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Proceedings of the INCO-DEV International Workshop on Policy Options for the Sustainable Use of Coral Reefs and Associated Ecosystems

Mombasa, Kenya, 19-22 June 2000

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Titles of Related Interest

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The ACP-EU Fisheries Research Initiative

The ACP-EU Fisheries Research Initiative was requested by the ACP-EU Joint Assembly, composed of Members of the European Parliament and Representatives of African, Caribbean and Pacific (ACP) Countries, in a Resolution on Fisheries in the Context of ACP-EEC Cooperation, adopted in October 1993. A series of dialogue sessions was conducted between ACP and European aquatic resources researchers, managers and senior representatives of European cooperation, using a draft baseline paper for the Initiative produced by intra-European consultation. Since then, the principles have attracted interest in other regions.

The Initiative aims at promoting sustainable economic and social benefits to resource users and other stakeholders, while preventing or reducing environmental degradation. It has set an agenda for voluntary collaborative research based on mutual responsibility and benefits. It promotes commitment to addressing the most crucial problems of restoring resource systems and their ecological and economic productivity with the objective of informing and supporting more directly economic and political decision making through pro-active and high quality research and stakeholder participation.

In the meantime, the principles have been successfully used in wider scientific cooperation with other developing countries and regions as a result of bi-regional dialogue e.g. with East and Southeast Asia (ASEM), Mediterranean (MOCO) and Latin America and the Caribbean (ALCUE).

Suitable instruments to fund research, capacity building and/or implementation are, among others, the European Development Fund (EDF), International Scientific Cooperation (INCO) as part of the EU RTD Framework Programmes, the Global Environment Facility (GEF), European Member States' bilateral research and cooperation programmes and partner institutions' own resources.

ACP-EU Fisheries Research Report Series

The ACP-EU Fisheries Research Reports are a series of publications that aim to share information about the development of the ACP-EU Fisheries Research Initiative and wider findings generated in order to maximise the impact of its activities. It includes proceedings of workshops and meetings, statements on policy and research activities under the Initiative. An increasing number of these go beyond the strict framework of ACP-EU bi-regional S&T cooperation, in line with the global nature of the issues at hand.

Preface

These proceedings contain most of the papers presented at the European Union (EU)-sponsored international workshop on **Policy Options for the Sustainable Use of Coral Reefs and Associated Ecosystems** held 19-22 June, 2001 in Mombasa, Kenya. The editors made it a point to include all the papers presented and made available to them by the participants at the workshop.

The interesting discussions at this workshop demonstrated clearly that Coral Reef related research could gain considerably especially with regard to informing policy by intensifying the collaboration:

- between natural and social scientists,
- between European and Non-European researchers, as well as
- between researchers and policy makers.

The workshop was jointly organised by:

The **Interdisciplinary Centre for Sustainable Development (IZNE)**, (Georg-August University of Göttingen), Germany

Dr. Heidi Wittmer (Project Coordinator)

Dr. Abdul B. Kamara

Dr. Zien-Elabdin Hassan

DAR-German Environmental Consultants, Germany

Dr. Lothar Schillak

The Royal Geographical Society, UK

Dr. Helge Peter Vogt

It was hosted by the:

Kenyan Marine and Fisheries Research Institute (KMFRI), Mombasa, Kenya

Mr. James Muhoro (Director Ag.),

Dr. Renison Ruwa (Deputy Director)

We take this opportunity to thank Dr. Cornelia Nauen from the EU for her invaluable support and guidance throughout this project, Dr. Rudolf Hermes and Dr. Anthony King as well as the co-organizers of the workshop, Dr. Lothar Schillak and Dr. Helge Vogt for their inputs and helpful comments concerning the proceedings. The support of Dr. Regina Birner and Prof. Dr. Rainer Marggraf from the IZNE is also gratefully acknowledged.

The Editors

Abstract

The present report contains the proceedings of the INCO-DEV International Workshop on "Policy Options for the Sustainable Use of Coral Reefs and Associated Ecosystems" convened in Mombasa, Kenya, 19-22 June 2000. It was convened to address issues associated with the ongoing degradation of coral reefs and associated ecosystems. This degradation takes place inspite of an impressing body of research results and and increasing number of technical solutions becoming available. Policy options for the sustainable use are only feasible if they allow reconciling the requirements of conservation with the economic and social demands of the people relying on these natural resources. By its very nature this challenge of managing coral reef ecosystems sustainably calls for international and interdisciplinary approaches.

