received from Saint Kitts and Nevis.

Table 4. Component 4: Implementation Process[6]

Stage/Activity	Output	Responsibility
First (inception) mission	• Outline activities to be undertaken to develop the National Climate Change Policy • Identify resources required from CPACC RPIU to implement C4	• CPACC RPIU (Technical support and resources) • National Focal Point (Coordination) • National Climate Change Committee (technical support)
Issues paper development	• Identify national context for evaluation of vulnerability issues and formulation of policy options • Identify critical issues to be addressed through adaptation policies and strategies • Prioritize identified issues • Document institutional and legal structures for responding to issues of concern	• National Focal Point, National Climate Change Committee, Project Coordinating Committee • CPACC technical assistance to review policy, legal and institutional structures
National consultative review of issues paper	• Refine issues paper to reflect consensus of public and private sector stakeholders	National Focal Points, National Climate Change Committee, private and public sector stakeholders
Second mission: National workshop	• Stakeholder participation in the ➢identification and evaluation of appropriate policy options ➢critical review of comments arising from national consultative review of issues paper • General agreement on appropriate ➢strategies and management mechanisms for GCC adaptation planning and management ➢Intervention options to address issues	National Focal Points, National Climate Change Committee, private and public sector stakeholders
First drafting of National Climate Change Policy	• Identify anticipated changes to local/regional climate • Outline anticipated impacts • Identify vulnerable activities and sectors • Outline appropriate adaptation planning and management policy options • Define implementation plan • Identify regional level activities to support and compliment national policy development • Identify legal, institutional and financial mechanisms (effect and coordination) • Outline policy review process (5-10 years)	• National focal point, National Climate Change Committee • CPACC RPIU provided Information Note to the Cabinet, and Guide to the preparation of Country Policy Papers on Climate Change Adaptation Planning and Management
Development of action plan/strategy for implementing Climate Change Adaptation Policy	• Details of activities, finances, resources and agency responsibilities for a 5-year program to implement policy directives contained in the *National Climate Change Adaptation Policy*	National Focal Point, National Climate Change Committee, private and public sector stakeholders
Review draft *National Climate Change Policy*	• Peer review process • Five countries have completed first drafts	National focal point, National Climate Change Committee, Private and public sector, CPACC stakeholders
Submission of final *National Climate Change Policy* to Cabinet for approval	• Preparation of the final text • Preparation of support documents to facilitate submission to the Cabinet	National Focal Point, National Climate Change Committee

[6] Based on CPACC, 2000.

in Saint Lucia. Draft policies have been developed in Dominica, Guyana, and Barbados, and documents are pending Cabinet approval in the Bahamas, Antigua and Barbuda, Belize, and Trinidad and Tobago. In some instances, Cabinet sub-committees have already reviewed these documents.

Coral reefs represent a coastal ecosystem of great economic and social importance to the countries of the Caribbean. Their conservation will have implications for economic development at the national and regional levels. Climate change adaptation polices will provide a policy framework within which meaningful strategies for sustainable coral reef management may be developed and implemented. The policy papers speak to the need for enhancing and conserving the resilience of coastal systems and set the groundwork for action through accompanying strategies. The conservation and enhancement of ecosystem resilience will require the integrated planning and management of land-based activities that currently threaten the region's coral reefs. As economic development is an adaptation strategy in its own right, the importance of sustainable management of the region's coral reefs to the region is that much more important.

Programs of sustained coral reef monitoring will contribute to the development of baseline data underlying stress-identification and mitigation assessments (Risk 1999) for both adaptation planning and climate change impact assessment. Much of the scientific research on coral reefs does not reach the decision-making process, and that which does is often not applicable to the decisions being made (McManus 2001). In many Caribbean countries, only limited coral reef data collection is currently undertaken by government agencies. Most of it is on a case-by-case basis for environmental impact assessments in support of monitoring. The major constraints that limit coral reef data collection are staff shortages (as opposed to shortages of technically competent staff to undertake coral reef monitoring (CANARI 2000)), financial constraints, and a narrow institutional focus (CANARI 2000; Murray 2001).

The CPACC project has attempted to address the widespread problem of limited human capacity by employing digital video technology to record benthic features. This technique was chosen as the preferred data collection method because it:

- Reduces the time spent collecting data in the field and hence the time that government officers are absent from the office;
- Reduces the need for taxonomic expertise in the field, thereby reducing the requirement of in-house technical expertise;
- Facilitates the transmission of data for processing and analysis at a centralized technical support facility;
- Generates permanent photographic records of the coral reef, allowing changes over time to be easily demonstrated to decision-makers.

Further support in addressing this issue has been provided through a collaborative arrangement among the CPACC project, the CMS, and the Caribbean Coastal Data Centre at the University of the West Indies (UWI) in Barbados. The CMS provides the pilot countries with technical data processing, analysis and archiving support. This arrangement reduces the workload of government agencies until they are able to develop the institutional capacity to undertake all aspects of the data processing and analysis.

Plans are being developed to duplicate the technical support system provided by this collaborative arrangement in anticipation of the expansion of the coral reef monitoring program to the eight CPACC countries in the eastern Caribbean. It is envisaged that a collaborative arrangement will be established between the CPACC project (and its successor project), the Coastal Zone Management Unit of the Government of Barbados, and the Natural Resources Management Programme of the UWI in Barbados. The technical support group will provide the data processing, analytical and management support that are currently provided by the CMS to the pilot countries in the northern Caribbean. It will also provide a roving support team that can assist, as necessary, the various Fisheries Departments in monitoring activities.

Small island states are among the locations most vulnerable to the potential adverse effects of climate change and sea-level rise (IPCC 2001). Adaptation measures must be put in place to minimize the social and economic impacts of both phenomena. Information on the potential site-specific climate change and the sea-level rise impacts must begin to inform planning and development decision-making processes immediately. Action must be initiated before complete knowledge of the nature and severity of local and regional impacts is available, and before the potential impacts are evident. The fact that many of the adaptation measures constitute sound coastal resource management practice means that the allocation of scarce resources to adaptation initiatives can be justified in terms of short-term planning and resource management benefits. At the same time, they address the more distant potential impacts of climate change and sea-level rise.

To ensure the development and ongoing refinement of local and regional climate, vulnerability, and risk assessment models, adaptation action must be based on the ongoing availability of accurate environmental data. It is this information that will be used to inform and refine national and regional adaptation policies and development plans.

Island states have small populations and limited human capacity to devote to coastal ecosystem monitoring and assessment. Despite this, the need for quality data to inform the climate change adaptation process means that innovative strategies must be developed to ensure that the necessary policy-relevant data and information are generated, accessible, and in the appropriate format.

Annex 1. CPACC Component 5 (C5) implementation history

Date	Activity	Results	Outcome
March 1998	Monitoring methods workshop	Consensus on parameters to be monitored, methodological approaches and options for institutional participation at the pilot country level	Selection of appropriate monitoring methods Identification of potential national lead institutions
June to Oct 1998	Institutional assessment missions to the Bahamas, Belize and Jamaica	Follow-up on suggestions for institutional participation made at March methods workshop Identification of lead agencies or a consortium for each of the three pilot countries that would be responsible for monitoring, data processing, analysis and reporting The identification of technical and logistic needs, and institutional and inter-organizational linkages	Finalization of institutional arrangements for implementing coral reef monitoring activities under C5
Dec 1998 to March 1999	Delivery of monitoring equipment (Sony DCR VX100 digital video camera, L & M Stingray underwater video camera housing, temperature data loggers and computers and software for data analysis)	Lead agencies received the equipment and software necessary for coral reef monitoring, data processing and analysis	Pilot country lead agencies had tools to monitor, process and analyze data Press coverage of handover in Belize
March 1999	Training workshop to ensure pilot countries select and monitor coral reef sites and analyze data in the same way, and to train pilot country team leaders in the monitoring, data processing and analysis protocols Established CC-Reefs e-group	Trained national monitoring teams in monitoring, data processing and analysis Creation of a global forum for the exchange of information on coral reef monitoring and climate change issues	Monitoring successfully conducted in 2000 Media coverage in the Bahamas
June 1999	Public awareness documentary on C5 produced in 3-minute and 10-minute versions	Convenient promotional tools were prepared that provided: a brief introduction to GCC and its implications; the role of the CPACC Project; an overview of C5; the training workshop aims and objectives; feedback on GCC and coral reef monitoring by the Environmental Minster and workshop participants	A documentary was made available to all Caribbean television stations on 3 June for showing on World Environment Day, 5 June 1999. Stations that acknowledged showing it were: Channel 5, Belize; ATV, Surinam; CBC, Barbados; St. Maarten Cable, St. Maarten; ZIZ TV, St. Kitts; GTV, Guyana; Little Rock TV, Guyana; SVG TV, St. Vincent
Nov 1999	Draft site selection protocol developed	Adoption of standardized methodological approach for activities	Recognition of a standardized approach to spatial arrangements for monitoring the region's coral reefs
June 2000	The data analyst conducted an assessment mission to the Bahamas and Belize to meet with representatives of the C5 lead agencies	Progress of the coral reef monitoring program reviewed Monitoring data reviewed and compliance with the video monitoring protocol determined Institutional capacity to monitor, process and analyze data assessed Plans for year 2000 monitoring reviewed Orientation dives on the Sea Viking site, New Providence, Bahamas undertaken	

2000	Pilot countries conduct coral reef monitoring	Baseline coral reef data collected by pilot countries	Training successfully applied in unsupervised monitoring Confirmation of capacity for pilot countries to undertake monitoring
March 2001	C5 brainstorming meeting	Monitoring methods and protocols reviewed and assessed	Refinement and endorsement of monitoring method Data requirements for assessing GCC impacts on reefs acquired
April 2001	Quality control/quality assurance assessment of data from 2000 monitoring campaign completed	Quality Control/Quality Assurance Manual Developed	Monitoring teams have access to information necessary to assure quality
May 2001	Planning	Links between C5 and the CRIS (C3) and the policy and mainstreaming process (C4) defined 2000 monitoring data reported and reviewed Monitoring methods reviewed and revised Technical and institutional aspects of C5 expansion discussed	Media coverage in Jamaica
July 2001	Applied statistical methodologies report	Report on statistical methods as applied to CPACC pilot country coral reef monitoring data released	Guidance on statistical approaches for reporting coral reef monitoring data for practitioners unfamiliar with statistical methods
August 2001	UNEP CPACC meeting	Commitment by UNEP to support Phase II reef monitoring and training	Increased sustainability and institutionalization of monitoring activities
2001	Data processing, analysis and reporting Monitoring for 2001	Country monitoring reports for 2000 Second year of coral reef data collection	Training successfully applied to data processing and analysis with assistance from UWI, CMS, and CCDC Documented site-specific baseline data on reef condition for pilot countries Institutionalization of coral reef monitoring
Dec 2001	Produce promotional CD-ROM	Increased awareness of C5 activities in the region	Decision-makers and heads of department supportive of C5

References

Bijlsma, L. 1997. Climate change and the management of coastal resources. Climate Resources 9:47-56.
Boesch, D. F., J. C. Field and D. Scavia (eds). 2000. The potential consequences of climate variability and change on coastal areas and marine resources. NOAA's Coastal Ocean Program. Decision Analysis Series No. 21.
CANARI. 2000. An assessment of capacity for reef monitoring in the Eastern Caribbean: towards the creation of an Eastern Caribbean global coral reef monitoring network (GCRMN) node in collaboration with the United Nations Environmental Programme. CANARI Technical Report No. 266.
CPACC. 2000. Policy framework for integrated adaptation planning and management (Component 4). Inception Mission Report.
Creary, M. M. 2001. Component 5: Coral reef monitoring for climate change. Paper presented to the
Caribbean Planning for Adaptation to Global Climate Change Planning and Technical Review Workshop, 21-25 May 2001, Kingston, Jamaica.
IPCC. 2001. Climate change. 2001: Impacts, adaptation, and vulnerability. Part of the Working Group II Contribution to the Third Assessment Report of the Intergovernmental Panel on Climate Change. UNFCC.
Maul, G. A. (ed.). 1993. Climate change in the Intra-Americas Sea. Edward Arnold, London, U.K., 389 p.
Miller, J. 2000. Using videotape to sample coral reefs. US Geological Survey. Biological Resources Division. Virgin Islands Field Station. St. John, USVI. (www.cpacc.org).
Murray, P. 2001. Institutional capacity and national priorities for coral reef monitoring in the OECS states. Proceedings of the CPACC Component 5: Coral Reef Monitoring for Climate Change Impacts, Planning and Technical Review Workshop, 21-25 May 2001, Kingston, Jamaica.
Nurse A. L. and G. Sem. 2001. Chapter 17 Small Island States. *In* Climate change 2001: Impacts, adaptation, and vulnerability. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Intergovernmental Panel on Climate Change. Cambridge University Press.
Risk, M. J. 1999. Paradise lost: how marine science failed the world's coral reefs. Mar. Freshwater Res. 50:831-7.
Romilly, G. de B. 2001. Coral reef monitoring in the context of climate change adaptation policy. *In* Proceedings of the CPACC Component 5: Coral Reef Monitoring for Climate Change Impacts, Planning and Technical Review Workshop, 21-25 May 2001, Kingston, Jamaica.
UNESCO. 1998. CARICOMP – Caribbean coral reefs, seagrass and mangrove sites. Coastal region and small island paper 3, UNESCO, Paris, France, 347 p.
Wilkinson, C. 2000. State of coral reefs of the world: 2000. Australian Institute of Marine Science, Townsville, Australia.
Woodley, J.D. 1999. CPACC Component 5: Coral reef monitoring. (Draft) Site Selection Protocol. Prepared for the CPACC Project.

Co-management and Valuation of Caribbean Coral Reefs: A Jamaican NGO Perspective

Mark Figueroa

Abstract

The Jamaican Government's policy statements on protected areas give support to a co-management framework. In the 1990s, eight protected areas were declared and non-governmental organizations (NGOs) were given mandates to manage them. One of the difficulties faced by NGOs that have sought mandates to manage marine protected areas is that many of the threats to coral reefs remain beyond their control because they originate from outside the protected areas. This paper examines what has been achieved within the non-governmental sector in terms of protection of coral reefs, and what are the likely prospects given the current institutional framework. Within this context, an attempt is made to identify the extent to which coral reef valuation might play a role in the development of an effective coalition for the protection of coral reefs.

Introduction

In the 1990s, Jamaica began to establish a system and related policy for parks and protected areas. The system was expected, in part, to provide a more coherent framework than that available under existing laws, such as the Beach Control Act and the Fishing Industry Act. Delegation of management to NGOs was proposed within a co-management framework. This paper examines the implications of that institutional framework for coral reef protection. The limitations faced by NGOs that manage maritime areas are assessed, and the potential for success where the threats to corals originate beyond the protected area boundaries is questioned. The short-run possibilities are examined, along with the prospects for an effective coalition for coral reef protection. The role of coral reef valuation in building such a coalition is discussed. Mention is also made of how the Jamaican experience differs from that of other countries in the Caribbean, and the lessons its experience may hold for them.

