SOCIO-ECONOMIC ASSESSMENT OF THE IMPACTS OF THE 1998 CORAL REEF BLEACHING IN THE INDIAN OCEAN: A SUMMARY

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INTRODUCTION

Coral reefs are a vital resource to many areas of the Indian Ocean. Coastal populations are continuously increasing (Table 1) and relying on this resource as the basis of the economy. Across the region, the two common socio-economic reef based activities are fisheries and tourism. For local subsistence fishermen, reef fisheries often represent their only livelihood. Degradation of coral reefs will first impact the reef fishery and subsequently, the local fishing community. Tourism also is often heavily dependent on coral reefs as the main attraction.

The countries of the Indian Ocean vary both physically and socio-economically (Table 1). The size of a country, the area of coral reefs, the coastal population utilising the reefs and the wealth of the country are all indicators of pressure and dependence on reef resources and their ability to cope with impacts such as coral bleaching. CORDIO was initiated in response to degradation of coral reefs caused by the 1998 coral bleaching event. However, other factors, such as rapidly expanding coastal populations or poor planning and management, may also cause reef degradation. Recently, Bryant *et al.* (1998) estimated that 9 000 km^2 of coral reef in the Indian Ocean were at high risk, 10 500 km^2 at medium risk and 16 600 km^2 at low risk of degradation from coastal development, marine based pollution, overexploitation of marine resources and inland pollution, including sedimentation. Within the CORDIO countries, the level of risk of reef degradation ranges from low in areas like the Chagos archipelago where there is negligible human activity, to high in areas such as Comoros and Mayotte where high population growth rates are exerting increasing pressure on these reefs (Figure 1).

This report is a summary of the complete project report assessing the socio-economic impacts of the coral bleaching in the Indian Ocean (Westmacott *et al.*, 2000) and presents the main approaches adopted to determine the importance of fisheries, particularly reef fisheries, and reef based tourism to countries and local communities in this region. Also, this report presents the results of specific case studies of the reef fishery of Kenya and of the tourism sectors of Maldives, Sri Lanka, Tanzania and Kenya. In addition, the assessment also highlights the need to account for other threats to coral reefs and the capacity to manage these resources.

POTENTIAL IMPACTS OF CORAL BLEACHING ON REEF FISHERIES

The effects of coral bleaching on reef fisheries are likely to be observed in the long-term through changes in the habitat complexity. Although controversy surrounds the proposed mechanisms by which reef fish communities are structured (Richards & Lindeman, 1987; Sale, 1991; Sadovy, 1996), it is generally thought that three ecological processes are involved. First, competition for food and space determines fish diversity and density (Robertson & Gaines, 1986). Second, patterns of recruitment of juveniles determine adult fish community structures (Eckert, 1984; 1987; Medley *et al.*, 1993; Lewis, 1997). Third, predation determines patterns of survival and consequently, the density of adult fish (Eggleston, 1995). The structural complexity of a reef habitat influences all three of these ecological processes (Figure 2). The reef provides niches for various species to coexist on a coral reef, suitable substrate for reproductive activities and larval settlement (Roberts, 1996) and also shelter for fish to escape predation (Williams, 1991; Polunin, 1996). Population structure, species diversity, density and biomass of the fish community can be related to the state of the coral reef which can be measured using various parameters (e.g. rugosity, live coral cover, algal cover) (McClanahan, 1994).

The way reef habitats affect a coastal zone fishery takes three forms. First, maximum yields are limited by the status of the habitat through habitat-fish interactions as described above. Second, the characteristics of a reef habitat (e.g. high coral cover, sandy lagoon floor) and the risk of damage to gear they pose will determine the type of gear used and, to a degree, the species of fish caught. Third, the spatial distribution of physical features that are perceived by fisherman to be attractive to their target species, such as large coral heads or converging currents, will determine the areas in which fishing effort is concentrated.

In a fishery that is entirely dependent on reef fish, catch rates may decrease and the catch composition may shift more towards the herbivorous species. These fish are often lower in value so, as a result, the economic position of fishers may deteriorate. Fisher communities that live on islands with few alternative sources of income will have difficulty sustaining their livelihoods. A fishery that targets large predatory pelagic species that forage on reef fish may also experience lower catches when these fish are forced to move to other less destroyed areas to hunt for prey. A fishery that targets small pelagic species that occupy a reef area or lagoon during certain phases of their life cycle may also experience lower catches when reefs disappear.