The focus of the workshop consisted in analysing how research can better contribute to the formulation and implementation of policy options for sustainable use. A special emphasis was placed on coordinating efforts between natural and social sciences. In four different panels challenges and opportunities concerning economic valuation of, technical options for, and stakeholder involvement in the sustainable use of reefs as well as the issues involved in co-ordinating policies for Marine Protected Areas on national and international scales were discussed. Working groups focussed on the potentials for improving cooperation between natural and social science research as well as between research on the one hand and policy makers and implementers on the other. Areas of policy intervention discussed include regulation of fisheries, the potential of reef restoration especially in combination with enhancing markets for sustainably produced marine products, tourism and developing alternative income generating activities. The workshop concluded by identifing issues for future research collaboration.

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Policy Options for the Sustainable Use of Coral Reefs and Associated Ecosystems: Challenges and Opportunities for Research[a]

By: Heidi Wittmer[b]

1. Background and Objectives

Coral Reefs, among the most diverse and fragile ecosystems on earth, are increasingly being destroyed. With the objective to reverse this global trend, essential knowledge for the conservation and rehabilitation of coral reefs has been accumulated over the past decades, and valuable technical options have been developed. However, as long as the framework conditions leading to the destruction of coral reefs and associated ecosystems persist, sustainable management and rehabilitation efforts will hardly be successful. Policy options for the sustainable management are only feasible if they allow reconciling the requirements of conservation with the economic and social demands of the people relying on these natural resources. By its very nature, this challenge of managing coral reef ecosystems sustainably calls for international and interdisciplinary approaches.

Against this background, an INCO-DEV International Workshop on Policy Options for the Sustainable Use of Coral Reefs and Associated Ecosystems was convened 19-22 June 2000 in Mombasa, Kenya. This EU-funded workshop offered a platform for subject matter experts from various regions of the world to share their expertise and experience and to identify research needs to improve policy options for the sustainable use of coral reefs and associated coastal ecosystems. The objectives of the workshop were

- ⇨ to create a forum of exchange and establish a network to facilitate future co-operation,
- ⇨ to review the lessons learned from recent approaches in coral reef management,
- ⇨ to assess transdisciplinary issues of managing coral reefs and coastal ecosystems, and
- ⇨ to identify priorities for social, economic, and policy research and research co-operation aiming to promote the management of reefs for sustainable benefits.

2. Organisation

Four panels - consisting of thematically focused presentations and discussions - debated key research and management issues of coral reefs and associated ecosystems, and derived policy implications:

1. The first panel dealt with the economic valuation of coral reefs including a session on tourism as one of the potentially sustainable uses with high economic significance.
2. The second panel presented technical options to improve reef assessment, reef conservation, and reef rehabilitation and identified conducive policy framework conditions for implementing these options.

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[a] Introduction and Conclusions from the EU-Workshop: Policy Options for the sustainable Use of Coral Reefs and Associated coastal Ecosystems; Mombasa, Kenya June 19th – 22nd, 2000

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3. The third panel reviewed experiences with the essential role of stakeholder participation in coral reef management and highlighted the associated policy processes.
4. The fourth panel discussed current experiences and future challenges of establishing conservation networks at the national, regional and international levels.

Suggestions for policy relevant research issues were derived from each panel session. A field trip allowed the participants to observe a well-protected reef in the area, and to get exposure to the local population's views on coral reef management. The working group sessions on the last day allowed the participants to take-up the suggestions identified during the panels and the field trip in order to develop proposals for future co-operation.

The present paper synthesises the results from the workshop sessions with respect to the challenges and the opportunities for policies enhancing the sustainable use of coral reefs. It draws conclusions regarding the institutional set up and the research needs emphasising the potential contribution of social sciences. It relates to the individual papers and places them into the policy context.