Jamaica's coral reefs

On the north coast, Jamaica's island shelf is less than 2 km wide but it stretches to a maximum of 25 km on the south coast.[1] Coral reefs fringe most of the north, east and west coasts but are less common in the south.[2] Since the early 1980s, Jamaica's coral reefs have faced a significant decline. This decline is often attributed to the impact of hurricanes Allen (1980) and Gilbert (1989), but the consensus is that greater significance should be placed on the impact of the die off of the grazing sea urchin *Diadema antillarum*.[3] This occurred throughout the Caribbean and has been traced to a water-borne pathogen. The decline in the reefs was made worse by locally generated factors, including high nutrients in the coastal waters, inappropriate landuse practices and long-term over-fishing. The loss of sea urchins and herbivorous fish fostered a macro algae bloom, while elevated nutrient levels promoted the growth of the macro algae.

Site-specific factors have also been at work. Stress on the reef imposed by tourists who engage in diving and other water sports is greater in the

[1] Jamaica is just under 100 km wide at its widest and 250 km at its longest. Its total area is just under 11 000 km^2. The land rises to a maximum height of just over 2250 m. The Island is centered roughly at 18°10'N and 77°25'W. For a summary of Jamaica's geography, reefs and fisheries, see Klomp (2001) and Aiken and Kong (2000).

[2] Jamaica also has significant offshore reef systems associated with oceanic banks within its maritime zone. The conditions within the coastal zone differ considerably from those offshore. It is not possible to deal with the latter within the scope of this paper.

[3] After some delay *Diadema* is now showing signs of strong recovery (see Cho and Woodley 2003).

resort areas of the north (Montego Bay, Ocho Rios) and west (Negril) coasts than it is on the south (Portland Bight) coast. Spear fishers do less damage in the south, as reefs are further offshore. Destructive practices like dynamite fishing are not present in all areas. Nutrient loads and sedimentation vary depending on sewage treatment, settlement, agricultural and other landuse patterns. Tidal flows are more conducive to reef health in some areas, and hurricane damage varies from place to place.

Institutional framework

The Natural Resource Conservation Authority (NRCA) was established under the 1991 Natural Resource Conservation Authority Act and became the main body responsible for protecting the Jamaican environment.[4] The NRCA has been augmented by the various policies and guidelines.[5] These include the Jamaica National Environmental Action Plan (JNEAP) (NRCA 1995a), a green paper (NRCA 1995b), and a white paper (NRCA 1997) setting out a parks and protected areas policy.[6] These policy documents called for a co-management partnership between "the Government…NGOs…community groups… private land-owners and government agencies with responsibility for the management of vast areas of land." The NRCA was granted power to delegate certain management functions, including management plan implementation, user fee collection, and regulation enforcement within protected areas.

The white paper identified "over 150 areas … as possible … Protected Areas". Up until 1999, eight had been declared, including three marine parks (Montego Bay, Negril and Ocho Rios), and two contain large marine areas (the Portland Bight and Palisadoes/Port Royal Protected Areas). Table 1 lists dates of declaration, the entities with an interest in managing the areas (or parts thereof) and their status as of August 2003. Regulations for parks were established simultaneously with the declaration of the first park (Montego Bay, June 1992). However, the delegation of management functions for this park was not effected until September 1996. Furthermore, this mandate has not been renewed since its initial three-year period expired in 1999. In fact, despite ongoing negotiations, only one other marine protected area (Negril) has been delegated. Nevertheless, protected areas have been declared, at times without any management plan or structure. Some NGOs have undertaken tasks associated with management before getting the legal authority to do so, while others have declined to accept delegation in the absence of guaranteed funding.

This situation is symptomatic of the fact that environmental policy has not been central to the political process in Jamaica. The drive to place the environment on the national agenda has come, in large part, from the global arena. It has not emerged as a front line political issue. International agreements (including some that have emerged in the Caribbean) have played a pivotal role. In addition, various multilateral and bilateral funding agencies have insisted that attention be paid to the environment.[7] These pressures have fostered the growth of institutions and programs within the Jamaican state, and provided NGOs with funding opportunities. The small but energetic NGOs have taken advantage of opportunities to place the environment on the agenda. At the same time, the technical staff members within the state agencies have played a similar role, and the scientific community, with its long record of research, has also sought to raise relevant issues.

In recent decades, Jamaica has faced a wide range of problems, including a stagnating official economy, periods of sharp political conflict, and high crime rates. Given the very tight budgetary situation, environmental concerns have been seen as a drag on development possibilities rather than central to the creation of solutions that are sustainable. Ironically, it was the budgetary constraints that encouraged the government's interest in a co-management approach. Driven by the global context to deal with environmental protection, the Jamaican state was faced with the problem of funding protected areas. Delegation of management, which was actively sought by

---

[4] The system still remains quite unwieldy. NCOCZM (2001) lists 27 laws and seven regulations/orders relevant to coastal zone management. The NRCA has recently become part of a more comprehensive National Environment and Planning Agency (NEPA) that includes Town Planning.
[5] NCOCZM (2001) has a list (incomplete) of 20 national policies and guidelines relevant to coastal zone management.
[6] For more details on the development of protected areas in Jamaica see Miller (1999) and Smith (1995).
[7] The original stimulus that eventually led to the Council on Coastal Zone Management came from issues relating to Jamaica's exclusive economic zone, territorial seas and disputes with neighboring countries. Attention to inshore waters and coastal management came later. Financial conditionality appears to have been the main reason for the declaration of two protected areas, one of which was not even in the original list of 150 proposed parks and protected areas. A third example is the Black River area, which has not yet been declared a protected area even though it has been declared a Ramsar site.

Table 1. Protected areas by date declared and entity interested in delegation

Area	Date	Entity	Delegation status
Montego Bay Marine Park	5 June 1992	Montego Bay Marine Park Trust	Was delegated 1996-99 (still to be renewed)
Blue and John Crow Mountains National Park	26 February 1993	Jamaica Conservation and Development Trust	1 October 2002 for ten years
Negril Environmental Protection Area	28 November 1997	Negril Area Environmental Protection Trust	-
Negril Marine Park	4 March 1998	Negril Coral Reef Preservation Society	9 October 2002 for five years
Palisadoes/Port Royal Protected Area	18 September 1998	-	-
Coral Spring – Mountain Spring Protected Area	18 September 1998	-	-
Portland Bight Protected Area	22 April 1999	Caribbean Coastal Area Management Foundation CCAM, and Urban Development Corporation	18 July 2003 for five years to CCAM
Ocho Rios Marine Park	16 August 1999	Friends of the Sea	-

Source: Protected Areas Branch, NEPA

some NGOs, held out the prospect of new resources, including funds not available to state agencies. There have been two problems with this approach. First, the state has tended to hand over the management rather than enter into genuine co-management with the NGOs. This has been unsatisfactory, as the NGOs do not have adequate resources to do the job. In addition, with two brief exceptions in the 1990s and, more recently, three in 2003, the NGOs have not been given legislative backing in the form of the delegation of management authority. The development of specific instruments, such as user fees regulations, which would allow the NGOs to obtain necessary resources from the protected areas that they manage, has also been slow. A small start has been made with the agreement to allocate 25 per cent of beach license fees from within the boundaries of the Montego Bay Marine Park to that park. There has also been some, albeit inadequate, direct funding to parks.

The lack of a deep philosophical commitment to co-management has been a second problem. The handing over of protected areas to NGOs might have appeared a convenient expedient. Yet, when the implications are considered more carefully, delegation becomes problematic for sections of Jamaica's state leadership. Institutions accustomed to fast-tracking their pet projects do not wish to be constrained. Agencies associated with water resources, forestry and urban development face potential conflicts with the protected areas managers, as do large-scale business enterprises engaged in tourism, industry and agriculture. In light of these difficulties, negotiations on new delegations have been protracted.

The technical staff members within the National Environment and Planning Agency (NEPA – formerly NRCA) are now more aware of the limitations of NGOs and of the need to play a larger role with respect to protected areas. The NGOs are also more conscious of the need to have stable funding and have pressed the government to provide them with core funding and with the authority to collect user fees. However, the major players within developmental agencies that might come into conflict with protected area managers have also been pressing their case with the government. Ten years into the development of Jamaica's parks and protected areas system, there are many unresolved issues and, consequently, limited successes.

On the positive side, the need for protected areas has been recognized and a number of the most important ones identified or actually declared. A policy has been set down and regulations established. Experience has been gathered with respect to the workability of various management models. The Protected Areas Branch of NEPA, although still very small (seven persons full-time), is larger than it used to be. Monitoring programs and research are ongoing. On the negative side, the funding for protected areas remains unresolved. The Environmental Foundation of Jamaica has provided a small facility for core funding to which NGOs can apply, but this is unlikely to make a major impact on the problem.[8] Some progress

[8] This is a debt for environment entity set up through an agreement between the Jamaican and US governments. It has a mandate to fund NGO projects. The Jamaica National Park Trust Fund was established under a similar arrangement to provide funding for the first two parks that were declared.

has been made with the promulgation in 2003 of procedures for the collection of user fees in terrestrial national parks, but the comparable regulations for marine parks have not yet been produced. The political will to protect the environment remains weak and the issues relating to overlapping and conflicting jurisdictions among state agencies are still unresolved. Meanwhile, the NGOs remain small, with weak organizational capacity. They are often highly dependent on the skills and vision of a few if not one key individual. It has even been suggested, ironically, that what we have is unsustainable organizations promoting sustainable development.

Problems for coral reef protection

As a part of the International Coral Reef Initiative, a consultation process on the Jamaica Coral Reef Action Plan (JACRAP) was initiated in 1995 (NRCA 1999). Had this comprehensive plan received the support it needed to be effective, it would have provided a framework within which the protected areas could play a crucial role in the management of coral reefs. However, like many other Jamaican environmental policy documents, JACRAP has remained a paper plan. Yet the absence of an effective national program is not the only factor limiting the NGOs. Definitely one and quite likely two of the main factors that led to coral reef degeneration are outside the control of any human agency (this is in addition to the possible impact of global warming). These are hurricane damage and the various diseases affecting corals and *Diadem*. It is possible that there are anthropogenic elements at work in the cycle of susceptibility and disease, but there is no evidence for this. More broadly, in as much as the factors that maintain coral reef health are not fully understood, this constitutes a third factor that is beyond the capacity of the individual NGOs.[9]

Most of the landuse practices that impact on the coral reefs take place beyond the purview of the managers of marine protected areas. The nutrient levels in coastal waters, for example, are in large part the result of the absence or ineffectiveness of sewage treatment, exacerbated by agricultural runoff. With respect to sewage treatment and water quality, there has been a reluctance to accept standards that are higher than those generally imposed by public health authorities in the developed world. Yet coral reefs require higher water quality standards than do humans and, in dealing with sewage, the developed world does not face the same challenges of coral reef protection and can arguably tolerate lower standards.[10]

While most of the damaging landuse practices take place far from the marine protected areas, an exception is the Negril Environmental Protection Area, which goes "from ridge to reef" and includes the Negril Marine Park. In many areas, managers must focus on negative practices within the immediate coastal zone. Among these are practices that disturb mangroves and upset the dynamic relationship between mangroves, sea-grass and coral reefs. Limiting the unsustainable harvesting of mangroves and landfilling in wetlands can contribute to healthier coral reefs. But this will have little benefit in areas degraded as a result of increased runoff and sedimentation caused by deforestation and unsustainable agricultural practices in the uplands.

Perhaps the main way in which the NGOs can help to protect the coral reefs is by altering the behavior of tourists, fishers and others whose interaction with the reefs is most direct. Before examining these and other ways in which reef health might be improved it is necessary to lodge two caveats. The difficult economic situation in Jamaica has, in recent years, left tourism as one of the few areas of the economy showing some buoyancy. Policy-makers are, therefore, not inclined to support measures that impose what are seen as additional constraints on the sector. Similarly, widespread rural unemployment and poverty leave the government disinclined to enforce stringent measures against fishers, or to restrict access to fisheries, even where it is very clear that a decline in fishing effort is likely to improve output.

Jamaica is not a country where laws and regulations are treated with an unquestioned respect. Law enforcement is often weak, if not

[9] I emphasize the need for further research at a number of points in my discussion. It is important to be clear that, although more research would improve our ability to protect coral reefs, the state of current research is by no means the binding constraint. Current action is lagging far behind current knowledge. Although scientists may disagree on the precise impact of the various factors, there is a broad consensus that simultaneous effort be directed at the various stress factors. The relative importance of every factor for each site may in fact be important when it comes to protecting a particular coral reef. The design and implementation of the kind of research program that can provide answers for knotty questions, such as the role of climate change and the causes of coral disease, are well beyond the scope of the individual NGO.

[10] Australia and Florida, USA, represent two exceptions from which the Caribbean might well learn.

completely absent. Even where offenders are brought before the courts they do not always feel the full force of the law, as the environment is not an issue of deep concern to many judges. The Jamaican state does not evince a high level of legitimacy among ordinary citizens, and there are concerns with respect to corruption, political bias, and unfairness in the award of permits, licenses and state contracts. This context makes the introduction of effective resource use regulation difficult and underlines the importance of participatory co-management approaches if regulation is to succeed.

Achievements and prospects

Despite a less than enabling environment, a number of NGOs have made considerable strides. They have often obtained funding and begun to take steps towards the management of the protected areas prior to delegation. The NGOs have helped to promote research and monitoring of site-specific threats. Surrounding communities and resource users have been educated. In some cases a considerable effort has been made to connect with specific resource users in a structured way that embodies co-management ideals. The effort made to involve the fishers and their organizations in the process of drafting regulations for the Portland Bight fisheries is one case in point (Figueroa and Espeut 1996). In Negril, resource users now see the value of mooring buoys for tourist and other boats visiting the reefs.

Nevertheless, with few exceptions and despite approaches, especially from the NGOs, commercial enterprises have failed to respond to the environmental challenge. This is true even for industries such as tourism and coffee that are very dependent on extremely fragile natural environments. There has been some support for research, and considerable interest in projects such as the creation of artificial reefs, but the environment has not become a central concern even where there are win/win choices that have been proven in other countries. More recently, the tourist sector has taken an interest in international certification that would enable it to participate in the market for environmentally conscious tourists. Yet, the response to the Environmental Audits for Sustainable Tourism project was not overwhelming.

Cooperation between Jamaican NGOs has not been as effective as it might have been. Initially there was not a great deal of cooperation. Subsequently, the NGOs that pioneered the management of protected areas formed a network through which to share experiences and form common positions. However, at the time of writing, this network was no longer an active force. The protected area managers have cooperated with the technical staff within the state sector and have contributed to the various environmental policies, regulations and legislative drafts. Indeed, the NGOs can claim, at minimum, joint authorship for a number of government documents. They can also take credit for the somewhat more participatory style that is now adopted by the state when developing new policy instruments. (Although it has been suggested that this can lead to the slower decision-making of which the NGOs often complain.) Despite the weaknesses in national policy, the representatives of the non-governmental sector appear confident that, with a bit more support, they could achieve a significant reduction in reef damage. The experience at Negril with mooring buoys could be applied in other areas – including Ocho Rios and Port Royal. Lessons learnt with respect to the education of resource users and the general public could also be applied more broadly. Best practices can be shared throughout the protected areas system.