METHODS

Fishery assessment

A study of the effects of coral bleaching and mortality on reef or coastal zone fish resources preferably includes historic data (Type I) and spatial data (Type II) enabling:

- An assessment of the qualitative and quantitative impact on the perspective of the total fishery performance – nation-wide.
- An assessment of the social/economic impact based on cases – coastal provinces/districts.
- Predictions of future developments in social/economic conditions of fishers, in response to the event based on past trends in the fishery performance.

Official marine fisheries statistics (Type I) were used to characterise the importance of reef fisheries in each country. Although the quality of official fisheries statistics is often weak, usually they remain the only information used by policymakers to assess the status of a country's fisheries. However, an analysis of data that were available previously and of those that were

collected by contributors from each country in the region identifies weaknesses in the information needed to assess the importance of reef fisheries on both a nation wide and region-wide scale. Information describing resource utilisation and fishery performance (Type II) was collected during a case study of the reef fishery of Kenya. This information, when combined with Type I data, enables an economic valuation of a reef fishery that includes both a financial analysis at the individual household level and, where possible, an economic analysis at the society level (Cesar & Pet-Soede, in prep).

RESULTS

Trends in marine fisheries in the Indian Ocean

Developments in the national demography and social economy of most countries in the Indian Ocean suggest a continuously increasing pressure on fish resources (McClanahan, in press). In some countries, total fish production is declining (Table 2). Most of the catch from coastal fisheries is used for local consumption, as it is the most affordable source of protein (FAO, 1999b). Shrimp and tuna are the main export commodities. In most countries, fishing gears used in coastal areas include traps, spears, gillnets, seine nets, hook and line, and cast nets.

The large number of small fishing vessels from which the millions of Indian Ocean fishers operate makes monitoring of stock status and implementation of fisheries management measures difficult (Table 3). Methods used to sample marine fisheries and the way the collected information is processed and presented in reports differs greatly between countries. Little regulation of fishing effort exists, except in a number of marine protected areas around the region and a closed season for the large net fishery off Mauritius.

The number of fishers may be small compared to the number of people engaged in other economic activities (Table 3). These fishers often have few other opportunities to make a living and the fish they catch is a vital source of protein. These factors make it relevant to study trends in fish catches to prepare for alternatives if capture fisheries collapse.

The importance of reef fisheries in the Indian Ocean

The percentage of the demersal fish landings compared to the total fish landings can be seen in table 4. However, when discussing the importance of reef fisheries per country, it is important to distinguish between its importance in providing food, foreign currency and employment (Table 5). A short description of the fisheries of each region within the central and western Indian Ocean is presented.

South Asia

In India, the relative contribution of the reef fishery to both earnings and total fish landings (1 790 702 tons in 1993) is low. This did increase from 1% in the early 1970's to 5% in the early 1990's. The importance of other demersal fish remained stable at 32% throughout the entire period (Figure 3) (CMFRI, 1980; 1995). This low importance is caused by the fact that most reefs are found in lightly populated regions such as the Andaman and Nicobar Islands (DOD & SAC, 1997; Bakus, 1994). In addition, there is a high demand for large pelagic fish, such as mackerel and tuna, at both domestic and export markets ensuring that the fishery in large reef areas, such as Lakshadweep, focuses on catching these large pelagics instead of demersal reef

species (James *et al.*, 1984; Bakus, 1994). On the mainland, most of India's coastal fishers make their living from either the pelagic fisheries, the prawn trawl fishery or from small-scale demersal fisheries using beach seines. However, this is likely to change as a result of increasing demand (foreign markets) for high quality reef fish such as grouper and snapper and because of declining catch rates resulting from over-capitalisation and exploitation of coastal shelf areas (Devaraj, 1997).

The reef fishery in Sri Lanka provides an important part of the fish consumed in the country. The demersal fishery does not provide employment to a large portion of the population. The coastal fish production is highly variable but increased five fold from 36 865 tons in 1951 to 157 500 tons in 1995 with highest production in 1982/83 of approximately180 000 tons (Figure 4). Coastal fisheries contributed almost 90% to the nations total fish production in the early 1970's but this importance decreased to 65% in 1996 with increasing importance of offshore fish landings of some 25% in 1996. Inland fish production was relatively important (18% - 19%) in the mid 1980's but decreased to approximately 9% in 1996.