3. Challenges

The workshop focused on policy options for sustainable use of coral reefs and associated ecosystems and thereby explicitly placed conservation of reefs as well as other ecosystems in the context of sustainable development. This implies as a matter of course that the needs and perceptions of the people have to be taken into account. Such a stakeholder focus is not only concerned with economic opportunities in general but also addresses social aspects and thereby at least a minimal level of equity.

The special challenge of conserving coral reefs lies in the fact that a growing number of people rely on coastal resources to provide their livelihood. In many tropical developing countries, rapidly growing populations require increasing numbers of alternative sources of income. However, their economies are often not able to ensure sufficient income opportunities thus the pressures on reefs will continue to increase (compare i.e. Odada, panel 4). Moreover, changes in the temperature regime of the oceans, such as the increase leading to the destruction of up to 90% of the corals in the Indian Ocean in 1998/9, can considerably reduce the available use-options. Against this background, it was stressed during the workshop that policy options for the sustainable use of coral reefs and related ecosystems need to simultaneously address conservation and developmental goals.

Reefs provide spawning and breeding grounds, as well as nursery and feeding grounds, for a large number of fish species, which form the livelihoods of many artisanal fishing communities. Other reef products, especially those sought by aquarium owners, like ornamental fish (see Marine Aquarium Council, at http://www.aquariumcouncil.org), live food fish in the Pacific (see the Live Reef Fish Information Bulletin, edited by Bob Johannes, at http://wasp.spc.org.nc/coastfish /News/lrf/lrf.htm), corals and other marine organisms have developed their own international markets. Additionally, reefs can provide income-earning opportunities through tourism, and fulfil functions for the stability of islands and coastlines through prevention of erosion. These functions depend on maintaining the current reef ecology to different degrees. While some functions like the protection of the coastal zone can possibly be replaced to some extent i.e. by artificial constructions (albeit only incompletely and at considerable cost), others like reef tourism depend on healthy reefs to a much larger extent.

As rehabilitation technologies are becoming more available and accessible (compare Schillak, panel 2), the restoration of degraded reefs may develop into a complementary tool for policy

makers in addition to more established reef conservation methods. However, it is important to keep two aspects in mind: (i) even with the possibility of rehabilitation policy needs to address the causes of reef degradation and keep impacts on reefs at a sustainable level in the future and (ii) there is a trade-off between rehabilitation and other measures in the sense that they compete for the same resources. This means that rehabilitation constitutes an important additional instrument for coral reef conservation policy that is useful only in the context of a consistent overall policy on the prevention of reef degradation or loss and the sustainable use of reefs and associated ecosystems. (Compare panel 2 as well as Shunula; Kairo, both panel 3 and Ruwa, panel 4)

In order to provide the growing population with medium and long-term livelihood opportunities four general strategies were identified and intensely discussed during the workshop. They imply some degree of equity in sharing of costs and benefits in order to be workable. In most cases, a mix of all of them should be pursued simultaneously:

1. **regulate** traditional uses mainly in **fisheries** in participatory ways that incorporate suitable incentives in order to conserve the resource and thereby enhance income generating potential;
2. **ensure** that other **extractive uses are carried out in a sustainable way**, while utilising the potentials of reef rehabilitation;
3. **enhance non-consumptive uses** like tourism while ensuring that their potential ecological, economic and social damage is contained; and
4. develop **alternative income sources** with coastal populations, including investment into human and social capital in order to bring a greater range of options within the reach of the present and future generations of coastal populations.

None of these approaches will work in isolation and with sole emphasis on the technical aspects at the expense of due consideration of the specific socio-economic context. The complex nature of the reef-cum-social system always involves trade-offs, for example:

- A regulation for fisheries which might be well designed from the point of view of maximising total fish catch over time will have a very low probability of being enforced if the legitimacy of the measure as perceived by the relevant stakeholders is low.
- A potentially more easily implementable design of a certification system might not provide for the best control of destructive fishing practises.
- Implementing a policy to optimally exploit the potential of tourism might imply additional restrictions on fisheries or vice versa. This implies either a significant conflict potential or innovative ways of sharing costs and benefits and avoiding exclusion of earlier right-holders to new streams of benefits.
- Concentrating resources on reef conservation may imply fewer resources available for education or health care and thus be socially unacceptable unless compensated by innovative approaches that maintain or improve benefits in other ways.