The reduction in fishing effort and improved fisheries management is another major focus for protected area managers. The potential for improvement in fish catches where effort is reduced (Sary et al. 1997) and reserves created (Woodley and Sary 2003) has been well documented. This experience could be applied in all the protected areas if fishing regulations were developed and rigorously enforced. The importance of enforcement can be seen from the Portland Bight area, where approximately 3 000 fishers operate. Of these, it is estimated that less than one per cent employ nets that are very destructive to the reefs and seagrasses or use explosives. Those with destructive nets have expressed a willingness to offer them up in a gear exchange. Owners of small size mesh traps and nets have also expressed their willingness to exchange if a comprehensive fisheries management plan is launched and fairly enforced. Potential fish sanctuaries have been identified and a consensus reached on the use of permits along with a "three out one in" system to further reduce fishing effort. All of this is set down on paper and endorsed in writing by the various fishers' organizations, but none of it can happen without effective state support. The state's tardiness in doing its part, despite much lip service (NRCA 1995a), leaves park managers without the tools they need.

However, it is clear that something can be done if there is the political will. The cost (political and economic) of implementing protection/enforcement measures depends on what is being targeted. While there is no space to provide a detailed political calculus, it seems clear that, if the system is resourced adequately and administered fairly, negative political fallout could be minimal even in the short-run. Issues of economic costs, cost effectiveness and the relationship between the costs and benefits that derive from coral reef protection require more attention in order to demonstrate benefits and beneficiaries and, thus, strengthen political will.

Economic valuation and coalition building

The techniques of economic valuation have been applied to Jamaican (and other Caribbean) reefs and to related marine and terrestrial areas. (See, for example, Wright (1995) and EMU (2001).) These studies have employed well-known techniques to develop valuations of various coastal resources along lines similar to those adopted in other countries. No attempt is here made to review or critique these studies from a technical point of view. Instead I reflect on the questions that valuation studies might seek to answer if they are to assist in the process of building coalitions for coral reef protection.

In building a coalition it is necessary to identify potential allies and opponents. Among the former are those who might currently be suspicious or even hostile to proposals for the protection of the environment, but whose long-term interest lies with coral reef protection. For those who are already convinced of the need for coral reef protection, the issue is "what paths lead to coral reef restoration?" There are four groups (not counting the relevant Jamaican regulatory agencies and their staff) who are firmly in the camp of coral reef protectionists. These are (1) scientists researching in relevant disciplines; (2) environmentalist, their organizations, and other NGO or community-based organizations that have championed coral reef protection; (3) water sports enthusiasts, especially divers who have witnessed the deterioration of coral reefs; and (4) international organizations, including bilateral funding agencies, that have taken a stand in favor of and/or provided funding for projects that promote coral reef protection. The first three groups identified do not need any economic arguments to convince them of the need for coral reef protection. Indeed many of them are quite suspicious of the application of economic valuation to the environment and might well fall into the category of those who offer zero protest bids in contingent valuation studies (Splash 2000).

Economists may need to convince members of these three groups of the merits of economic valuation. In attempting to do so it would be very important to make it clear that economic valuation does not establish absolute values for the environment. Whatever figure is estimated constitutes a lower bound, as it usually only captures the most obvious and most easily calculated values. Many issues, such as those relating to option and non-use and, indeed, non-economic values, make it impossible to capture the value of the environment in dollars and cents. Failure to concede this point is likely to alienate many of the most enthusiastic supporters of coral reef protection. At the same time, many of these same people are happy to receive a positive endorsement from valuation studies, particularly where it is possible to demonstrate that the potential benefits that are derived from their work (even when valued at the lower bound) exceed the financial cost of supporting their actions. Cost-benefit analyses are the bread and butter of group four, agencies engaged in projects and/or funding; they need no convincing of the importance of valuation.

There are groups that should be on the side of coral reef protection but which, through ignorance or shortsightedness, are in an ambiguous position. Among these are the main resource users, including fishers, water sports operators, hoteliers and others with tourism interests. At the national level the Ministry of Finance and Planning, various regulatory agencies and the country's leadership within all walks of life should be included. For the resource users, there is no doubt that a sustainable relationship with the coral reef ecosystem is in their best interest, but many are yet to understand or be convinced that such an approach can work. The pressing resource situation and demands for solutions to developmental problems encourages short-term approaches. Those who engage in development, planning and finance, are also unconvinced of the ability of coral reef protection to ease resource constraints over time. Winning over these groups is essential if an effective coral reef coalition is to be created, but doing so requires a targeted approach.

Neither small-scale artisanal resource users nor hard-nosed capitalists are likely to be convinced by abstract or general valuations of coral reefs and the like. The small-scale users need to be convinced of the benefits of behavioral change in a very concrete way. In the circumstances of open access resource use, they need to be convinced that free riders will be effectively excluded. They may also need subsidies to tide them over periods when resource use may have to be curtailed, or to finance a shift to less destructive methods of harvesting. Economic valuation is of less use in winning their support than it might be in convincing financial decision-makers that subsidies are worthwhile investments.

The tourist sector is one that, by its very nature, is globally competitive. The sector is, therefore, very sensitive to anything that it sees as imposing an additional cost. If economic valuation is to convince the shrewd businessperson in tourism it will have to address some very specific questions. It also needs to rest on a firm base of science. Beach, sand and water quality are central to Jamaica's nature-based tourist product. Yet the precise role of the coral reefs and related ecosystems in this process is still inadequately understood. For example, hoteliers routinely clear seagrass beds to improve the swimming experience of their guests. The long-term impact of this practice is not clearly understood by ecologists, nor is it clear what might be the best compromise that allows the current visitor to enjoy the beach while ensuring a similar experience for future visitors.

To convince hoteliers that they should modify practices, economic valuation has to be refined considerably. Hoteliers need to see the relationship between specific environmental goods and services and the demand for their product. They need to see the relationship between the impact they cause and the damage to the environmental goods or services that are at the foundation of their product. Demonstrating the relationship between water quality and tourism arrivals or between reef health and sale of reef tours may be methodologically challenging, yet, in the absence of such concrete connections, tourism interests are not likely to be spurred by economic valuation to accept the necessary short-run costs to secure their long-run interests.

The Ministry of Finance and Planning and other planning agencies are more accustomed to use micro data than macro data. Carefully prepared economic valuations might help to order priorities in favor of resource conservation. In convincing planners, however, general asset valuation is not enough; cost-effective considerations are also important. An integrated approach, such as that alluded to in Gustavson and Huber (2000), is likely to be more convincing. Given the formidable array of interests that are potential opponents to measures for coral reef protection, such an approach is important. At the same time, in balancing economic costs and benefits, we need to be clear that optima arrived at based on economic valuation techniques are not necessarily overall optima.

Large and small-scale agriculture, industrial enterprises, and the construction, mining, transportation and water sectors all impact negatively on the coral reefs. The imposition of more stringent landuse practices on agriculture, and the enforcement of tougher pollution standards on industry and the water sector, would reduce nutrient loads in coastal water and help to prevent sedimentation. This would also impose additional costs on these sectors and would be likely to be resisted.[11] Carefully prepared economic valuations may help to convince decision-makers that the imposition of costs on these sectors is justified given the benefits to be derived by sectors that are dependent on coral reef health.

Decisions to protect coral reefs imply shifts in resource allocation that can have far-reaching implications. Those engaged in economic valuations need to be aware of the range of political variables and social dynamics that impinge on the decision-makers. Where it is demonstrated that a net benefit can be derived from coral reef protection, the question that arises is "who will actually benefit?" Is it predominantly the majority (poor, rural, local small-scale producers and workers who stand to benefit), or the minority (the better-off, urban, local elite, often from a racial minority), or foreign tourists? Distributional issues relating to residence and occupation as well as race, class and gender are never far from the surface and cannot be avoided if economic valuation is to

[11] An area worth exploring is the making of claims against shipping companies and insurers where ships run aground on coral reefs. Unfortunately, the reefs in many ports are so degraded that it may be difficult to achieve high awards in some cases.

help convince the national leadership to pay more attention to coral reef protection.

Conclusion

The main elements of an effective co-management framework for the protection of coral reefs have not yet been established in Jamaica. A small number of NGOs have developed valuable experience in working with their various communities to prepare for a genuine co-management approach. But, co-management is not an easy task in Jamaica, because many of the socio-cultural attributes of the country, as well as its political history, have been built on an ethic that disempowers people through authoritarian structures, and discourages them from taking responsibility for their world. In addition, there is a legacy that leads to a disregard for laws and regulations, and a state that fails to command a high level of legitimacy. These tendencies – and they are more marked in Jamaica than most other Caribbean countries – pose very difficult problems for building the consensus that is required for effective bottom-up co-management regimes. It also poses difficulties for enforcement that are less acute in most other Caribbean countries.

The NGOs have, with experience, developed a deeper understanding of what is involved in managing protected areas. The technical leadership of the NRCA/NEPA has also gained useful insights into what it can expect from the NGOs. The NEPA staff is now more committed to the view that, if co-management is to work, then the organization will have to be a more active participant and provide central services to support the protected area managers in the field. It will need to set and monitor measurable goals for protected areas. Other state agencies, such as the Fisheries Division and the Forestry Department, will also have to be active agents in co-management. All now recognize the need for a genuine system of protected areas rather than a set of isolated delegations. The local and foreign research communities and the international agencies remain supportive, but there is a limit to what contribution they can have in the absence of a fully developed national system.

The time taken to make decisions that are vital to the protected areas is unacceptable. If this were due merely to a lack of resources or bureaucratic inertia, it would be bad enough. The reality is that there is no unity of purpose within the state sector that stands behind the philosophy of co-management and the goal of effective environmental management. A number of state agencies that have been accustomed to doing their own thing are resistant to features embodied in the policy framework for protected area management. Vested interests are always a threat to environmental management, and there is an absence of strong political will to make the kind of breakthroughs that are required to transform the way Jamaican society relates to its natural environment. The commercial sector, the opinion-leaders and the general public have yet to understand concepts of sustainable development, let alone take steps to integrate them into their daily lives at work, at home and within their communities.

In the absence of an effective national program for the protection of coral reefs in Jamaica, there is a limit to what can be achieved within the protected areas. Yet, there is much that can be done to limit the damage caused by those who most directly interact with the reefs and related ecosystems within the protected areas. The protected area managers have already produced some positive results and can continue to do so even if left to their own devices. But what they can achieve without support is far from adequate. More significant changes will require urgent action to conclude negotiations, promulgate regulations and create a system that guarantees adequate core funding to protected areas.[12]

Building a momentum for the protection of coral reefs requires the formation of a coalition that includes all those who are already convinced, along with all those whose long-term interests are directly associated with the health of the coral reefs. It will be necessary to persuade the national leadership that the sacrifices that other sectors need to make in order to protect the coral reefs are a necessary price to pay for the greater benefits that will rebound from the recovery of the reef ecosystems. In building such a coalition, economic valuations can play a role – but to have a greater impact they need to be refined to the point where they can address the concerns of the target audiences, which are susceptible to an appeal to pecuniary calculations.

[12] At the time of writing work was ongoing on a new systems plan for protected areas scheduled for completion in June 2004.

In terms of practical environmental management, Jamaica has some catching up to do in comparison with other countries such as St. Lucia and Belize. Protected area management in St. Lucia has been singled out as a successful case study in co-management. Similarly Belize, which has always had more effective fisheries management (including enforcement), is embarking on an integrated coastal zone management program with funding from the Global Environment Facility. Unfortunately, despite its long history as a research site and its more developed technical infrastructure compared with its smaller neighbors, Jamaica is often cited as an example not to be followed.

References

Aiken, K. and G. Kong. 2000. The marine fisheries of Jamaica. NAGA – The WorldFish Center Quarterly 23: 29-35.

Cesar, H. (ed.) 2000. Collected essays on the economics of coral reefs. CORDIO. Kalmar, Sweden.

Cho, L. L. and J. D. Woodley. 2003. Recovery of reefs at Discovery Bay, Jamaica and the role of *Diadema antillarum*, p. 331-338. *In* M.K. Kasim Moosa, S. Soemodihardjo, A. Nontji, A. Soegirto, K. Rominohtarto, Sukarno and Suharsona (eds). 9th International Coral Reef Symposium Proceedings. Indonesian Institute of Science in cooperation with the State Ministry for Environment, Jakarta, Indonesia.

Environmental Management Unit (EMU). 2001. Resource valuation exercise for the Ocho Rios Marine Park, EMU, University of the West Indies, Kingston, Jamaica.

Figueroa, M. and P. Espeut. 1996. Preparing for participatory environmental planning in the English speaking Caribbean: the case of the SCCF in Jamaica. Paper presented to Integrating Economic and Environment Planning in Island and Small States, 14-16 March 1996, Malta. Islands and Small States Institute of the Foundation for International Studies in collaboration with the Directorate of the Planning Authority, Malta.

Gustavson K. and R. Huber. 2000. Ecological economic decision support modeling for the integrated coastal zone management of coral reefs, p. 183-202. *In* H. Cesar (ed.). Collected essays on the economics of coral reefs. CORDIO. Kalmar, Sweden.

Miller, Learie A. 1999. Perspectives on the sustainability of protected areas in Jamaica. Caribbean Geography 10(1):52-62.

Klomp, Kristi D. 2001. Coral reefs of Jamaica's northern coast: Assessment of condition and key threats. Final Report of the Atlantic and Gulf of Mexico Rapid Reef Assessment. Coral Gables, Florida NRCA.

________1995a. Jamaica National Environmental Action Plan. Natural Resource Conservation Authority. Kingston, Jamaica.

________ 1995b. Towards a national system of parks and protected areas. Green Paper 1/95. Natural Resource Conservation Authority, Kingston, Jamaica.

________ 1997. Policy for the national system of protected areas. Natural Resource Conservation Authority, Kingston, Jamaica.

________ 1999. Jamaica coral reef action plan. Natural Resource Conservation Authority, Kingston, Jamaica.

NCOCZM. 2001. Towards an ocean and coastal zone management policy in Jamaica. National Council on Ocean and Coastal Zone Management Green Paper 9/01. Ministry of Foreign Affairs. Kingston, Jamaica.

Sary, Z., H. A. Oxenford and J. D. Woodley. 1997. Effects of an increase in trap mesh size on an over-exploited coral reef fishery at Discovery Bay, Jamaica. Marine Ecology Progress Series 154:107-120.

Smith, D. 1995. Implementing a national park system for Jamaica: The PARC project, p. 249-258. *In* D. Barker and D. F. M. McGregor (eds). Environment and development in the Caribbean: geographical perspectives. UWI Press, Kingston, Jamaica.

Splash, C. 2000. Assessing the benefits of improving coral reef biodiversity: The contingent valuation method, p. 40-54. *In* H. Cesar (ed.). Collected essays on the economics of coral reefs. CORDIO. Kalmar, Sweden.

Woodley, J. D. and Z. Sary. 2003. Development of a locally-managed fisheries reserve at Discovery Bay, Jamaica, p. 627-634. *In* M.K. Kasim Moosa, S. Soemodihardjo, A. Nontji, A. Soegirto, K. Rominohtarto, Sukarno and Suharsona (eds). 9th International Coral Reef Symposium Proceedings. Indonesian Institute of Science in cooperation with the State Ministry for Environment, Jakarta, Indonesia.

Wright, Matthew G. 1995. An economic analysis of coral reef protection in Negril, Jamaica. Working Paper 11, UWI Center for Environment and Development. Kingston, Jamaica.

Policy Implications in the Management of Kenya's Marine Protected Areas

Sam Weru

Abstract

Coral reefs exist along most of Kenya's coast as coral flats, lagoons, reef platforms and fringing reefs. The total area of coral reef is estimated at 50 000 ha. Currently, a total of 183 species of stony corals belonging to 59 genera have been identified on these reefs. In general, the reef communities are similar to other parts of the Western Indian Ocean. They are dominated by *Porites* spp. assemblages in calm waters and *Acropora* spp. assemblages in high energy environments.