In Maldives reef fisheries contribute least to total fish production, although this is increasing. However, the indirect importance of reef fisheries to the entire fish production is much higher because bait fish for the tuna fishery are caught in the lagoons and near the reefs. Total fish catches have increased dramatically in recent years from 39 000 tons in 1983 (Anon., 1998a) to 118 115 tons in 1998 (Anon., 1998b) (Figure 5). With its vast area of coral reefs, it is remarkable that reef-associated demersal species have not been heavily exploited in the past. The majority of Maldivians have a high preference for tuna. Some demersal fish were caught, mostly with a single hook hand-line, to supply the tourist resorts and the Sri Lankan market for salt-dried low value reef fish (Anderson *et al.*, 1992).

The Ministry of Fisheries and Agriculture collects data from every inhabited island. However, the Catch Effort Data Recording System (CEDRS) focuses on tuna catches and fisheries. The importance of reef fish has increased following increased demands from new export and domestic markets. It is believed that the current expansion creates overexploitation of the resources and conflicts among resource users (Shakeel & Ahmed, 1997). Reef fishing is most important in the atolls where tuna fishing is poor. In the other atolls reef fishing remains the second most important fishing activity. Catches increased significantly (nearly 5 fold) between 1988 and 1994, but CpUE seems to have declined. Grouper fishing is increasingly important and caters to the international market.

East Africa

The catches of reef fish increased during the 1970's but at the beginning of the 1990's catches decreased to levels recorded in the 1950's. In Tanzania, especially in the northern districts and Zanzibar, the demersal fisheries provide employment to a large portion of the coastal population. Overall, marine landings are decreasing, mainly because of declining pelagic catches. This results in an increase in the relative importance of the demersal fish production (Table 4). The majority of Tanzanian fisheries (96%) are small-scale and exploit the reef-associated habitats (Darwall & Guard, in press). There are 3 232 registered vessels and their fish production varied between 36 000 tons and 56 000 tons between 1990 and 1995.

Reef fish in Kenya is less important in the total fish production. Nevertheless, the high numbers of coastal fishers have few alternatives to make a living. The total marine fish catch seems to have collapsed in the early 1990's and, although catches have increased since then, only by the late 1990's was production back to 5 000 tons, the level that was produced in the early 1980's (Dept. of Fisheries, Mombasa) (Figure 6). Some 4 700 fishers are active in coastal regions of Kenya. The contribution of demersal fish to the total marine fish production has been quite stable during recent years at approximately 30% - 40%.

Indian Ocean Islands

In Madagascar, 43% of the fishery is based on the coral reefs (65 090 tons). Of the total fish production, 20% is exported, which means an important amount of foreign earnings is derived from the demersal fishery (Table 4). Export of fish almost doubled between 1986 and 1989 to 24 264 tons, of which 8 000 tons were shrimp. In 1994, the value of the exported shrimp catches was 80 million US$ and landed by-catch represented 45% of the total fish landings in that year. This was a 27% increase during 1994, therefore shrimp trawling poses a growing threat to the sustainability of Madagascar's demersal fisheries. In 1994, 117 500 tons of fish were produced of which 55% was captured in small-scale fisheries. Approximately 50 000 people are involve in this fishery using 22 000 boats and living in 1 250 villages. Total fishing effort increased five fold between 1977 and 1994.

In the island states of Mauritius, Reunion and Rodrigues the relative contribution of demersal and reef related fisheries to total fish production is high (Table 4). In 1999, there were between 2 500 and 3 000 professional fishers in Mauritius. Total landings in the artisanal lagoon fishery (traps) in Mauritius have been relatively stable and have increased only slightly from approximately 1 600 tons in 1991 to nearly 2 000 tons in 1999 (Naim *et al.*, in press). An important fishery in Mauritius is the Banks fishery along the Mauritius-Seychelles Ridge with 15 vessels that produced another 4 424 tons of fish in 1996. The vessels are large (200-430 GRT) each employing between 50 and 60 fishers and 20 crew.