Unlike disciplinary researchers who often concentrate on a single issue, policy makers have to make decisions that adequately address these trade-offs. A special focus during the workshop was therefore placed on identifying areas where interdisciplinary research can provide better information and understanding to meet the needs of policy makers and others confronted with social and economic decision-making. The institutional framework conditions for the respective policies and decision making were also analysed.

4. Opportunities

Policy options are summarised for each of the above mentioned possibilities to generate income sustainably for the population living close to coral reefs, i.e. on fisheries, other marine products, tourism and alternative income opportunities. Options for improving the institutional set-up in order to facilitate a more sustainable coastal management as discussed in the workshop are presented.

Regulating fisheries: creating incentives for sustainable use

There is a considerable body of literature about the regulation of fisheries in order to sustain fish yields over time. Although many issues are still debated and remain unclear, the workshop did not contribute to this general debate. Rather, the focus was on certain reef-specific aspects. One such question was whether and how reef lobster fisheries can be enhanced (compare Hartnoll, panel 2) or whether Marine Protected Areas (MPAs) imply an increase in the fish yield in adjacent waters, within which time frames and to what extent (compare McClanahan & Mangi, panel 1). This knowledge is important for the successful economic valuation of the effects of reef conservation. How should the designation of MPAs be organised so that total benefit is maximised. This involves questions addressing the minimum size of MPAs, their functions as sources or sinks for eggs and larvae, the network potential for MPAs in the region and MPA management issues including cost-benefit analyses. However, even if total benefits are larger than total costs, it is also important to analyse much more explicitly the distributional aspects of such measures as the Malleret King paper (panel 1) shows: who looses and who gains?

Interactions like, how are fisheries affected by restoration of reefs, can they recover more quickly? To which extent and over which time spans can habitat restoration rebuild the degraded ecosystem functionality and its earlier productivity? What are the impacts of the installation of rehabilitation equipment on fisheries? Questions like these may be considered experimental or at pilot stage, since not much information is available. These are definitely issues for future research. Clearly, if the absence of alternative sources of income and break-down of traditional (self)regulation has resulted in a highly destructive fisheries or in other activities destroying their own natural capital base (e.g. reef-blasting), mitigating the effects without addressing the underlying causes will not lead very far (compare Mathew, panel 1). In other words, extreme poverty leads to high discounting of the future and such 'mining' strategies. Conversely, greater stability, social organisation and some perspective for the future creates favourable conditions for rehabilitation, including reef restoration.

The effects of the gear used in fishing are central to the regulation of almost any fishery. It is also crucial for reef conservation, not only due to its effect on the fishery itself, but even more so due to the effect on the reef ecosystem. Cyanide and dynamite fishing are clear examples for this. Research needs arise concerning the effects of different gear on the fisheries and the ecosystem (see McClananhan & Mangi). However, restricting gear usage almost always has distributional effects as well. The use of a certain gear is usually related to a certain group in society and requires further assets either in form of skills, capital, access, etc. Thus, when designing regulations based on gear type these aspects need to be taken into account to assess whether the regulation has a good potential for being respected and to compensate for undesirable distributional effects where possible (compare Working group 2).

The institutional challenge consists in designing adequate rules and assuring compliance. Within fisheries there is an important on-going discussion on recovering traditional management systems, where possible, through decentralisation as well as through co-management. These represent important global trends in the design of fisheries regulations in recognition of the need for social and political legitimacy for rule-sets as a precondition for

compliance. Questions concerning the optimum level of decentralisation especially with respect to nature conservation remain disputed; however, examples of decentralisation in various countries have shown that fisheries have improved if managed locally under guidance of trained and experienced staff. Decentralisation requires major legislative support, e.g. the Local Government Code of the Philippines (compare Zaragoza *et al*., panel 3). Another important issue in this context is the monitoring of decentrally-managed fisheries (should it also be decentralised?)