The Kenyan government recognized in Session Paper No. 3 of 1975, "Statement of Future Wildlife Management in Kenya", the need to manage and conserve the country's natural resources. Accordingly, the Fish Industry Act and the Wildlife (Management and Conservation) Act were enacted by Parliament in 1968 and 1976, respectively. With this legislation, Kenya set a precedent for the rest of Africa. In 1968, the government declared the first marine protected area, and, subsequently, it continued to put other coral reef areas under a two-tier conservation system that is recognized by law. As a result of this differential management system, coral reefs in Kenya exhibit significant differences in ecological health. These differences are related to the degree of protection afforded the reef. However, despite delivering benefits in terms of reef health, reef protection measures sometimes impose serious socioeconomic costs on fishers forced to relocate or change their lifestyles.

Recent moves to develop management plans on the basis of community consultation are demonstrating the potential for less costly, but nevertheless, effective conservation measures.

Introduction

The Kenyan coastline, approximately 500 km long, stretches from 1^0 42'S to 4^0 40'S, and borders Somalia in the north and Tanzania in the south. The continental shelf covers an area of about 19 120 km^2 (UNEP 1998). Well-developed fringing reef systems are present all along the coastline except where major rivers (the Tana and the Athi/Sabaki) discharge into the Indian Ocean. Patch reefs occur around Malindi and Kiunga in the north, and around Shimoni in the south. Seagrass beds are usually associated with reef systems growing in shallow lagoons, creeks and bays. Nine species of mangroves are found in Kenya, protecting the coral reef community from land-based effluents and nutrients.

The coral reefs existing along most of the Kenya coast occur as coral flats, lagoons, reef platforms, and fringing reefs. The total area of coral reef is estimated at 50 000 ha. Currently, 183 species of stony corals belonging to 59 genera have been identified on these reefs. Other important reef-building organisms, including soft corals, coralline red algae and calcareous algae, exist but have received less attention. In general, the reef communities are similar to those in other parts of the Western Indian Ocean. They are dominated by *Porites* spp. assemblages in calm waters and *Acropora* spp. assemblages in high energy environments.

In Session Paper No. 3 of 1975, "Statement of Future Wildlife Management in Kenya," the Kenyan government recognized the need to manage and conserve the country's natural resources. Accordingly, it enacted the Fish Industry Act (1968) and the Wildlife (Management and Conservation) Act (1976) (Laws of Kenya 1983; 1977). With this legislation, Kenya led the way for the rest of Africa. In 1968, the government established the first marine protected area (MPA). Since then, other coral reef areas have continued to be put under a two-tier conservation system that is recognized by law.

Government policies

The Fish Industry Act was established to "provide for the reorganization, development and regulation of the fish industry, to make provision for the protection of fish and for the purposes connected therewith". Through this act, the Fisheries Department (FiD) was established. This department, in cooperation with other appropriate agencies and other departments of Government, promotes the development of traditional and industrial fisheries. It does this by providing extension and training services, conducting research and surveys, promoting cooperation among fishers, promoting arrangements for the orderly marketing of fish, providing infrastructure, stocking waters with fish, and supplying fish for stocking.

In the course of fisheries management, the FiD may use legislative measures to:

- Declare closed seasons for designated areas, species of fish or methods of fishing;
- Prohibit fishing areas for all or designated species of fish or methods of fishing;
- Place limits on fishing gear, including mesh sizes of nets that may be used for fishing;
- Limit the amount, size, age, species or composition of species of the fish that may be caught, landed or traded;
- Regulate the landings of fish and provisions for the management of fish landing areas;
- Control the introduction into or harvesting or removal from any Kenya fishery waters of any aquatic plant.

The Wildlife (Management and Conservation) Act was established to "consolidate and amend the law relating to the protection, conservation and management of wildlife in Kenya; and for purposes connected therewith and incidental thereto". These powers were placed in a consolidated service, the prime objective of which "should be to ensure that wildlife is managed and conserved so as to yield to the nation in general and to individual areas in particular, optimum returns in terms of cultural, aesthetic and scientific gains as well as such economic gains as are incidental to proper wildlife management and conservation and which may be secured without prejudice to such proper management and conservation." The Wildlife (Management and Conservation) Act recognizes the need to balance wildlife conservation and management with the varied forms of land use. By way of a 1989 amendment, the Wildlife Act established the Kenya Wildlife Service (KWS), a state corporate body with the above objectives and the following functions:

I. Formulation of policies regarding the conservation, management and utilization of all types of fauna (not being domestic animals) and flora;
II. Advising the government on the establishment of National Parks, National Reserves and other protected wildlife sanctuaries;
III. Management of National Parks and National Reserves;
IV. Sustenance of wildlife to meet conservation and management goals;
V. Conduct and coordinate research activities in the fields of wildlife conservation and management;
VI. Provision of advice to the government, local authorities and landowners on the best methods of wildlife conservation and management and to act as the principal instrument of the government in pursuit of such ecological appraisals or controls outside urban areas as are necessary for human survival; and
VII. Administration and coordination of international protocols, conventions and treaties regarding wildlife in all its aspects.

It is worth noting that all these policy and legal statements are quite ambiguous and do not refer specifically to coral reefs and marine life protection and management. However, the powers vested in the KWS, and its predecessor the Wildlife Conservation and Management Department (WCMD), by the Wildlife Act has led to the recognition of the value of coral reefs and resulted in the gazettal of four fully protected marine areas, namely Marine National Parks, and six partially protected marine areas (Marine National Reserves). In one of the management plans, marine protected areas (MPAs) are defined as "areas set aside by law to protect and conserve the marine and coastal biodiversity and the related ecotones for posterity by enhancing the regeneration and ecological integrity of the mangroves, coral reefs, seagrass beds, sand beaches and their associated resources which are vital for sustainable development through scientific research, education, recreation and other compatible resource utilization" (Weru et al. 2001). In this plan, the overall objectives for management of MPAs are outlined below:

Preservation and conservation of the marine biodiversity for posterity

- To protect a representative sample of the coral reef and seagrass ecosystems on the Kenyan coast.
- To restore and rehabilitate the damaged marine ecosystems.

Provision for ecologically sustainable use of the marine resources for cultural and economic benefits

- To ensure that activities within the marine protected areas are controlled and conform to the management regulations for ecological sustainability.
- To enable the stakeholders to participate in a wide range of eco-friendly recreational activities.
- To implement zoning as a management tool in the marine protected area in order to eliminate conflicts between user groups.
- To enhance management-oriented research for optimum resource use.

Promotion of applied research for educational awareness, community participation and capacity building

- To ensure information flows to stakeholders so that they are in a better position to understand management decisions.
- To enable young and upcoming researchers to investigate their theories and hypotheses developed at tertiary institutions of learning.
- To provide an information base for education and awareness programs for local communities.

Implications of these policies

Ecological implications

As a result of these policies, coral reefs in Kenya can be categorized into three management regimes.

1. ***Fully protected***: These are contained within a Marine National Park, of which there are four (see Table 1). The park is usually the core area consisting of a reef lagoon, reef flat, reef edge and/or slope, in a (usually) larger reserve. Within these parks, no extractive use is allowed, with or without a license, and the Wildlife Act takes precedence over other policies or legislation. For purposes of research and education, samples may be collected with the authority of the Office of the President in collaboration with the KWS.

2. ***Partially protected:*** These are otherwise referred to as Marine National Reserves, of which there are six (see Table 1). These reefs act as buffer zones to marine parks and as multiple use areas. Harvesting, in terms of fishing and collection of other marine organisms, is allowed, albeit with a license from FiD. Only traditional harvesting techniques (mostly fishing traps made from coconut palm fronds and straw, locally known as *madema* and *uzio)* as well as the universally known hook-and-line are permitted. Collection of sea cucumber and aquarium fish species is also allowed under license. Tourism activities, such as sport fishing, scuba diving and other water sports are allowed at a nominal fee. Both Acts relating to fisheries and wildlife proscribe the use of destructive harvesting methods, such as dynamite fishing, seine netting and coral mining.

3. ***No protection:*** This category applies to coral reefs outside the designated conservation areas. However, even in these areas, the Fish

Table 1. Marine protected areas in Kenya

Name of MPA	Park size (km2)	Reserve size (km^2)	Year established	Status
Mombasa	10	200	1986	Operational
Kisite/Mpunguti	28 (combined)	11	1978	Operational
Malindi/Watamu	16 (combined)	245	1968	Operational
Kiunga	0	250	1979	Semi-operational
Diani	0	250	1995	Not operational

Industry Act applies and is enforced by the FiD. Although no formal management is in place, destructive methods such as dynamiting and coral mining are proscribed. The FiD may enlist the support of the KWS, the police or the Kenyan navy in the enforcement of the Act. Nevertheless, due to the lack of control over how and by whom the unprotected resources will be used, there is gross over-exploitation. As a result, these reefs are the most degraded.

In addition to their undisputed value in attracting tourists, Kenya's coral reefs are also important for fisheries, with the tourism industry as one of the main markets for fish products. The tourism industry has also created demand for other reef resources, such as corals and shells. Many species are probably being over-exploited and careless collection methods have led to serious habitat damage (UNEP 1998).

The fisheries resources of the Kenyan coast are estimated at 6 000 to 9 000 metric tonnes (UNEP 1998). Approximately 80 per cent of the marine fish catch is demersal, mainly from shallow coastal waters and reefs. An estimated 4 000 to 4 500 artisanal fishers, using different types of gear including trap, hook and line, seining, gill netting spear fishing and gleaning, are involved. They catch mainly finfish of the families *Lethrinidae, Siganidae* (rabbit fish), *Scaridae* (parrot fish) and *Lutjanidae* (snappers). Crustaceans, including crabs, lobsters and prawns, as well as octopus are commonly collected from reefs, seagrass beds or mangroves during low tides. Commercial trawling activities take place off the reefs in deeper waters. A series of studies conducted in the 1990s (McClanahan 1994; McClanahan 1997; Weru 1994) indicates major differences between protected and unprotected coral reefs in terms of fish diversity, fish biomass, topographic complexity, coral cover and sea urchin predation. According to these studies, fish biomass was higher in protected than unprotected reefs. This is particularly true for fish in the families *Balistidae, Lutjanidae, Lethrinidae, Pomacanthidae, Acanthuridae* and *Scaridae*. However, some typical coral reef fish (such as *Pomacentridae* and *Labridae*) did not show significant differences in terms of diversity. In fact, they seem to prefer highly disturbed areas (snorkeling and diving sites). Fish density within the marine parks is 900 to1 200 kg/ha, much higher than the fish density in reserves (500 kg/ha) and unprotected areas of reef (100 kg/ha). Parks, therefore, act as a refuge and breeding ground for many fish species. Figures 1 and 2 illustrate the density and diversity of eight families of fish on reefs with different levels of protection. The removal by fishing of large species of predatory fish has resulted in sea urchin density being higher in both unprotected and partially protected areas than in protected areas (parks).

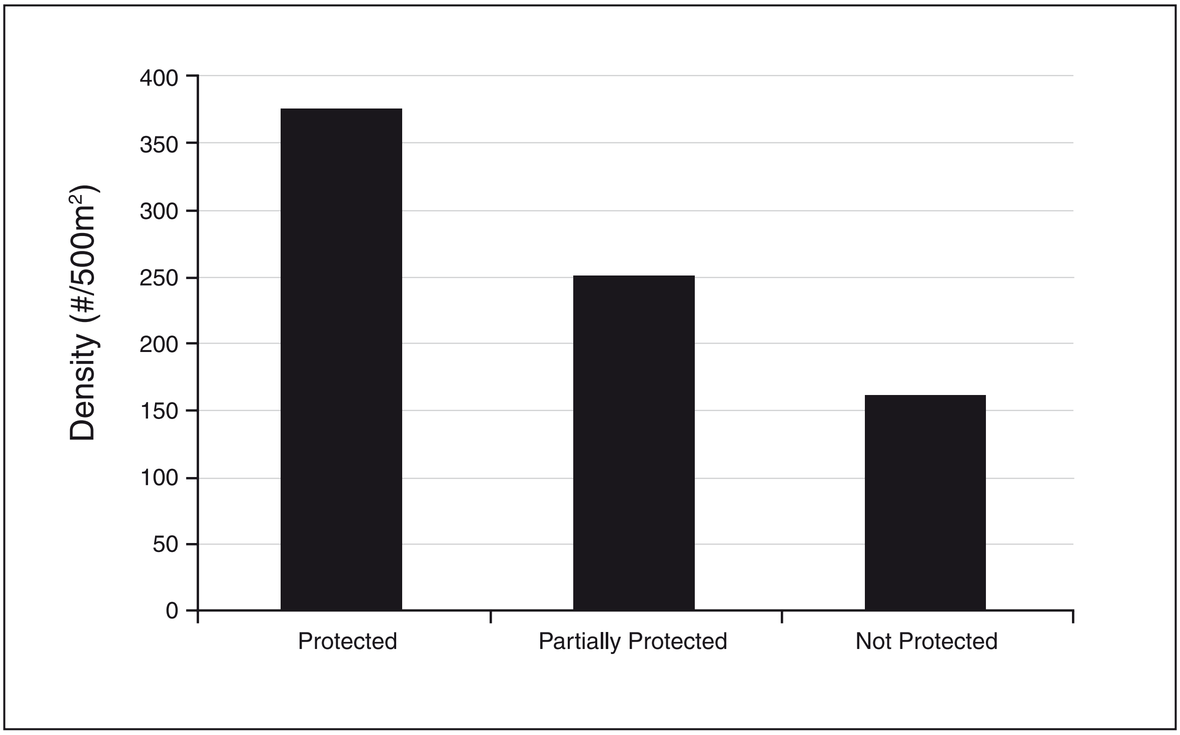


Figure 1. Variation of density (number of fish/500 m^2) with different levels of reef protection (Adapted from McClanahan 1994)

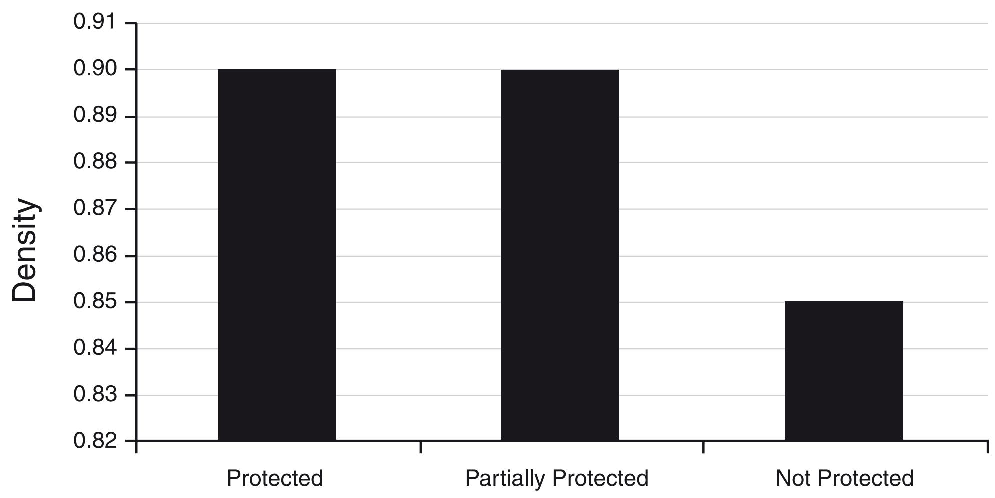


Figure 2. Diversity of fish (eight families) in areas with different levels of protection (Adapted from McClanahan 1994)

Coral cover and topographic complexity were also much lower in unprotected areas (McClanahan 1994; McClanahan 1997). Stony coral cover was found to average between 30 per cent and 40 per cent (McClanahan 1994; McClanahan 1997). However, the 1997-98 El Nino event caused extensive bleaching that resulted in local mortality of up to 95 per cent. The reefs have a high topographic complexity that creates habitats for numerous other reef species, including 350 species of fish, 135 species of gastropods, at least 200 species of algae, and 12 species of echinoids.