Fisheries in Seychelles include an industrial fishery of foreign licensed tuna purse seiners and longliners, a semi-industrial fishery of longliners for swordfish, and the reef fishery. In 1992, handlining and traps set on sandy or sea-grass substrate that target rabbit fish contributed most of the total fishing effort (Jennings *et al.*, 1995). Handlines caught 78.3% of the 5 718 tons of fish landed in that year (Figure 7). Seychelles relies largely on fish exports and tourism for foreign revenue. In 1992, 200 tons of fresh fish and 839 tons of frozen fish were exported. In 1995, artisanal fish production was 4 313 tons of which 420 was exported for 10 million SR.

In Comores there are approximately 8 000 fishers. All are artisanal fishers and live in approximately110 fishing villages. Total fish catch in 1995 was13 000 tons of which 72% was pelagics. (8 000 tons were caught at Grande Comores). The monetary value of the catch in that same year was estimated at 9 million francs of which 6 million was contributed by Grande Comores alone.

Assessment of the effect of bleaching and coral reef degradation on coral reef fish and fisheries in Kenya: A Case Study

The Coral Reef Conservation Project (CRCP) is a U.S. based NGO of The Wildlife Conservation Society that has monitored Kenyan coral reefs since 1986 and fish catches associated with coral reefs since 1995. The project includes a study of fish populations in Kenya's older (>25 years) fully protected marine parks (Malindi and Watamu MNP), a more recently created park Mombasa MNP (1991), and four sites on heavily fished unprotected reefs (Vipingo, Kanamai, Ras Iwatine and Diani). This study was conducted in late 1997 and repeated in early 1999, around four months before and 10 months after the coral bleaching event. For the purpose of assessing possible effects of the 1998 bleaching event, abundance and composition of the reef fish community was determined, together with biomass and composition of individual fish catches.

The underwater visual census data showed no clear changes in fish community structure that can be attributed solely to the bleaching and mortality of corals. Only the increase in abundance of surgeon fish, which are grazers that feed on algae on the surface of the dead coral, may be related to coral mortality. It appears that there is a strong relationship between management (marine park versus exploited reefs) and fish abundance for many of the studied fish families (McClanahan & Arthur, in press). The catch assessment data show a significant decline in catch between 1995 and 1999, whereas the total fishing effort, measured in numbers of fishers or boats remained constant. There is no significant deviation from this trend after the 1998 bleaching event. Therefore, it must be concluded that, at this stage, the fishery has not been significantly affected by the bleaching and mortality of corals. Nevertheless, the declining catches may be a result of overall environmental degradation. Therefore, it is expected that the effects of the recent bleaching and coral mortality may become more evident once the reefs are further eroded in the future.

ASSESSING THE IMPACTS OF THE CORAL BLEACHING ON REEF BASED TOURISM

The second major socio-economic impact of coral bleaching would be expected on the tourism industry. Tourism will be affected by bleaching in those areas where a substantial proportion of the industry is based on reef activities and where there are few other attractions or activities for tourists to enjoy. Tourism varies throughout the countries of the Indian Ocean and the diversity of the tourism product ensures a greater or lesser dependence on coral reefs. Table 6 indicates the level to which each of the countries is dependant on coral reefs, and the national growth rate in tourism seen over the past five years.

Reef based tourism is a major industry in both Maldives and Seychelles, although they are marketed quite differently. Maldives caters for the diving market (45% of all tourists dive) and the honeymoon market. Seychelles, Seychelles, on the other hand, offers a variety of activities and people may snorkel and dive as a small part of their vacation (only 7% of all tourists dive). Similar patterns were seen in Zanzibar where people spend, on average, less than 40% of their vacation time diving and snorkelling. In Kenya and mainland Tanzania, wildlife parks and safaris are probably the main attraction for visitors. However, visitors may often spend a week on safari and then a week at the coast where the reef based attractions form an important component of their vacation. Island states, such as Comoros and Rodregues have small-scale tourism industries. In Comoros, tourism employs 600 people and in Rodregues 254 are

employed, of which only five are employed directly in the dive industry. India supports a huge tourism market, although relative to the size of the country and its economy it is of lesser importance compared with some of the smaller island states. The reefs of India tend to be remote and difficult to access so reef based tourism is limited. Sri Lanka has some reef based tourism, but has also many other attractions. There has been enormous overuse of certain areas, such as Hikkadua where over 90 glass bottom boats operate. Visitors to Reunion and Mayotte are generally friends and family of residents and those visitors that are genuine tourists are usually from France or, in the case of Mayotte, from Reunion.