Developing markets for sustainable marine products

Trade in corals and ornamental fish is a growing market with important potentials for economic benefits as well as for environmental destruction. Motta (panel 1) shows the importance in both respects for Mozambique. Actively addressing these issues in policy formulation can help to create awareness and facilitate finding solutions. However, it is important to keep in mind that where attractive markets exist, trade will take place, if not officially then in the black market and this will, of course, render monitoring close to impossible. Trade regulations, especially concerning corals, are extremely difficult to impose and enforce, as the CITES experience with corals and other marine organisms shows. Another important aspect illustrated in Motta's paper is how little of the total value of traded corals (less than 20%) currently remains in the country.

Technical options for a sustainable production or harvesting of these organisms, like coral farming or catching ornamental fish with non destructive gear (e.g. hand net and slurp gun) are becoming increasingly available. However, a significant challenge lies with being able to clearly distinguishing these products from others collected in a destructive way. One suggested solution to this is certification. One option is the marking of corals with permanent tags. In the Philippines, it was suggested that metal tags would be attached to farmed corals in situ. Over time, these tags will be partly overgrown by corals thus making it difficult to fake such metal tags (on certification also compare www.aquariumcouncil.org). Under prevailing conditions, implementing certified trade requires a tremendous effort in research, institutional set up, and awareness creation for the importance of using sustainable techniques, thereby building up the willingness to pay higher prices for sustainably collected products. This usually implies that either politics and/or consumers have to exert pressure in this direction. In order to have an impact, this process has to include at least the most important suppliers and consumers in a given market on a global scale.

With respect to marine organisms traded in world markets, the regulation of these markets was identified as a priority policy area, and a prerequisite for all technical options to impact the sustainability of supplying these organisms. Research on the design and implementation of systems of certified trade constitutes a priority area for international interdisciplinary research and multilateral implementation, as individual countries can hardly achieve this on their own. The set up costs, including awareness raising, organisational requirements and accompanying research required are formidable and are best addressed through partnerships, including also the private sector[a].

Enhancing tourism development in a sustainable way

Tourism is increasingly recognised as an ambiguous option for sustainable use. Over the last decade, tourism constituted one of the fastest growing economic activities in the global

[a] The launching of a system for certified aquarium trade by the Marine Aquarium Council shortly before this volume went into print constitutes an encouraging first step in this direction, compare: www.aquariumcouncil.org.

economy with an important potential to generate income on a stable base. Tourism ideally generates a non-consumptive use value of coral reefs. It has helped to provide a sustainable livelihood in many regions, often creating a considerable amount of employment especially in lower skilled jobs and in remote or less developed areas. Experience world-wide and especially in the tropics has also shown, however, how difficult it is to organise tourism in a sustainable way. The challenges are equally distributed between the three dimensions of sustainability: Even if coral reefs themselves are used in an environmentally safe way, tourism produces a considerable amount of pollution, which often affects reefs. At the same time, tourism creates a high demand for seafood and can thereby be devastating to marine life. Its economic benefits are often very reduced due to the considerable proportion of foreign exchange earnings required for imports and pay back for foreign investment in the tourism industry. In addition, tourism can have considerable negative social impacts, which are well documented.

Tourism development as discussed in the papers and during the workshop can be classified into five different categories depending on who manages tourism and with what objective. Table 1 gives a summary of which policy measures might help to improve the sustainability in each of the categories, considering the three dimensions of sustainable development separately.

The discussion stressed the importance of assuring benefits to the local communities. Malleret King's paper (panel 1) shows how inequalities can be intensified and how hard it is to generate such benefits, given problems of accessibility, distance and "volatility". Community based tourism in the absence of a strong educational and training infrastructure and broad-based skill profiles often also has considerable problems on the economic dimension due to high costs and poor service. Training and public sector support for some functions, as well as contracting certain services with professional providers can help to reduce these costs (compare Mburu & Birner[a]). Awareness building is crucial to ensure environmental sustainability. Even if the activity has income generating possibilities depending on the vitality of the reefs and thus provides an important incentive for its conservation, the impacts of tourism and other activities on the reef ecology will not automatically be understood. Regulation of certain damaging activities and internalisation of environmental costs may also be necessary to increase environmental sustainability. NGOs can play a vital role in training and developing new projects for community-based tourism as is illustrated in the contribution by Romero (panel 3).

[a] Mburu, J. and R. Birner, (Forthcoming) Analyzing the Efficiency of Collaborative Wildlife Management: The Case of two Community Sanctuaries in Kenya. In: *International Journal of Organization Theory and Behavior*.