Socioeconomic implications

In order to create and manage coral reefs as conservation areas, certain economic activities had to be discontinued in the designated areas. Fishers, who previously had had unlimited access and use of the marine resources, had to seek other livelihoods and/or locations. A number of the younger ones were able to convert their boats so that they could be used to ferry tourists interested in snorkeling and sailing to the newly protected areas. Those who could not adapt this way simply had to move away and compete with others at unprotected sites. The immediate reaction to this was strong opposition to the conservation movement. Even those who could adapt had to conform to certain standards in order to be licensed to carry tourists into the parks. These standards relate to safety equipment, such as life jackets and/or rings and fire extinguishers; insurance; and certificates of sea worthiness. In addition, crews had to pay park entry fees. Lack of managerial skills and shortage of funding often prevented individuals meeting these standards and hence doing business. Most of those who were able to comply and operate were actually foreigners or had foreign connections in tourist hotels. This increased the opposition to marine conservation areas by local stakeholders, and clashes with government policy were inevitable. Even within the government, there was conflict between the wildlife and fisheries policies, with the FiD licensing fishers and the KWS managing for conservation. This conflict was particularly apparent in the marine reserves, where both wildlife and fisheries law are implemented.

About 30 years after the first MPA was established the KWS embarked on a serious exercise to develop management plans for the operational MPAs. The planning process was consultative, and collated views on management issues from as many stakeholders as possible. Although the conflicts are far from resolved, the KWS and FiD have realized the need to consult widely *before* rather than *after* the establishment of MPAs. They have also realized the potential for community-managed conservation areas. Educating the fishers on the value of MPAs as nursery grounds for fish has also resulted in some of them supporting the conservation movement.

In conclusion, it is paramount to underscore the fact that, if not well researched, policy implementation, although designed for positive gains, may have far reaching psychosocio, socio-economic and ecological impacts. Conservation is about changing people's behavior positively and using resources wisely for the benefit of mankind in the present and for posterity.

References

Laws of Kenya. 1977. The Wildlife (Conservation and Management) Act: CAP 376. Government Printer, Nairobi, Kenya.

Laws of Kenya. 1983. The Fish Industry Act: CAP 378. Government Printer, Nairobi, Kenya.

McClanahan, T. R. 1994. Kenyan coral reef lagoon fish: effects of fishing, substrate complexity and sea urchins. Coral Reefs 13:231-241.

McClanahan, T. R. 1997. Effects of fishing and reef structure on East African coral reefs. Proceedings of the 8th International Coral Reef Symposium, 24-29 June 1996, Panama City. Coral Reefs 2:1533-1538.

UNEP. 1998. Eastern Africa atlas of coastal resources 1. UNEP, Nairobi, Kenya.

Weru, S. 1994. Optimum coral reef resource use: Case study of a marine protected area. University of Nairobi, Kenya. M.S. Thesis.

Weru, S., G. Amboga, E. Verheij, A. Koyo, N. Muthiga, B. Kavu, J. Kareko and M. Litoro. 2001. *In* T. van't Hof. (ed.). Management plan: Mombasa Marine National Park and Reserve. Kenya Wildlife Service, Mombasa, Kenya.

Coral Reef Conservation and Management in China[1]

Qiaomin Zhang

Abstract

This paper summarizes the status of coral reef conservation and management in China. Coral reefs in China include fringing reefs found in southern China's coastal waters and associated with 128 atolls in the South China Sea Islands. These atolls have a combined area of about 30 000 km^2. As a result of rapid socioeconomic development and population growth in the coastal region of South China over the last several decades, many coral reefs have been seriously damaged or degraded, largely by inappropriate human activities and consequent pollution. Until now, even though the government has taken some measures to protect and manage the reefs – including issuing relevant laws, establishing natural reserves, creating marine zones – the condition of the reefs has continued to worsen. Surveying, monitoring, assessment and research of coral reefs in China needs to be strengthened in order to meet the changing needs for protection, management, restoration, reconstruction and sustainable development of the coral reef ecosystems.

Distribution of coral reefs in China

Coral reefs in China include fringing reefs found in southern China's continental coastal waters and around offshore islands, and as atolls in the South China Sea (Zhao et al. 1999). Typical fringing reefs occur mainly on parts of the coasts of Hainan Island and Taiwan Island. Owing to the high latitude and low winter temperature, only limited and scattered, sub-tidal coral communities and locally fringing reefs occur along the southern coastline of continental China. These fringing reefs stretch from Dongshan Bay (23°45′N), the western-most bay of Fujian Province, to the western coast of Luizhou Peninsula, and from around the Diaoyudao Islands (25°45′N), to the north of Taiwan Island, to Weizhou Island in Guangxi. Within the vast waters of the South China Sea there are about 128 atolls, or platform reefs, (with a total area of about 30 000 km^2) forming the South China Sea Islands. About half of the atolls (covering an area of only about 5 000 km^2) are emerged atolls, while the remainder are drowned atolls (Zhang 2000, 2001a). The total areas of all reef flats and limesand islets (of which there are about 53) on emerged atolls of the South China Sea Islands are only 907.1 km^2 and 11.41 km,[2] respectively (Zhao et al. 1999).

Status of coral reefs in China

Because of rapid economic development and population growth in the coastal regions of South China over the last several decades, many coral reefs have been seriously damaged or degraded. This damage and degradation can be traced to human-induced causes, such as coral mining, over-fishing, destructive fishing, and pollution (Zou 1995; Liu 1998; Zhang 2000, 2001a). It has been estimated that as much as 80 per cent of the fringing reefs along the coasts of Hainan Island are damaged or degraded (State Oceanic Administration 1996). In the 1960s, hermatypic corals of the Luhuitou coastlines around Sanya City on Hainan Island consisted of 12 families, 24 genera and 83 species (Zou et al. 1975). They formed approximately 70 per cent of all species on Hainan Island. By the 1990s, these corals had been reduced to only 10 families, 21 genera and 58 species. About one third of hermatypic coral species have become extinct and more than 70 per cent of coral colonies are less than 30 years old (Yu and Zhou, 1996). In the area near Sanya Port and Sanya River inlet, the hermatypic corals are almost completely destroyed and cannot be restored (Zhang 2001b, 2001c).

[1] Projects No. 49776303 and 39970143 supported by the National Natural Science Foundation of China and key project B supported by the Chinese Academy of Sciences.

The threats to coral reefs in China vary from place to place. The threats to fringing reefs in Hainan Island arise mainly from extractive activities, such as coral mining for building materials and limestone; corals and shell collections for the curio trade; over-fishing and destructive fishing etc. Such activities usually have direct and immediate detrimental effects on the biological and ecological conditions of the reefs. In July 1994, in the northeastern embayment of Hong Kong (Bay of Hong Kong), a strong hypoxia event caused massive mortality of benthic organisms. In that event, the damage to hermatypic corals caused up to 80 per cent mortality on some reefs (Hodgson and Yau 1997). This hypoxia event may have been related to a 100-year record freshwater discharge from the Pearl River combined with calm weather; the combination of the two possibly created the stratified condition (Hodgson and Yau 1997). Higher temperature discharge from the third nuclear power plant at Kenting in southern Taiwan has caused coral degradation and summer bleaching (Zou 1995; Dai 1991) and become an important local threat. In the South China Sea Islands, the greatest pressures on coral reefs come mainly from over-fishing in reef waters and from climate change, with high sea surface temperatures causing coral bleaching.

The general condition of coral reefs in China is still deteriorating. Human impacts are continuing in some coral reef regions, while the rapidly developing coastal tourism industry is expected to seriously increase the pressures on China's coral reefs.

Coral reef conservation and management in China

The general situation

In 1984, the Chinese government declared "environment protection" to be a fundamental national policy; in 1997 "sustainable development" was adopted as a national development strategy. The government has also promulgated a series of laws or regulations related to the protection and management of coral reefs. For example, the State Law of Marine Environment Protection, and the State Management Regulation Preventing Coastal Engineering Projects from Marine Environmental Damage and Pollution, both laws issued in 1983 strictly prohibit coral destruction by any coastal engineering activities (Chen 1993). The former was revised in 2000, putting more emphasis on coral reef protection, restoration of damaged reefs and establishment of marine reserves.

The State Environmental Protection Administration of China conducted the China Biodiversity Protection Action Program in cooperation with nine other government departments with the support of UNDP/GEF. The "China Biodiversity Protection Action Program" was published in 1994). The protection of the coral reef ecosystem was listed as one of the priorities of the program.

The "Hainan Province Regulation of Coral Reef Protection" issued in 1998 prohibits coral mining for building materials and limestones; blast fishing and cyanide fishing; coral and shell collection for the curio trade; and the establishment of waste outfalls into coral reef marine reserves.

In 1996, a program called "Restoration of Coral Reef Ecosystem and Protection and Management of its Biodiversity in South China Sea of China" was included as one of the priority programs of the "21st Century Ocean Agenda of China" (State Oceanic Administration 1996). The "State Law of Ocean Use Management" issued in 2001 requires that all coastal development programs accord with the division of marine functional zones declared by the government. The State Oceanic Administration issued the State Regulation of Natural Reserves in 1994, and the Rules of Marine Natural Reserves Management in 1995. In 1990, the State Council of China approved the first five national marine protected areas managed by the State Oceanic Administration. A further two were approved in 1991. In 1990, the government established the Sanya National Coral Reefs Nature Reserve (5 568 ha) in Hainan Province, and, in 1998, the Dongshan Bay Provincial Coral Reefs Nature Reserve (11 070 ha) in Fujian Province. The reserves implement a policy of "prioritize conservation, appropriate utilization, and sustainable development" (Zhang 2001a). In addition, since 1996, several marine parks or marine protected areas, with the sole aim of conserving coral reefs, have been established in Hong Kong (e.g. Hoi Ha Wan Bay, 260 ha, 1996; Cape d'Aguilar, 18 ha, 1996; and Ping Zhau Island, 270 ha, 2000) (Morton 2000).

A series of studies have been completed on coral reefs associated with fringing reefs and atolls in the South China Sea Islands. These have focused on the resources, environment and ecology of coral reef ecosystems, with some emphasis on the protection and management of coral reef ecosystems (for example, Zou 1995; Zhao 1996; Chen 1997).

Coral reef conservation and management in Sanya Reserve

The Sanya Reserve, the only extant national coral reef reserve, is located midway along the coastline of Sanya City, lying between 109°21 to 109°40E and 18°10 to 18°15N. It has a total area of 56 km^2, of which about 50 km^2 is in coastal waters. It was established in 1990, and the management office was set up in 1992. The Sanya Reserve is made up of three different coastal regions or sections, namely Luhuitou–Dadonghai coastal section; Dongmaozhou Island and Ximaozhou Island section (in Sanya Bay); and Yalong Bay section (including Yezhudao Island, Dongpai Reef and Xipai Reef). Yalong Bay is the most remote region; and has the most luxurious corals (Wang et al. 1997) in the reserve. The coral reef ecosystem along Sanya City coastline has, for some time, been the source of income for coastal populations that derive their livelihood from the resources. Some of the goods and services generated by the reefs are shoreline protection, nutrient cycling, recreation, tourism and fisheries. The initial aim of the reserve's management was to monitor and end destructive extraction activities in the reef region through both education and enforcement of rules and regulations. In 1995, the authority, in collaboration with a local enterprise, started an experiment on the appropriate use of coral reef resources for tourism in Yalong Bay. The activities included permitted underwater sightseeing of coral reefs from glass-bottom boats, swimming and water sports. Sanya City became one of the 119 major national scenic spots in 1993, with unique tropical coastal tourism resources. Its coral reef ecosystem has become one of the key resources for coastal tourism. Yalong Bay and Dadonghai have become tourism resorts for viewing coastal and underwater coral reefs.

In 1997, 1.3 million tourists visited Sanya City; of these 120 000 were foreigners. About half of the tourists directly or indirectly participated in activities related to coral reef ecosystems. In 2001, Sanya City's GDP was 3 295 million Chinese Yuan (US$399 million), of which 73.75 per cent was generated by tourism activities. A portion of the income from the Yalong Bay tourism enterprise has been used in the construction of Yalong Bay sub-stations of Sanya Reserve and for management activities. The experiment appears to be successful in that alternative sources of livelihood have been established while coral reefs appear to have been protected (Chen 1997). However, in developing similar projects, the authority should closely monitor the carrying capacity of the reef sites to ensure that the reefs are protected. Already, Yalong Bay and Dadonghai are both subject to increasing pressures from tourism activities, highlighting the need to ensure that the Reserve and the coastal activities are sustainably managed. Although tourist operators are trained to disseminate environmental messages to visitors, appropriate protection cannot be achieved if existing tourist programs are not monitored (WWF Hong Kong 1999).

Currently, there is little coral reef monitoring in China. The first Reef Check training and practical activity in continental China was conducted at Dadonghai in the Sanya Reserve in December 2000. UNEP EAS/RCU and Reefcheck Foundation Hong Kong supported this activity (Chen Gang, personal communication 2001).

Marine zones in China

In China, a system of marine zones determines dominant functions for zones. It is based on natural attributes and takes into account social requirements. It is an important basis for, and approach to, integrated coastal zone management, sustainable management, and conservation of marine resources and coral reefs in China. The marine zones for China and onshore provinces in Guangdong, Guangxi and Hainan were published during 1990-93 (Lin Xingqing et al. 1991; Oceanic Bureau of Hainan Province 1992). With the marine zone for Hainan Province, one national coral reef natural reserve (Qinglan Habour–Bo'ao Habour, on the east coast of Hainan) and two provincial coral reef natural reserves (Yangpu Habour-Junbijue Cape, on the west coast of Hainan, and Xisha-Zhongsha-Nansha Islands, in the South China Sea) will be established in the future. Since 1997, the more detailed mapping of marine zones for each onshore city and county has been in progress. National standards (GB17108-1997) for marine zones were issued in 1997 (State Technical Control Bureau 1998).

Perspectives on coral reefs management in China

For the last twenty years, coral reefs in China have been under great stress and management has faced many problems. Special coordinated efforts from the government, local community and scientists are needed to address these problems. The major challenge of coral reef conservation and management for China is to strike a balance between the growing economic development of activities that depend on coral reefs (for example, fishing, aquaculture and tourism activities) and the protection, maintenance and sustainable management of those resources. Both the government and society need to seek a balance between short-term economic benefits and long-term sustainable use of the resources, despite the difficulties involved. Effort needs to be directed to the development of ecologically and socially sound models for better management, and to effective education or awareness programs related to marine parks conservation. Regional and international cooperation programs will also need to play a vital role in these aspects. Surveying, monitoring, assessment and research related to fringing reefs and atolls in China need to be strengthened to satisfy the changing requirements for the protection, management, restoration, reconstruction and sustainable development of coral reef ecosystems.