Perhaps more importantly than the total arrivals, is the actual financial gain a country or region might receive from tourism. The World Travel and Tourism Council produce simulated forecasts of world tourism. The revenue generated from travel and tourism and the contribution of this to the national economy (GDP) is shown in Figure 8. Maldives shows that 55.9% of the national economy is based on travel and tourism. The next highest is Mauritius at 27.9%, followed by the Seychelles at 20.7%. All these countries are small island states and most of this tourism will be all or partly based on the reefs. Those countries with lower revenue from travel and tourism depend heavily on industry for their national economies.

Two specific case studies were carried out to examine the financial and economic impacts of the coral bleaching on tourism. The first was conducted in Tanzania and Kenya and the second in Maldives and Sri Lanka. The following sections give a brief synthesis of these two studies.

Assessing the impacts of coral bleaching on tourism in Tanzania and Kenya

One of the specific case studies initiated as part of the socio-economic assessment of the impacts of the coral bleaching within the CORDIO programme was carried out in Tanzania (Zanzibar) and Kenya (Mombasa). The aims of the research were to:

- Establish whether tourists are familiar with coral bleaching
- Estimate the financial and economic cost of coral bleaching to tourism in Zanzibar and Kenya
- Compare the recreational value of the reef before and after the bleaching event.

METHODS

This research is based on a questionnaire survey of tourist divers in Zanzibar and Mombasa. The economic analysis is based on the contingent valuation methodology (CVM). Financial costs are based on expenditure data given by the respondents. The questionnaire was initially developed for use in Zanzibar and Mafia Island, Tanzania and had been through pre-testing and a full survey (Andersson, 1997). Although a few questions were omitted and a few added, it was not felt that it was necessary to pre-test the survey again. In Zanzibar, 199 divers were surveyed, the sample being split evenly between the two sites. Initially, in Mombasa, a total of 105 divers were interviewed. Surveys were carried out at the dive shops of Zanzibar and Mombasa.

RESULTS

The divers visiting Mombasa were found to be on average older and more experienced divers than those in Zanzibar. However, the respondents in Zanzibar had a higher level of education than those in Mombasa. In Zanzibar, it was estimated that divers spent approximately 42% of

their vacation participating in reef related activities compared to 50% in Mombasa. The importance of the reef can be seen in the diver's ranking of the various attractions in Figure 9.

Diver awareness of coral bleaching

The study found that only a limited number of tourists surveyed at the two case study sites were actually aware of coral bleaching. In Zanzibar, this was 28% and in Mombasa this was 45% (Figure 10). This low awareness could be related to their country of origin, level interest in the marine environment and dive experience. These links were explored but the sample size of those aware of the bleaching was too small to make any significant conclusions. However, of those who were aware of the bleaching, over 80% stated that knowledge that an area was bleached would affect their decision to either visit that area or to dive and snorkel in that area (Figure 10). This enabled estimations of the financial and economic costs of the coral bleaching to be made.

Valuation of the reef resources

In estimating the financial and economic costs of the coral bleaching, the survey techniques and the valuation methods developed by Andersson (1997) for the previous survey in Zanzibar were used. The financial cost of the bleaching are the losses to the local community and tourism economy resulting from those tourists deciding not to visit or simply not to dive in the locations because of the bleaching. This is calculated using the diver's and snorkeller's expenditure data collected during the survey. The economic cost of the bleaching represents the loss of value to the same group of tourists, either not visiting because of the bleaching, or visiting but not diving. This loss affects the divers and snorkellers for not having access to healthy reefs. The economic cost is calculated from the diver's and snorkeller's stated willingness to pay. There are two components to the willingness to pay. The first is the consumer surplus, which is the additional money the tourists would be prepared to pay to still visit the place. This reflects the value of the benefits they gain from recreation exceeding the total cost they have spent on visiting the place. The second is the willingness to accept compensation for the fact that they are unable to dive because of the degraded reefs. The first value is used as the cost when divers do not visit the area and the second is used when divers visit but choose not to dive. When aggregating the results, a range (% of tourists diving) is used if the exact figure is not known. This is thought to be in the region of 20% - 30%. In Maldives, a diving destination, 45% of the tourists were recorded as divers. These aggregated costs can be seen in Table 7.