Table 1: Policy measures to enhance the ecological, economic and social sustainability in different forms of tourism

Type of Tourism	Ecological Sustainability	Economical Sustainability	Social Sustainability
Community based tourism	• Awareness building • Regulation • Internalisation	• Reduce costs e.g. through training or public advertisement	• Ensure fair chances for all participants
State managed tourism	• Regulation • Awareness building	• Privatise certain services	• Investment and employment policies
Private enterprise - without conservation goals: ***elite tourism***	• Educate tourists and firms • Regulate internalisation of damage, tourists can easily pay for this	Possibly • taxes on imports to compensate foreign exchange losses + to stimulate demand for domestic products	• Redistributative taxes
Private enterprise - without conservation goals: ***mass tourism***	• Taxes on tourism to pay for necessary infrastructure • Work together closely with open minded tour operators • Awareness building	Possibly • taxes on imports to compensate foreign exchange losses + to stimulate demand for domestic products	• Work together with open minded tour operators, define rules of conduct
- with conservation as an explicit goal	No specific measures required	No specific measures required	• Rights of communities should be clearly defined

State management has similar problems, often with the added problem of corruption, lack of accountability and transparency. Through a careful design of employment policies, regulations, incentives, awareness building and contracting out of certain services to private enterprises sustainability can be improved in all three dimensions.

Mauritius, as presented in Vogt's paper in panel 1 can serve as an example for elite tourism. The fact that flight costs are kept high, services are expensive but excellent, reduces the number of tourists coming to Mauritius while keeping generated income high. Thus, this option should work quite well economically. By reducing the number of people involved the ecological impact can also be reduced considerably. The effect on the environment does, however, depend on the activities tourists engage in and high-paying tourists also have a high potential for destructive activities. A policy option with elite tourism is to internalise environmental costs, i.e. have hotels pay for the costs of sewage disposal, a policy successfully practiced for some time by the Egyptian Environmental Affairs Agency with the Sinai-based resorts (EEAA & EC, 1997[a]). These costs can easily be assumed by the tourists

[a] Egyptian Environmental Affairs Agency & European Commission, 1997. Environment conservation matched with tourism development: the Gulf of Aquaba Marine Protected Area. *EC Fish.Coop.Bull.*, 10(1):9-10

involved. Social impacts of this kind of tourism depend heavily on the kind of jobs generated, to which degree locals have the skill-mix and leverage to benefit from the development and on how much tourism affects local customs and culture. Through taxing tourism and investing this income in health and educational facilities or programmes for the poorer sectors of the population, the benefits of tourism can be spread more widely.

The situation is more complicated with mass tourism, as the contribution by Wolf (panel 1) shows. Margins are extremely low, competition is extremely high and the market is very volatile. Once a site becomes degraded or otherwise loses attractiveness, it is replaced by another. Policy choices are restrained and it might be worthwhile to carry out a complete economic evaluation of the project or activity up-front to assess whether it is worthwhile for the country and its population, particularly when taking environmental and social damage into account and calculating the costs and benefits of tourism with shadow prices[a].

Working together closely with open minded tour operators can help to identify the areas with the highest potential for sustainability even at lower costs. Setting minimal standards concerning environmental and social impacts through policy and enforcement also constitutes a potential for containing negative impacts.

The example presented in panel 1, the case of Chumbe Island (Riedmiller & Carter, this vol.) constitutes an interesting case of a private stakeholder whose primary interest lies in the conservation of the reef environment. The presented case has excellent results in all three dimensions of sustainability. Effective conservation is the primary goal with tourism installations (again in the variety of elite tourism) established to cover the cost of conservation, unlike most other cases in the tourism industry where the primary objective is the generation of income and conservation, if at all, is pursued to assure this income stream over time. To cover the high initial costs, the owner and other private conservationists invested voluntary work. Additionally, some donations for nature conservation were obtained. Park rangers ensuring enforcement are paid out of the proceeds of the tourism activities. The project has created employment for local people and enables school children to obtain first hand environmental education. All these measures are oriented towards conserving the reef ecology and underpinning the achievements through educational efforts aiming at the internalisation of the conservation concept.