In the past two decades, the government and general public of China have allocated increasing resources to overcome environmental problems and, specifically, to conserve and manage coral reefs. This has been elaborated in more research projects and financial support dedicated to these matters. Nevertheless, the challenges for ecological and environmental conservation in China, as well as for coral reef conservation and management, relate to the need to address the fact that improvements at some places are counter-balanced by degradation at many other places; improvements at some points are counter-balanced by deterioration across entire areas; and the rate of destruction exceeds the benefits accruing from improvements. The scope of the degradation continues to expand and the intensity of this destruction continues to worsen. The overall scenario of coral reef management in China is not good. (Zhang 2001a).

References

Chen Gang. 1997. Sustainable development and ecological utilization of coral reef resources. Research and Development of South China Sea 4:53-55. (In Chinese).

Chen Zhenyu. 1993. Legislation on mangrove ecosystem conservation in China. Journal of Guangxi Academy of Sciences 9(2):132-135. (In Chinese).

Compiler Group of the China Biodiversity Protection Action Program. 1994. The China biodiversity protection action program. China Environment Science Press. Beijing. (In Chinese).

Dai C. F. 1991. Reef environment and coral fauna of southern Taiwan. Atoll Resources Bulletin 354:1-28.

Lin Xingqing, Ma Yingliang, Yu Mianyu and Xu Guoxuan (eds.) 1991. The division of marine functional zonation of Guangdong Province. Science Press, Beijing: 1-134. (In Chinese).

Liu Ruiyu. 1998. The effects of human activities on benthos diversity, p. 39-46. *In* Center for Coastal Ocean Sciences and Technology, Zhongshan University (ed.). Symposium on Coastal Ocean Resources and Environment '97, Proceedings of SCORE '97. Center for Coastal and Atmospheric Research, The Hong Kong University of Science and Technology. (In Chinese with an English abstract).

Hodgson G. and E.P.M. Yau. 1997. Physical and biological controls of coral communities in Hong Kong, 459-464 . *In* H.A. Lessios and I. G. Macintyre (eds). Proceedings of the 8th International Coral Reef Symposium. Panama, Smithsonian Tropical Research Institute.

Morton B. 2000. Coastal zone management for marine conservation in Hong Kong: The need for regional co-operation in southern China, p. 3-33. *In* B. Morton (ed.). The marine flora and fauna of Hong Kong and Southern China. Proceedings of the Tenth International Marine Biological Workshop, The Marine Flora and Fauna of Hong Kong and Southern China, 6-26 April 1998, Hong Kong. Hong Kong University Press, Hong Kong.

Oceanic Bureau of Hainan Province. 1992. The division of marine functional zonation of Hainan Province. Ocean Press, Beijing, P.R. China, 134 p. (In Chinese).

State Technical Control Bureau. 1998. Technical directives for the division of marine functional zonation. National Standard (GB17108-1997). China Standard Press, Beijing, P.R. China, 20 p. (In Chinese).

State Oceanic Administration. 1996. 21st century ocean agenda of China. Ocean Press. Beijing, P.R. China. (In Chinese).

Wang Lu, Wang Daoru and Chen Gang. 1997. Distribution of submarine landscape in Yalong Bay. Research and Development of South China Sea 2:45-52. (In Chinese).

WWF Hong Kong. 1999. Environment education survey at Yalong Bay, Sanya, Hainan Island, China. WWF Project Final Report (Contract REFERENCE: CN0073.05/China), P.R. China, 39 p.

Yu Dengpan and Zou Renlin. 1996. Study on the species diversity of the scleractinian coral community

on Luhuitou fringing reef. Acta Ecologica Sinica 16(5):469-475. (In Chinese with an English abstract).
Zhao Huanting. 1996. Development of organic reef study in China. Quaternary Sciences 3:253-262. (In Chinese with an English abstract).
Zhao Huanting, Zhang Qiaomin, Song Chaojing, Qiu Zhang, Lin Xigui and Yuan Jiayi. Geomorphology and environment of the South China Coasts and South China Sea Islands. Science Press, Beijing, P.R. China: 370-453. (In Chinese).
Zou Renlin, Ma Jianghu and Song Shanwen. 1975. Hermatypic Scleractinia in Shallow Waters of Hainan Island. Science Press, Beijing, 66 p. (In Chinese).
Zou Renlin. 1995. Status and protection initiatives of coral reefs in China, p. 281-290. *In*
Biodiversity committee of the Chinese Academy of Sciences and Department of Protection for Wild Animals and Forest Plants, Forest Ministry of China (eds). Research progress of biodiversity: Proceedings of first meeting on biodiversity and sustainable development. Chinese Scientific and Technologic Press, Beijing, P.R. China. (In Chinese with an English abstract.)
Zhang Qiaomin. 2000. Mangrove and coral reef coastal resources of China and its development, p. 228-234. *In* Chen Bang-Fuh, Wu Chaoyu, Chen Jaychung (eds). Symposium on Coastal Ocean Resources and Environment '99: Proceedings of SCORE '99, Guangzhou. Center for Coastal and Atmospheric Research, The Hong Kong University of Science and Technology, Hong Kong. (In Chinese with an English abstract).
Zhang Qiaomin. 2001a. Status of tropic biological coasts of China: Implications on ecosystem restoration and reconstruction. Oceanologia et Limnologia Sinica 2(4):454-464. (In Chinese with an English abstract).
Zhang Qiaomin. 2001b. The biogeomorphology of Luhuitou fringing reef of Sanya City, Hainan Island of China. Paper presented at the International Symposium on Monsoon Climate, Geomorphologic Processes and Human Activities, 2000 IAG Thematic Conference, 25-29 August 2000, Nanjing, P.R. China. Chinese Science Bulletin 46(Suppl.):97-102.
Zhang Qiaomin. 2001c. Sad stories of coral reef. Men and the Biosphere 1:21-22. (In Chinese with an English abstract).

Section IV

Future Research Directions in Coral Reef Management – Workshop Discussion Outcomes

Future Research Directions in Coral Reef Management
Chiew Kieok Chong, Herman Cesar, Mahfuzuddin Ahmed and Hari Balasubramanian

Future Research Directions in Coral Reef Management[1]

Chiew Kieok Chong[2], Herman Cesar[3], Mahfuzuddin Ahmed[4] and Hari Balasubramanian[5]

Introduction

At the International Consultative Workshop on Economic Valuation and Policy Priorities for Sustainable Management of Coral Reefs, 10-12 December 2001, Penang, Malaysia, participants were divided into three working groups to discuss the future research directions for sustainable management of coral reefs. The groups focused on one of the following three themes: (i) economic valuation; (ii) policy analysis; and (iii) community participation. This paper is based on the outputs resulting from the group discussions.

Future research directions for economic valuation of coral reefs

The group discussions paralleled the ideas expressed by the International Coral Reef Action Network (ICRAN), stressing the importance and influence of economic valuation in coral reef management and protection. The working group noted that such studies could contribute to:

1. *Increased efficiency* – by showing the maximum net benefits to society, for instance in the choice between reef-related tourism and commercial fishing;

2. *Effective advocacy* – by providing the so-called "power of numbers", quantifying and demonstrating to decision-makers the full costs of using public goods;

3. Better understanding of the stakes involved in multiple stakeholder problems, thereby providing crucial information for decision-making processes in tropical coastal zone management, and building solid partnerships among the business community, the public sector and the consumer society;

4. Insight into how local communities and governments can capture (appropriate) the net benefits from healthy tropical coastal ecosystems.

In its strategic vision, ICRAN sees the use of economic valuation and cost-benefit analysis in economic and ecological research relating to reef areas and threats as a priority. It also sees the need for guidelines to be developed and variables to be selected so as to enable the estimation of the economic values of coral reefs. Finally, ICRAN encourages the development of standard methodologies and protocols for conducting economic valuation studies.

Recommendations by topic

The group suggested that research related to the economic valuation of coral reefs focus on the following nine areas.

1. **The need to understand better the impact of changes in management on biophysical characteristics and social welfare. The following chain is seen as important:**

   Change in management → Change in biophysical characteristics → Change in welfare

Recommendations:

- Change the economic focus by comparing the change in welfare with the change in the cost of management in cost-benefit analyses; focus also on the cause-effect relationship between management and biophysical characteristics to arrive at a more accurate cost-benefit analysis.

[1] WorldFish Center Contribution No. 1720
[2] MEECON Research Sdn. Bhd. (formerly with WorldFish Center)
[3] Institute for Environmental Studies, Vrije Universiteit Amsterdam
[4] WorldFish Center, Batu Maung, Penang, Malaysia.
[5] Government of Canada's Youth Employment Strategy (implemented by the Marine Institute of Memorial University in Newfoundland and supported by the Department of Foreign Affairs)

- Conduct research to explore the general (as opposed to solely site-specific) effects of Marine Protected Areas (MPA) management on reef health, and the impact of land-based pollution on the growth of various reef species.
- Explore the effects of management on coral reef ecosystem health.

2. **The need for a standard in coral reef valuation techniques and an agreed methodology to compare values across sites.**

Recommendations:

- Conduct economic valuation studies to determine the total economic values of coral reefs.
- Market valuation should be used for fish production, tourism and coral extraction, as well as producer surplus and resource rents.
- Use stated preference techniques or choice modeling techniques to establish non-use values.
- Conduct indirect use valuation using productivity change, replacement cost or related techniques.
- Conduct partial value calculations to arrive at a lower boundary of the economic value of coral reefs if funds are limited.

3. **The need for valuation of coral reef management options.**

Recommendations:

- Conduct valuation studies and cost-benefit analyses in non-MPA areas as well as in MPAs.
- Develop techniques to deal with the difficulties in the appropriation of values outside MPAs.

4. **The need to appropriate value in practical terms (actual money flows) to the beneficiaries of positive reef management strategies.**

Recommendations:

- Disseminate results of valuation studies in understandable terms to potential beneficiaries.
- Explore mechanisms for appropriating these values to local populations, reef managers, and local, provincial and national governments.
- Explore opportunities for exploiting further the value of reefs, through user-fees, marine park trusts, bio-prospecting, or other relevant systems.

5. **The need for rational use of reef ecosystems and sustainable management options.**

Recommendations:

- Explore options for sustainable reef use and encourage sustainable management regimes.
- Conduct research on the carrying capacity for tourism, and the effects of different scales of extractive activity.
- Conduct research on mechanisms to promote sustainable use of coral reefs, for example a zoning system for differential use of the resources.
- Explore options for the optimal use of reef ecosystems both from ecological and economic perspectives.

6. **The need for stakeholder analysis to identify and consider all groups that will be affected by coral reef management decisions.**

Recommendations:

- Identify and analyze all the stakeholder groups that will be affected by the management plan or policies for particular coral reefs.
- Conduct research on the values placed on different management options by different stakeholder groups.
- Conduct research on the incentives to different stakeholder groups under different management decisions and determine the possibility of compensation for these groups.

7. **The need to apply other research methods, such as benefit transfer, to estimate the value of coral reefs in a broader perspective.**

Recommendations:

- Conduct meta-analysis research on existing coral reef valuation studies to build models and parameters useful for benefit transfer.
- Explore the gaps that meta-analysis research will reveal in the existing literature on coral reef valuation.
- Ensure that results are accessible to all those who are unable or under-funded to do an all-encompassing total economic value study based on local data.

8. **The need for a systematic method for conducting coral reef valuation studies, which could be provided in an economic valuation manual.**

Recommendations:

- Explore the commonalities between valuation studies and the benefits of varying kinds.
- Develop a standard valuation technique, so that comparisons across studies can more easily be made.

9. **The need to choose representative study sites for the economic valuation research in the ICRAN plan.**

Recommendations:

- Determine where to spearhead large-scale economic valuations of coral reefs to represent best the diversity of coral reef locations and situations around the world. These will be based on: socioeconomic factors – social, economic, and cultural; MPA designation – whether a reef area is an MPA or non-MPA zone; biophysical characteristics – reef type, species diversity, species richness, resource productivity, water conditions, habitat quality and intensity of use; type of marine tenure; and proximity to markets.

Future research directions for analysis of coral reefs policy

The results of the working group discussion indicated future research related to policy analysis and instruments would be likely to follow an issue-driven policy agenda. This would address the main issues affecting coral reefs, which the working group identified as:

1. Pollution from various sources;
2. Illegal and destructive activities that cause habitat degradation, such as certain types of fishing, mining, tourism activity and other coastal development;
3. Coral bleaching caused by global warming and climate change; and
4. Over-exploitation of coral reef resources.

After identifying the important causes of the key problems, the working group discussed the future research directions needed to overcome these problems at local, national and global levels.

Recommendations by topic:

The group suggested that research related to the analysis of coral reefs policies focus on the following six areas, which are presented in no particular order. Comparative case studies at national or local levels should be used to provide regional or global synthesis of major issues confronting sustainable management of coral reefs.

1. **The need for better governance and legal systems for fisheries, marine ecosystems and coastal management as, currently, lack of legal support, overlapping legal mandates and decentralization of management result in inefficient management and pollution of coastal resources.**

Recommendations:

- Create well-established governance and legal systems with a focus on reducing pollution, and illegal and destructive activities, such as certain types of fishing, mining and habitat degradation.
- Conduct research on the effectiveness of marine protected areas (MPAs) and on coastal management zones, trade issues and climate change.
- Include in MPA studies research on community management, legal mandates, linkages between levels of government, institutional arrangements and comparisons of MPAs in different countries and continents.
- Incorporate case studies focusing on comparative analyses across countries and between developed and developing countries, on consistencies of policies at national and local levels, and on laws affecting revenue collection.
- Conduct research on trade issues with a focus on the sustainability assessment of macro-policies and on climate change adaptation strategies and policies.

2. **The need to increase awareness among coastal resource users of the importance of promoting sustainable use of coastal resources.**

Recommendations:

- Research the use of standard certification and ecolabeling to identify products generated

from natural resources by way of environmentally friendly production methods.
- Conduct research on the definition and operation of ecotourism and ecolabeling. Incorporate case studies on the effectiveness of national marine parks, with special focus on ecologically representative MPAs or on successful traditional practices.
- Analyze the effectiveness of MPA management through a rating system that qualifies the best-managed MPAs.
- Market MPA areas and explore the application of user fees as incentives (and disincentives for over use).
- Highlight examples of positive ecolabeling, such as the label currently being established under the Marine Aquarium Council (MAC), whereby areas in buffer zones of MPAs are set aside for sustainable ornamental fisheries to prevent cyanide fishing and general overfishing.

3. **The lack of resources and information to ensure that coastal resources are maintained in sustainable conditions.**

Recommendations:

- Acquire sufficient information on the conditions of reef ecosystems over time, and on vulnerabilities, such as damage due to coastal development, pollution, and climate change.
- Conduct research, and include case studies, on the effectiveness of capacity building and institutional strengthening (training, etc.) mechanisms for information dissemination in localized MPAs, and education of enforcement agencies and the judiciary.
- Explore the potential for acquiring and allocating various resources, such as financial, physical and human capital, necessary for coral reef resources to be managed in a sustainable manner.