Comparison of economic value between 1996 and 1999

One of the main components of this research was the ability to compare diver and snorkeller valuations of the reefs of Zanzibar before and after the coral bleaching by incorporating the data collected in 1996/7 by Andersson (1997) into analyses. Compared with the 1999 results, the overall consumer surplus was unchanged indicating that a complete holiday to Zanzibar was valued the same in 1996 as it was in 1999. The level of reef use was also comparable. However, the willingness of the divers and snorkellers to accept compensation for non-access to the reefs had increased 20% between 1996 and 1999. This indicates that the reef remains an important component of the visit and the value placed on having access to reef related activities has actually increased.

The willingness to pay for reef conservation can be related directly to the state of the reef in 1996 and in 1999. In 1996, the average willingness to pay to maintain the reef in the same state was

$30. In 1999, this had dropped to $22, a 27% decline from 1996 to 1999. This reflects either a decline in the perceived state of the reef or a change in the type of tourist and their willingness to pay for reef conservation. However, comparison of the socio-economic data obtained in 1996 with those obtained in 1999 determined that the only difference between the two groups was that divers surveyed in 1996 were generally more experienced than those surveyed in 1999. In 1996, the average number of dives each diver had completed was 83, compared with only 33 in 1999. This may be an indicator that the more experienced divers are aware of reef conditions and their decision has already been affected by stories of reef degradation or that these divers are traveling elsewhere, where they can get more adventure and extreme conditions of diving.

Management implications of the results

One of the major findings of this research was the fact that, although only a limited number of tourists were aware of coral bleaching, or of reef degradation generally, their decision to visit may well be affected. From a management perspective, this has implications for the type of information that the tourists are receiving on the state of the reefs. Should bleaching adversely affect the reefs, tourists may still visit the area if alternatives are supplied. These may be marine based or even land based. Planning for a change in tourism activity may need to take place sooner rather than later.

The decrease in willingness to pay for the conservation of the reefs may be related to the state of the reefs but also could be related to the level of visible management. To gain support for reef conservation from visitors, management efforts need to be visible through public information, brochures, active rangers and patrols. What is useful from the data collected is the approximation of a willingness to pay being approximately 2% - 3% of the total vacation expenditure. This type of data can be utilised when establishing protected areas and generating revenue through user fees.

Limitations of the study and further research

There were several limitations of the study imposed by time and financial constraints. For full analysis and comparison of results obtained in 1996 and 1999, the survey needed to cover the higher-price hotels along the east coast also. In addition, Zanzibar was only mildly affected by the coral bleaching whereas Mafia Island was heavily affected. The 1996 survey was also carried out on Mafia Island and a re-survey of this area could provide some useful insights into financial and economic costs of the bleaching. Broadening the survey to cover all tourists both at home and abroad would also increase the understanding of tourist behaviour with respect to coral bleaching and reef degradation.

Assessing impacts of coral bleaching on tourism in Maldives and Sri Lanka

This study focuses on impacts of coral bleaching and subsequent mortality on tourism in the Maldives and Sri Lanka. In Maldives, with 430 000 tourists in 1999 (Ministry of Tourism, 2000), diving and other reef-related tourism are the main income generating activity in the country. Sri Lanka has a similar number of tourists but very few come specifically for reefs, even though they are attracted in general to the coastal areas. The current study addresses socio-economic questions related to coral bleaching and tourism primarily by recording tourists' perceptions of

coral bleaching. Also, estimates of the financial and associated welfare losses resulting from the 1998 coral bleaching event are provided.

METHODS

This research was based on both questionnaire surveys and secondary data sources. Four different surveys were carried out: (i) one for tourists departing from Male airport in Maldives and from coastal tourist locations in Sri Lanka; (ii) one for key informants such as dive operators and glass bottom boat captains in Sri Lanka; and tour operators in Italy; (iii) one for tourists at the airports of Amsterdam, Duesseldorf and Milan on their way to Maldives and Sri Lanka; and (iv) dive tourists were asked via the internet about their knowledge of coral bleaching in Maldives and whether bleaching and coral mortality was a factor that influenced their decision to go there. The secondary data sources were the official tourism statistics of Maldives and Sri Lanka.