This kind of effort is an alternative, which is gaining importance as a conservation strategy. There are increasing numbers of NGOs and private nature enthusiasts becoming involved in private conservation by buying areas of interest to nature conservation. As in the Chumbe Island case, they too often have to rely on funds generated within the conservation activity, and tourism is an important option for this. The incentive to manage these projects economically increases with the percentage of own funds invested and they should fare very well on the economic and environmental dimensions. Scepticism is, however, often justified concerning the social dimension. The designation of private areas to conservation can be used to drive poor coastal people out of their traditional livelihoods. An important policy option to help mitigate social effects is to assure the use rights of the local population and invest in human and institutional capital opening avenues for value added products and services with higher knowledge content and concomitant reduced dependence on direct resource consumption.

The general economic frame conditions for tourism development are especially important to attract private investment. The contribution on the Chumbe Island case in panel 3 (Riedmiller

[a] The concept of shadow prices takes into account the value for the society at large not for the individual economic agent. It thereby reflects the scarcities of resources at the national level.

& Carter, this vol.) illustrates how difficult this kind of investment can be. Therefore an important potential for policy concerns facilitating private involvement in conservation as well as in economic or social development. Setting framework conditions to create incentives for private investments therefore constitutes a key area for policies to enhance sustainable development. To achieve this goal it is, however, necessary to identify - and ideally value - the potential impacts on all three dimensions of sustainable development carefully before policies providing economic incentives like temporary tax reductions and public investment to enhance tourism development are designed and put in place.

Creating alternative income opportunities

The option of providing alternative income opportunities to the coastal population requires an understanding of rural livelihoods, local opportunities and expectations and a thorough investigation with respect to all three dimensions of sustainability. One possibility for funding alternative income generation consists in creating programmes for compensating the lost access to fishing ground through MPA establishment, particularly during initial periods. Education plays a key role in this context. By investing in human capital the options of the individuals to obtain better income earning opportunities not directly dependent on natural resource exploitation increase. Such improvements consequently also enhance the potential for regional economic development.

Policy options to improve the institutional set-up for coastal management

Policies are implemented in a specific institutional context where different organisations hold rights and responsibilities and pursue their respective objectives. Often the institutional set-up itself prevents steps towards enhancing more sustainable uses of coastal resources. Policy options discussed during the workshop included:

- Environmental impact assessment (EIA) was identified as a potential starting point for improving the sustainability of any project. Such approaches are now commercially and competitively available at least for larger scale operations and do not necessarily require massive scientific research co-operation.
- Another option is to include marine resources, their ecosystems and societal functionalities much more explicitly in development plans and agendas at all levels (from local to international).
- An important potential for cost-effective improvements lies with the better co-ordination of efforts between institutions. This applies to the different types of institutions concerned with coastal resource management, as well as co-ordinating efforts for creating socio-economic opportunities through knowledge and investment at the different levels (local, regional, national and international). Such efforts must take into account the specific dynamics resource management has at these different levels. This may, among others, refer to the priorities, the ways decisions are made, the possibilities for implementation and for ensuring compliance.
- Interactions between the different levels and different thematic foci also have to be taken into account. Where need arises, a forum including all relevant organisations may be formed to discuss conflicts between different institutions as well as different user groups. The examples from Mozambique (panels 1 and 4) and the Philippines (panel 3) presented in the workshop serve to illustrate these points. Uruguay has also made some interesting experiences with such a committee (compare www.csiwisepractices.org).
- The potentials of international collaboration could be enhanced by linking coral reef conservation efforts more strongly to international conventions like the Convention on Biological Diversity; the aid mechanisms contemplated there can be used (i.e. UNEP's -

Global Environmental Faciliy (GEF) or the International Coral Reef Initiative, ICRI). Co-operation with actors from outside may also be beneficial in broadening the conceptual framework, bringing new ideas and experiences from elsewhere and essential skills and knowledge not available within the local or national institutions. This is particularly relevant in relation to essential scientific knowledge, which is usually most cost-effectively built-up through international S&T co-operation, as demonstrated by the successive programmes operated by the European Commission (from Science and Technology for Development (STD) – to International S&T Cooperation (INCO) programmes).