4. **The lack of information on the distribution of equity, especially among primary and secondary stakeholders whose livelihoods depend on coral reef resources.**

Recommendations:

- Analyze the issue of equity, keeping in mind that coastal communities depend on coral reefs for income, employment and subsistence.
- Conduct research, including case studies, to improve the understanding of equity distribution among primary and secondary stakeholders, poverty alleviation projects and their effectiveness, and alternative sources of livelihood.

5. **The limited information on economic values of coral reef ecosystems, and policy decisions made without consideration of the total economic value of reef resources.**

Recommendations:

- Highlight the increasingly important role of economic valuation in natural resources management decisions.
- Conduct valuation studies on resources, as well as on the livelihoods in coastal communities in particular, to understand better the value of livelihoods dependent on coral reef ecosystems.

6. **The lack of economic incentive for stakeholders to conserve resources.**

Recommendations:

- Highlight that, in order to manage coastal zones sustainably, the economic incentives of all stakeholders in the area need to be known and in line with the objectives of the management strategy.
- Conduct research on financial resources, or sustainable financing sources arising from various forms of economic incentives for the different stakeholders.
- Encourage legitimacy and compliance by highlighting the economic efficiency and individual benefits created by the strategy.

Future research directions for community participation in coral reef management

The working group identified information gaps in the existing literature relating to community participation in coral reef areas. The discussion was more process-oriented than the other working groups. Some general areas of economic valuation and policy instruments related to coral reef research were taken into account in developing recommendations. Gaps that need to be addressed in the management of coral reef areas include:

1. Participatory research
2. Social/cultural capital/values
3. Distributional/equity issues
4. Citizen jury approaches
5. Livelihood dependency on reefs

Recommendations by topic:

The group suggested that research related to the analysis of coral reefs policies focus on the following four areas.

1. **The need for participatory research in valuation and policy.**

Recommendations:

- Conduct research on the benefits to valuation studies and policy research by following a participatory process and identify the appropriate methods of participation.
- Elucidate success stories demonstrating strategies that worked and why they worked.
- Conduct research on and evaluate the range of participatory models that have been used.
- Outline successes and failures of the participatory approach to identify best-case practices.

2. **The need to address distributional and equity issues when conducting valuation studies and developing policies.**

Recommendations:

- Address issues concerning the difference between willingness to pay and ability to pay in order to arrive at more accurate valuation estimates.
- Address distributional issues, such as skewed resource considerations.
- Consider the effects of management decisions on all stakeholders and mitigate possible increases in income equality.

3. **The need for the valuation of social/cultural capital and values for more complete valuation analyses.**

Recommendations:

- Conduct valuation research on social-cultural values and capital as well as on economic capital in order to arrive at a more complete cost-benefit picture.
- Assess and consider the economic values embodied in the participatory process itself, as it relates to the manifestation of social capital.
- Consider the strength of community values versus individual social values before their inclusion in valuation studies.
- Conduct research on the relative importance of values – for example, considering what they are and from whom they come.

4. **The need to understand and recognize that there is livelihood dependency on coral reefs.**

Recommendations:

- Assess the importance of valuing livelihoods themselves as distinct from the values that the livelihoods produce.
- Explore opportunities for changes in livelihood, especially for situations where alternatives are scarce.

Conclusions

The outcomes of the group discussions indicate the utility of economic valuation research in assisting policy changes leading to better management of coral reefs. Notwithstanding, research on the economic value of coral reefs at present lacks comprehensiveness. Many suggestions of ways to fill in gaps in the current literature were made by the working groups. The main areas on which future research efforts should be focused are summarized below.

Research conducted with the participation of users should highlight their concerns and better assess values beyond those that directly relate to livelihood, such as social and cultural values. Equity distribution needs to be researched in order to understand livelihoods dependant on coral reefs and encourage compliance by primary and secondary stakeholders. Valuation of ecological function, along with direct economic benefit, should be assessed in order to give a more holistic view of the real worth of coral reefs. Value appropriation and the perception of value by different stakeholders needs attention and should be addressed through stakeholder analysis. The discussions expounded the need for the development and implementation of standard valuation techniques to enable better comparisons between reefs at different locations. Government interventions with economic incentives or disincentives, and improvement in governance and legal systems are necessary for more efficient management of coral reefs. Better resources, more information and increased awareness among reef users are important for improving reef management. Users should have access to information in order to understand better the value of their environment.

Although the literature relating to the total value of coral reefs is currently sparse, there are many areas to which we can look to fill in the gaps in order to have a better idea of the worth of the reefs. Participatory research should be conducted to assess the variety of values of coral reefs. The core research foci should be on filling in the gaps of coral reef valuation; understanding and valuing the livelihoods dependent on reef resources; and strengthening government and legal systems to ensure policies will be effective. This work will give policy-makers a more thorough base from which to make informed decisions, and the institutions required to implement them.

Appendix 1

Participants and Resource Persons*

Attzs, Marlene
Senior Technical Officer
Sustainable Economic Development Unit (SEDU)
Department of Economics
University of West Indies
Saint Augustine
Trinidad & Tobago
Tel: +1 (868) 662-6555
Fax: +1 (868) 662-6555
mattzs@hotmail.com

Bennett, Jeff
Professor of Environmental Management
National Centre for Development Studies
Australian National University
Canberra ACT 0200
Australia
Tel: +61 (2) 6125 0154
Fax: +61 (2) 6125 8448
jeff.bennett@anu.edu.au

Cesar, Herman
Researcher
Institute for Environmental Studies
Vrije Universiteit Amsterdam
De Boelelaan 1115, 1081 HV Amsterdam
The Netherlands
Tel: +31 (20) 4449577
Fax: +31 (20) 4449533
hermancesar@hotmail.com

Figueroa, Mark Frederick Emanuel
Lecturer
Department of Economics
University of the West Indies
Mona, Kingston 7
Jamaica
Tel: (876) 977-1188
Fax: (876) 977-2396
mfiguero@uwimona.edu.jm

Glover, David
Director
Economy and Environment Program for South East Asia
7th Storey, RELC Building
30 Orange Grove Road
Singapore 258352
Tel: 65 831 6854
Fax: 65 235 1849
dglover@idrc.org.sg

Lal, Padma
Director
Graduate Studies in Environmental Management and Development
National Centre for Development Studies
Australian National University
Canberra ACT 0200
Australia
Tel: +61 (2) 6125 0093
Fax: +61 (2) 6125 8448
Padma.Lal@anu.edu.au

Lokina, Razack Bakari
Ph.D. Student
Goteborg University
Department of Economics
Goteborg University
Box 640, SE 405 30 Goteborg
Sweden
Tel: +46 (31) 773 4337
Fax: +46 (31) 773 1326
rlokina2000@yahoo.co.uk

Moosa, Mohammad Kasim
Senior Research Scientist (Research Professor)
Secretary, Project Management Office of Coral Reef Rehabilitation
and Management Program
Indonesian Institute of Sciences
Jalan Raden Saleh, No.43, Jakarta Pusat, Jakarta 10330
Indonesia
Tel/Fax: +62 (21) 390 8380
coremap@indosat.net.id

Pham, Khanh Nam
Lecturer
Environmental Economics Unit
Faculty of Development Economics
University of Economics - Ho Chi Minh City
1, Bis Hoang Dieu Street, Phu Nhuan District
Ho Chi Minh City
Vietnam
Tel: +84 (08) 8 452 712
Fax: +84 (08) 8 453 897
khanhnam@hcmueco.edu.vn

* As of December 2001.

Ngazy, Zeinab M.
Researcher (Economist)
Institute of Marine Sciences
Mizingani Street, Malindi, Zanzibar
Tanzania
Tel: +255 (24) 2230741
Fax: +255 (24) 2233852
zngazy@hotmail.com

Othman, Jamal
Associate Professor
Department of Agricultural and Resource Economics
Faculty of Economics
University Kebangsaan Malaysia
Bangi 43600, Selangor
Malaysia
Tel: +60 (3) 89293762
Fax: +60 (3) 89292789
jortman@pkrisc.cc.ukm.my

Padilla, Jose E.
Senior Policy Officer
Southeast Asia Policy Program
c/o WWF-Philippines
69 Masikap Extension cor. Marunong Sts.
Central Distict, Quezon City
Philippines
Tel: +632 433 3220
Fax: +632 426 3927
jpadilla@wwf-phil.org.ph

Purnomo, Agus Heri
Researcher
Center for Marine and Fisheries
Division of Socio-Economics
Komplek Perikanan, Jalan KS Tubun
Petamburan, Jakarta Pusat
Indonesia
Tel: +62 (21) 5709157
Fax: +62 (21) 5709158
purnomo@bogor.wasantara.net.id

Smith, Barney
Research Program Manager, Fisheries
Australian Centre for International Agricultural Research
ACIAR Fisheries Program
C/- NSW Fisheries Research Institute
202 Nicholson Parade
PO Box 21 CRONULLA NSW 220
Australia
Tel: +61 (2) 9527 8462
Fax: +61 (2) 9523 5966
bsmith@fisheries.nsw.gov.au

Spurgeon, James
Principal Environmental Economist
JacobsGIBB Ltd
Tel: +44 (0) 118 963 5000
Fax: +44 (0) 118 926 3888
Email: james.spurgeon@jacobs.com

Tana, Touch Seang
Undersecretary of State
Council of Minister
New Building, Sahakpoan Russy Blvd.
Phnom Penh
Cambodia
Tel: +855 (12) 993 839
Fax: +855 (23) 881 303
012993839@mobitel.com.kh

Torell, Magnus
Senior Program Officer
Swedish International Development Cooperation Agency (Sida)
Sveavagen 20, S-105 25 Stockholm
Sweden
Tel:+46 (8) 698 5000
Fax:+46 (8) 698 5653
m.torell@cgiar.org

Verebalavu, Jese
Lecturer in Marine Affairs
The Marine Studies Programme
The University of the South Pacific
Suva
Fiji Islands
Tel: +679 (212) 881
Fax: +679 (301) 490
Faletoese_J@usp.ac.fj

Walling, Leslie John
Deputy Project Manager/Coastal Zone Management Specialist
CPACC Project
Regional Project Implementation Unit
Lazaretto Complex, Black Rock
St. Michael, Barbados, West Indies
Jamaica
Tel: (246) 417-4580
Fax: (246) 417-0479
wallingcpacc@sunbeach.net

Weru, Sammy Marathi
Marine Ecologist
Kenya Wildlife Service
Mama Ngina Drive, Mombasa
Kenya
Tel: +254 (72) 413020
Fax: +254 (11) 486549
werus@africaonline.co.ke

White, Alan T.
Deputy Chief of Party Organization
Coastal Resource Management Project
5th Floor, CIFC Tower,
North Area, Cebu City, Cebu 6000
Philippines
Tel: +63 (32) 232 1821
Fax: +63 (32) 232 1825
awhite@mozcom.com

Yeo, Bee Hong
Environmental Economist
World Wide Fund for Nature (WWF) Malaysia
No. 49, Jalan SS23/15, Taman SEA
47301 Petaling Jaya, Selangor
Malaysia
Tel: +60 (3) 703-3772
Fax: +60 (3) 703-5157
bhyeo@wwf.org.my

Zhang, Qiaomin
Coral Reef Specialist
South China Sea Institute of Oceanology
Chinese Academy of Sciences
164, West Xingang Road
Guangzhou 510301
China
Tel/Fax: +86 (20) 84451672
qmzhang@ns.scsio.ac.cn

OBSERVERS

Ab. Rahim Gor Yaman
Head of Unit Marine Park Terengganu
Department of Fisheries
21080 Chendering
Terengganu, Malaysia
Tel: +60 (9) 617 3353 ext. 25
abrgor01@dof.moa.my

Hiew, Wai Phang Kevin
National Programme Director
World Wide Fund for Nature (WWF) Malaysia
49, SS23/15, Taman SEA
47301 Petaling Jaya, Selangor
Malaysia
Tel: +60 (3) 7803 3772
Fax: +60 (3) 7803 5157
khiew@wwf.org.my

Ismail, Hashimi bin
World Wide Fund for Nature (WWF) Malaysia
49, SS23/15, Taman SEA
47301 Petaling Jaya, Selangor
Malaysia
Tel: +60 (3) 7803 3772
Fax: +60 (3) 7803 5157
IHashimi@wwf.org.my

Miller, Andre Sean
Water Quality Analyst
Coastal Zone Management Unit
Bay St., St. Michael
Barbados, West Indies
Jamaica
Tel: (246) 228-5955
Fax: (246) 228-5956
wetrootz@yahoo.com

Ooi, Lean Sim Jillian
Ph.D. candidate/Lecturer
University of Malaya
2-9-6 Pantai Panorama
Kg Kerinchi, 59200 Kuala Lumpur
Malaysia
Tel: +60 (3) 7954 5146
Fax: +60 (3) 7954 5146
h1phangs@umcsd.um.edu.my

Ramu, Santha Chenayah
Lecturer
Faculty of Economics & Administration
University of Malaya
50603 Kuala Lumpur
Malaysia
Tel: +60 (3) 7967 3733
Fax: +60 (3) 7956 7252
santha@um.edu.my

Schuttenberg, Heidi
Fulbright Scholar
Coastal Resources Institute
Prince of Songkla University
Thai Wah Tower 1, 3rd Floor
21/5 S.Sathorn Road, Bangkok
10120 Thailand
Tel: +66 (01) 770 2640
Fax: +66 (02) 285 0583
hzs1@hotmail.com

Syed-Ibrahim, Nora
Fellow (i.e. Academic Staff)
School of Biological Sciences
University Sains Malaysia
11800 Penang
Malaysia
Tel: +60 (4) 657 7888
Fax: +60 (4) 656 5125
nora@usm.my

Yusri Bin Yusuf
Research Officer
University Sains Malaysia
School of Biological Sciences
11800 Minden, Penang
Tel: +60 (4) 657 7888 ext. 3508
Fax: +60 (4) 656 5125
altok@yahoo.com

Zaidnuddin Bin Ilias
Marine Ecologist
Fisheries Research Institute
11960 Batu Maung, Penang
Tel: +60 (4) 626 3925
Fax: +60 (4) 626 2210
zaiali01@yahoo.com

WorldFish Center Staff

Ahmed, AKM Mahfuzuddin
Program Leader
Policy Research and Impact Assessment Program (PRIAP)
Project Leader
Valuation and Policy Analysis for Sustainable Management of Coral Reefs
m.ahmed@cgiar.org

Azhar, Azmarya
Former Program Assistant
FRRP/PRIAP
a.azhar@cgiar.org

Balakrishnan, Vasheela
Research Assistant
PRIAP
v.balakrishnan@cgiar.org

Bell, Johann
Program Leader
Coastal and Marine Resources Research Program (CMRRP)
j.bell@cgiar.org

Chong, Chiew Kieok
Research Associate
PRIAP
c.chong@cgiar.org

Fabres, Boris
Officer In-charge
ICLARM Philippine Office
Biodiversity and Genetic Resources Research Program (BGRRP)
b.fabres@cgiar.org

Fischers, Kenneth
Deputy Director General - Research
k.fischers@cgiar.org

Garces, Len
Assistant Scientist
CMRRP
l.garces@cgiar.org

Gardiner, Peter
Deputy Director General - Science Quality and Assurance and Project Development
p.gardiner@cgiar.org