RESULTS

Interest in the marine environment

In Maldives, there seemed to be three main categories of tourists: (i) divers; (ii) honeymooners; and (iii) 'relaxers'. Around 45% of all tourists going to Maldives were divers. In Sri Lanka, only approximately 8% were divers. Italians tend to visit Maldives for their honeymoon while Germans go to dive. The number of dives made while visiting each country also varied considerably. In Sri Lanka, of the 8% that went to dive, 50% did only one or two dives, while in the Maldives, 69% of divers did more than five dives. With respect to their interest in the marine environment, 52% of the tourists at Male airport responded that the importance of marine life was very high, 34% answered that is was rather important and only 13% said that it was not important. In Sri Lanka, the results were quite the opposite. Only 18% stated that marine life was very important, while 32% and 51% said that marine life was rather important and not important respectively.

Divers' and snorkellers' knowledge of coral bleaching

The media coverage of the coral bleaching episode of 1998 has been substantial. Dive journals have given considerable attention to the bleaching event and to reactions of divers. Yet, interviews at the European airports showed that many tourists on their way to Maldives did not know of the episode. Fifty percent of Germans surveyed had heard of the coral bleaching event in Maldives, compared with 30% of the Italians and 16% of the Dutch. This can be explained partly by the exceptionally large media coverage in Germany and by the large percentage of divers among German tourists. At Male airport, 68% of departing tourists had heard of coral bleaching, while in Sri Lanka, less than one third knew of this problem.

Losses in Tourism Revenues in Maldives

Possible losses to Maldives' economy were analysed based on the official tourism statistics up to December 1999. Figure 11 presents tourist arrivals since the 1972. Surprisingly, there was not a significant drop in tourist arrivals in 1998-1999. In fact, tourism arrivals have increased 8% in both 1998 and 1999.

However, trends in bed occupancy rates since 1975 give a different picture (Figure 12). Given the time lag between the planning phase of expansion and the additional bed capacity, occupancy rates give a proxy for expected growth in tourism and the decrease in 1998/9 was substantial. However, the Asian crisis was also affecting tourist numbers. Another way of looking at expected growth of tourism arrivals is to check the official government tourism forecasts. In 1997, an annual growth of 10% was expected for the years of 1998 and 1999 (Ministry of Tourism, 1997), which was 2% higher than the realised figures. Here, we assume that half of this difference was due to coral bleaching.

Welfare losses from divers

Besides financial losses to the local economies, coral bleaching can also affect tourists' holiday satisfaction and thereby create a loss in their welfare. In order to calculate these welfare losses, the surveys at Male airport focused on tourists' willingness to pay for 'better reef quality'. In order to ensure the tourists value the same change in reef conditions, two pictures were shown, one of a reef that had completely died because of bleaching and another that was still intact. The question asked of tourists was how much extra were they willing to pay to go to hypothetical remote areas in Maldives where reefs were not affected by coral bleaching and which were, in all other respects, the same. Figure 13 shows the distribution of this willingness to pay (WTP) and illustrates that the tourists surveyed were willing to pay an average of US$ 284 more to visit these hypothetical reefs. Divers were prepared to pay more than other tourists, though the difference was surprisingly small. The mean WTP for divers was US$ 319 while for non-divers it was US$ 261. The aggregated losses can be seen in Table 8.

Finally, tourists were asked about the most disappointing part of their Maldives holiday. The possible answers were: (i) the price of food and beverages; (ii) the weather (humidity, clouds, etc.); (iii) the fact that a lot of the corals were dead; (iv) the mosquitoes; (v) the resort accommodation; (iv) others. Figure 14 summarises the responses, showing that 47% considered the dead corals the most disappointing experience, while the price of food and beverages was second with 28%.

This last result is interesting, because nearly all resorts are based on half or full board, so that the actual amount of money spent on additional food and beverages is quite low, though beer is expensive at around US$ 5 per bottle. The interesting aspect of these responses is that they allow us to compare and therefore scale the willingness to pay WTP values. Surprisingly, the average WTP for better reef quality was not statistically different for those who found coral mortality most disappointing and those who found other parts of their holiday most disappointing. Note that one could buy more than 50 bottles of beer for the average WTP for improved corals, which might either suggest an inconsistency in the way people respond to the various questions or, alternatively, there are quite a few very hefty drinkers among the tourists. Unfortunately, it might also mean that many tourists do not really care about the death of coral reefs.

Assessing the future tourism impacts

The two case studies show a number of interesting similarities as well as differences.

- Awareness of the 1998 coral bleaching event among tourists going to destinations with coral reefs is generally rather limited.

- Current losses in tourism revenue due to coral bleaching event have, so far, been rather low. In Maldives, it is estimated that only US$ 3 million was lost during 1998 and 1999 combined. In Mombasa, the losses were estimated to be much higher (US$ 13-20 million), but these were hypothetical losses assuming permanent disappearance of tourists.
- A key determinant of losses in tourism revenues was the ability to attract other types of tourists who, despite being interested in coral reefs and reef based activities, were not interested only in diving. This flexibility could help explain the lower losses in Maldives compared with Zanzibar and Mombasa.
- Divers seemed willing to pay considerable sums for better reef quality. In Maldives alone, the total welfare loss for 1998/99 was estimated at US$ 19 million.

Future tourism losses remain uncertain. Key determinants are the long-term impact of relatively slow word-of-mouth reports or TV documentaries on bleaching. Despite the loss of some avid divers who appear to be going to areas that have not been impacted by bleaching, they are easily replaced by the hundreds of new divers that appear on the market. The key uncertainties are related to the impacts of coral mortality on fish populations and on beach erosion.

The impacts of the coral bleaching on tourism should be seen in the wider picture of reef degradation which, in itself, is not the only issue affecting tourism. Mombasa has seen a huge decrease in tourism relating to public opinion on personal safety. Much of this impression is created in national newspapers indicating the power of the media in altering public perception.

A further aspect of analysing the impacts of events such as the bleaching, is to look carefully at who is being impacted. The tourist has a variety of alternative locations and may not be affected, whereas the local dive guide may be unemployed as the dive industry adjusts or is impacted.

DISCUSSION

The 1998 El Niño event has so far not affected socio-economic indicators dramatically. Reef fisheries in many areas in the region have been showing a general decline over the last decade and data collected can not yet tell what the added negative impact of coral bleaching is. On the other hand, diving tourism has been growing rapidly all over the world (except in East Africa). Again, the added influence of coral bleaching on these trends is uncertain. Tourism studies show however, considerable financial costs ranging between US$ 3.1 and US$ 4.6 million in Zanzibar and US$ 13.3 and US$ 20.0 million in Mombasa. In Maldives, financial costs were estimated at US$ 3.0 million, while economic costs over the last two years were roughly US$ 63 million.

In the long run, the impacts may be rather more dramatic if increased erosion of the reef and a loss of reef complexity occurs, which would be expected to take between two and 10 years. Given the lack of other global coral bleaching events, the likelihood of this scenario is uncertain. Yet, major declines in fisheries and tourism can not be excluded, with corresponding impacts on marginal populations in coastal areas.

Furthermore, coral bleaching has re-opened the discussion about effective coral reef management. Reducing the pressure on coral reefs from their over-usage has never been an easy

task. However, it will be essential if reefs recover from the bleaching and survive future threats. The bleaching of corals is more difficult to control. If this is a natural event, there is little man can do to manage it. We can only assist in recovery through appropriate protection of the reefs and vital sources of larvae. If, on the other hand, coral bleaching is caused by world-wide pollution and the consequences of climate change and global warming, it will take a massive global effort to reduce impacts in the future. If continued coral reef degradation is going to be a widespread phenomenon in the Indian Ocean, the following questions need answering:

- To what extent will reef fish stocks be affected?
- Will a decline in reef fisheries or change in population composition affect pelagic fisheries?
- Will reef based tourism be replaced by other forms of tourism?
- What will happen to the Marine Protected Areas dependent on tourists visiting the reefs for their income?
- Can we maintain the tourism industry and utilise the tourism market for basic monitoring of reef fish and habitats?
- What are the links between reef usage and the bleaching?

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