Gupta, Modadugu
Director
International Relations Office
m.gupta@cgiar.org

Kamaruddin, Roslina
Research Assistant
PRIAP
r.kamaruddin@cgiar.org

Ng, Li Ping
Program Associate
FRRP/PRIAP
l.ng@cgiar.org

Oliver, Jamie
Project Leader
ICRAN, CMRRP
j.oliver@cgiar.org

Ponniah, A
Program Leader
BGRRP
a.ponniah@cgiar.org

Prein, Mark
Program Leader
Freshwater Resources Research Program (FRRP)
m.prein@cgiar.org

Salamanca, Albert
Assistant Scientist
PRIAP
a.salamanca@cgiar.org

Santos, Rowena Andrea (Bing) Valmonte
Assistant Scientist
PRIAP
b.santos@cgiar.org

Sayegh, Edward
Associate Director General, Corporate Services
e.sayegh@cgiar.org

Silvestre, Geronimo
Project Leader
Sustainable Management of Coastal Fish Stocks in Asia
CMRRP
g.silvestre@cgiar.org

Sultana, Parvin
Project Scientist
PRIAP
p.sultana@cgiar.org

Tay, Puay Kiang
Research Assistant
PRIAP
p.tay@cgiar.org

Teh, Lye Hooi
Research Assistant
PRIAP
l.teh@cgiar.org

Vergara, Sheila G.
Senior Research Associate
CMRRP
ICLARM - Philippines Office
s.vergara@cgiar.org

Viswanathan, K. Kuperan
Project Leader
Fisheries Co-management, PRIAP
k.viswanathan@cgiar.org

Williams, Meryl J.
Director General
m.williams@cgiar.org

Appendix 2

PROGRAM

9 December	Arrival of Participants	
10 December		
0830	Registration of Participants	

Opening Ceremonies
Chairperson:
Kenneth Fischer, DDG, World Fish Center

0900	Overview of the Workshop	**Mahfuzuddin Ahmed** Program Leader, PRIAP Project Leader, Valuation of Coral Reef
0915	Welcome Address	**Meryl J. Williams** Director General WorldFish Center
0930	Messages	**Dato' Mohd Hashim** Director General Department of Fisheries, Malaysia **Magnus Torell** Swedish International Development Cooperation Agency (Sida)
1000	Photo Session/Coffee/Tea Break	

SESSION 1
ECONOMIC VALUATION AND EFFECTIVENESS OF POLICY INSTRUMENTS
FOR CORAL REEFS MANAGEMENT
Chairperson:
Dr. David Glover, EEPSEA
Rapporteurs:
Ms Chiew Kieok Chong and Ms Bing Valmonte-Santos

1030	An Overview of Problems and Issues of Coral Reef Management	**M. Ahmed and Chiew Kieok Chong** WorldFish Center Malaysia
1050	Economic Valuation and Socioeconomics of Coral Reefs	**Herman Cesar and C.K. Chong** Institute for Environmental Studies Free University, Amsterdam
1120	Estimating the Value of Coral Reef Management Options	**Jeff Bennett** National Centre for Development Studies, Australian National University, Australia
1150	Coral Reef Use and Management – The Need, Role and Prospects of Economic Valuation in the Pacific	**Padma Lal** National Centre for Development Studies, Australian National University, Australia

1220	Policy Instruments for Coral Reef Management and Their Effectiveness	**Alan White and Catherine A. Courtney** Coastal Resource Management Project, Philippines
1250	Implementing Policy and Strategy for Coral Reef Rehabilitation and Management: Lessons Learnt from Indonesian Effort	**Mohammad Kasim Moosa** COREMAP, Indonesia
1320	Lunch Break	
1400	Valuation of Coral Reefs: The Next 10 Years	**James P.G. Spurgeon** JacobsGIBB Ltd, UK
1420	Plenary Discussion	

End of Session 1

1515	Coffee/Tea Break	

SESSION 2
CASE STUDIES ON ECONOMIC VALUATION, MANAGEMENT MEASURES AND POLICY INSTRUMENT OF CORAL REEFS
Chairperson:
Dr Mahfuzuddin Ahmed and Dr James Spurgeon
Rapporteurs:
Ms Chiew Kieok Chong and Mr Albert Salamanca

1530	Coral Reef Management Challenges in Kenya	**Mohamud Jama** Institute for Development Studies University of Nairobi, Kenya
1550	Policy Implications in the Management of Kenya's Marine Protected Areas	**Sam Weru** Kenya Wildlife Service, Kenya
1610	Coral Bleaching and the Demand for Coral Reefs: A Case Study	**Zeinab M. Ngazy** Institute of Marine Sciences Tanzania
1630	Instruments for Fisheries Management in Developing Countries	**Razack B. Lokina** Environmental Economics Unit Gotenborg University, Sweden
1650	The Socioeconomic Impact of Tourism Development on Coral Reefs in the Pacific Island Countries	**Jese Verebalavu-Faletoese** The University of the South Pacific, Fiji
1710	Policy Issues and Caribbean Coral Reefs – Surfing in the Perfect Storm	**Boris Fabres** WorldFish Center, Philippines
1730	Sustainable Coral Reef Management in the Context of Climate Change Adaptation Policy	**Leslie J. Walling and Marcia Chevannes Creary** CPACC, Jamaica
1750	End of Day 1	

1915	Welcome Dinner	

11 December
Continuation of Session 2

0900	Co-Management and Valuation of Caribbean Coral Reefs: A Jamaican NGO Perspective	**Mark F.E. Figueroa** Department of Economics University of West Indies, Jamaica
0920	Economics and Coral Reef Management in the Caribbean: Case studies from the Buccoo Reef in Tobago	**Marlene Attzs** University of West Indies, Trinidad
0940	Institutional Arrangements for Coastal Management Training	**Sheila Vergara** WorldFish Center Philippines
1000	A Framework for the Sustainability Assessment of Live Fish for Food Fisheries	**Jose Padilla** Philippines
1020	Coral Reef Conservation and Management in China	**Zhang Qiaomin** Chinese Academy of Sciences Guangzhou, China
1040	Coffee/Tea Break	
1055	An Economic Analysis of Coral Reefs in the Andaman Sea of Thailand	**Udomsak Seenprachawong** School of Economics, Sukhothai Thammathirat Open University, Thailand
1115	Economic Valuation of the Coral Reefs at Bolinao: An Application of Non-market Valuation Techniques	**M. Ahmed, G.M. Umali, C.K. Chong** WorldFish Center Malaysia
1135	Recreational Value of the Coral Surrounding the Hon Mun Islands in Vietnam	**Pham Khanh Nam and Tran Vo Hung Son** Faculty of Economics University of Economics, Vietnam
1155	Coral Reef Management in Koh Sdach Archipelago of the Cambodian Sea	**Touch Seang Tana** Cabinet of Council of Minister Cambodia
1215	The Recreational Benefits of Coral Reefs: A Case Study of Pulau Payar Marine Park, Kedah, Malaysia	**Bee Hong Yeo** World Wide Fund for Nature Malaysia
1235	Estimating the Recreational Benefits of Coral Reefs: The Contingent Ranking Approach	**Jamal Othman** Universiti Kebangsaan Malaysia Bangi, Malaysia

1255	Lunch Break	
1400	A Research Framework for Coastal Resource Management in Seribu Islands	**Agus Heri Purnomo** Center for Resource Economics and Policy Studies, Bogor, Indonesia
1420	Plenary Discussion	

End of Session 2

SESSION 3
FOCUS AND THEMES OF FUTURE RESEARCH
Chairperson:
Dr Jeff Bennett
Rapporteurs:
Ms Chiew Kieok Chong and Ms Bing Valmonte-Santos

1520	ICRAN Strategic Plan	**Jamie Oliver** Project Leader, ICRAN, CMRRP
1535	Economic Valuation and Policy Analysis under ICRAN Initiatives	**M. Ahmed**
1550	Coffee/Tea Break	
1615	Plenary Discussion on ICRAN ideas and focus of future studies (regions, countries, types of methodologies used, fund raising, format for specific proposals to be used in the small group discussion.)	
SESSION 4	SPECIFIC RESEARCH PROPOSALS	
1715	Overview and Analytical Framework	**M. Ahmed**
1730	Break-up/Group Discussions	

Group 1.
Valuation and Socioeconomic Research on Coral Reefs
(Coordinator: Herman Cesar)
(Chiew Kieok Chong and Lye Hooi Teh)

Group 2.
Policy Instruments of Coral Reefs and their Effectiveness
(Coordinator: Alan White)
(Bing V. Santos and Roslina Kamaruddin)

Group 3.
Community Participation and Stakeholder Management
(Coordinator: Padma Lal)
(Sheila Vergara and Sheela Balakrishnan)

1830 End of Day 2

12 December

Continue on Working Group Discussions

1030	Coffee/Tea Break	
1045	**Group 1 – Economic Valuation and Socioeconomics of Coral Reefs**	
1105	Plenary Discussion	
1130	**Group 2 – Policies Instruments of Coral Reefs and Their Effectiveness**	
1150	Plenary Discussion	
1215	**Group 3 – Community Participation and Stakeholder Management**	
1235	Plenary Discussion	
1300	Lunch Break	
1400	Discussion on Workplan for Future Research	**M. Ahmed**

Closing Session

1420	Workshop Summary	**M. Ahmed**
1440	Feedback from participants	
1455	Vote of Thanks	
1515	Closing Remarks	**Kenneth Fischer** Deputy-Director General, Research, WorldFish Center
1530	Farewell Coffee/Tea/Refreshment Break	

END OF WORKSHOP

Appendix 3

Abbreviations and Acronyms

ACIAR	Australian Center for International Agriculture Research
ADB	Asian Development Bank
ADMP	Adaptive Decision-Making Process
APBD	Local Development Budget
APBN	National Development Budget
APL	Adaptable Program Loan
ASC	Associate of Caribbean States
AusAid	Australian Development Aid
CANARI	Caribbean Natural Resources Institute
CARICOMP	Caribbean Coastal Marine Productivity
CAST	Caribbean Alliance for Sustainable Tourism
CBA	Cost-Benefit Analysis
CBM	Community-based Management
CCA	Caribbean Conservation Association
CCAM	Caribbean Coastal Area Management Foundation
CCDC	Caribbean Coastal Data Centre
CDB	Caribbean Development Bank
CDERA	Caribbean Disaster and Emergency Response Agency
CEHI	Caribbean Environmental Health Institute
CEIS	University of the West Indies, the Caribbean Energy Information System
CERMES	Center for Resource Management and Environmental Studies
CFRAMP	CARICOM Fisheries Resource Assessment and Management Programme
CFV	Cultural Function Value
CIDIE	Committee of International Development Institutions on the Environment
CITES	Convention on International Trade in Endangered Species
CMS	Center for Marine Sciences
CORDIO	Coral Reef Degradation in the Indian Ocean
COREMAP	Coral reef Rehabilitation and Management Project
CPACC	Caribbean Planning for Adoption to Global Climate Change
CRFM	Caribbean Regional Fisheries Mechanism
CRM	Coastal Resource Management
CRMP	Coastal Resource Management Project
CS	Consumer Surplus
CTO	Caribbean Tourism Organization
CV	Contingent Valuation
CVM	Contingent Valuation Method
DA	Department of Agriculture
DA-BFAR	Department of Agriculture- Bureau of Fisheries and Aquatic Resources
DANIDA	Danish International Development Agency
DC	Damage Cost
DENR	Department of Environmental and Natural Resources
DFID	Department for International Development
DKP	Ministry of Marine Affairs and Fisheries
DOSTE	Department of Science, Technology and Environment
ECLAC-CDCC	Economic Commission for Latin America and the Caribbean-Development and Cooperation Committee
EEPSEA	Economy and Environment Program for Southeast Asia
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EMU	Environmental Management Unit
EoP	Effect on Production
EPU	Economic Planning Unit

EPV	Ecological Process Value
FAO	Food and Agriculture Organization
FiD	Fisheries Department
GBRMPA	Great Barrier Reef Marine Park Authority
GCC	Global Climate Change
GCRMN	Global Coral Reef Monitoring Network
GDP	Gross Domestic Product
GEF	Global Environment Facility
GEF	Global Environment Fund
GESAMP	Scientific Aspects of Marine Environmental Protection
GHG	Greenhouse Gas
GIS	Geographic Information System
GOI	Government of Indonesia
HP	Hedonic Pricing
IAEA	International Agricultural Exchange Association
ICCAT	International Commission for the Conservation of Atlantic Tunas
ICLARM	International Center for Living Aquatic Resources Management
ICM	Integrated Coastal Management
ICRAN	International Coral Reef Action Network
IDRC	International Development Research Centre
IMO	International Maritime Organization
IPCC	Intergovernmental Panel on Climate Change
ITCM	Individual Travel Cost Method (Model)
IUCN	World Conservation Union
JACRAP	Jamaica Coral Reef Action Plan
JNEAP	Jamaica National Environmental Action Plan
KWS	Kenya Wildlife Service
LAC	Limited Acceptable Change
LATEN	Latin America Technical Department
LGUs	Local Government Units
MAC	Marine Aquarium Council
MACC	Mainstreaming Adoption to Climate Change (MACC)
MBIs	Market-based Instruments
MCDP	Maharishi Corporate Development Programme
Men LH	Ministry of Environment
MEY	Maximum Economic Yield
MOU	Memorandum of Understanding
MPAs	Marine Protected Areas
MSY	Maximum Sustainable Yield
NCDC	National Climatic Data Center
NCOCZM	National Council on Ocean and Coastal Zone Management
NEPA (NRCA)	National Environment and Planning Agency (Jamaica's Natural Resources Conservation Authority)
NGOs	Non-Government Organizations
NICU	National Implementation Coordinating Units
NIPAP	National Integrated Protected Areas Programme
NIPAS	National Integrated Protected Areas System
NOAA	National Oceanic and Atmospheric Administration
NPV	Net Present Value
NRCA	Natural Resource Conservation Authority
OAE	Open Access Equilibrium
OAS	Organization of American States
OECS	Organization of Eastern Caribbean States
OLS	Ordinary Least Square
PAMB	Protected Area Management Board
PBPA	Portland Bight Protection Area
PKPSL- IPB	Marine and Coastal Resources Studies Center of IPB

PMO-COREMAP	Project Management Office - Coral Reef Rehabilitation and Management Project
PPP	Polluter Pays Principle
RA	Republic Act
RC	Replacement Cost
RPIU	Regional Project Implementation Unit
RSFs	Resources, Services and Functions
SEA	Strategic Environmental Assessment
Sida	Swedish International Development Coorperation Agency
SIDS	Small Island Developing States
SPREP	South Pacific Regional Environment Programme
SSDP	Southern Seaboard Development Project
SST	Sea Surface Temperature
TB	Total Benefit
TC	Travel Cost
TEV	Total Economic Value
UNDP	United Nations Development Program
UNEP- CEP	United Nations Environment Programme Caribbean Environment Programme
UNEP- EAS- RCU	United Nations Environment Programme East Asian Seas Regional Co-ordinating Unit
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNESCO-IOC	United Nations Education, Science and Cultural Organization-Intergovernmental Oceanographic Commission
UNFCC	United Nations Framework Convention on Climate Change
UP-MSI	Philippines – Marine Science Institute
UWI	University of the West Indies
UWICED	University of the West India Centre for Environment and Development
WCMC	World Conservation Monitoring Centre
WCMD	Wildlife Conservation and Management Department
WECAFC	Western Central Atlantic Fishery Commission
WRI	World Resources Institute
WTP	Willingness to Pay
WWF	World Wild Fund for Nature
ZTCM	Zonal Travel Cost Model