- The empowerment of local coastal communities and their involvement and knowledge in the decision making process were identified as another important potential to enable sustainable use (compare discussion second session panel 1 and Working group 2). It was considered crucial to develop mechanisms that ensure that the needs of local people are taken into account when policy is designed (at all levels involved). Participation of stakeholders (as well as participatory research with extended peer review) constitutes an important operating mode in this respect.
- Regional co-ordination and co-operation, particularly in relation to capacity building, knowledge creation, sharing and learning and promoting environmentally and socially responsible investment, especially with regard to MPAs, are key mechanisms to chart sustainable futures for coral reef ecosystems (compare Younis; Wells; and Llewellyn *et al*., all panel 4). They are particularly relevant, where they can simultaneously draw on different policies (e.g. development and S&T co-operation, environment as well as knowledge policies) and allow for synergistic use of their respective instruments (see e.g. Nauen, in press[a]). Examples would be international scientific co-operation in combination with development funding (as was the case for this workshop and which is encouraged and increasingly practised in the context of European international scientific co-operation in different bi-regional and thematic contexts in Latin America and the Caribbean, Africa, Asia and the Mediterranean, Nauen, pers.comm.). The concept of the European Research Area open to the world should in this context be promoted at a much larger scale.

5. Policy related research needs

Three main issues concerning research needs were intensily discussed throughout the workshop: the type of information policy makers need, the contribution of social sciences and how research can contribute to a better implementation of policies.

Information requirements

First of all, policy requires information to underpin as broad a cognitive basis for the development of policy options as possible. Nevertheless, information alone is never a sufficient condition to bring about change. The political and economic margin for manoeuvre needs to be there or to be created before effective policy change can be brought about.

With respect to coral reefs and associated ecosystems, it is important to provide a sound scientific foundation for conservation and to demonstrate options (or the loss thereof), which

[a] Nauen, C.E., in press. How can collaborative research be more useful to fisheries management in developing countries? Chapter 25, in McGlade, J.M., Cury, P., Koranteng, K. & N. Hardman-Mountford (eds.), 2002. The Gulf of Guinea Large Marine Ecosystem. Environmental forcing and sustainable development of marine resources. Amsterdam, Elsevier. Large Marine Ecosystem Series, Vol. 1

can be examined by economic and political decision makers. The economic value of reef conservation vs. reef destruction can be converted into a powerful argument in the political discourse if reliable numbers are available (compare Hassan, panel 1). The impact on fisheries, not only the immediate impact in one location, but medium and long-term effects on the different reef, mangrove and sea grass bed related fisheries is of special interest due to the increasing population depending on these resources. The impact of different gears, not only on the fisheries, but also on the income of the different groups of fishers involved, is one of the fields identified, where natural and social scientists should jointly do research. By providing information and insights not only on the environmental aspects of marine resources but also on economic and social issues scientific information could become much more immediately relevant for policy makers. Research design could also be improved by including the generation of impact as one of the objectives, beyond the "addition to the body of knowledge" on a research object. This would also facilitate monitoring. (compare panel 1 and discussions of panel 1 first session and panel 4).

Social sciences' contribution

Social sciences can make an important contribution in their core area, the *understanding of the social conditions*. It is within these conditions that resource use and conservation take place. This includes issues such as: the determinants of rural livelihood systems, understanding strategies of risk and uncertainty management, identifying potentials for the improvement of rural livelihoods without destroying traditional systems of social security and/or the natural resource base.

A second crucial area is *understanding institutional change*. This, of course, implies an understanding of what institutions are currently functioning and their perceived legitimacy. Are traditional rules of resource management applied at the community level, even if they lack a formal legal backing? Are there institutions with the authority to design rules and/or enforce compliance? Where do the limits of this authority lie, which would imply a delegation of enforcement to other institutions possibly with different bases of legitimacy? Who bears the costs and reaps the benefits? What are obstacles to building trust between governments, coastal communities, entrepreneurs and other actors and how can these obstacles be overcome? Wittmer & Birner (panel 3) give an overview of possible research contributions (also compare Kamara as well as King, panel 3, Malleret King, panel 1).

The workshop highlighted several specific areas where research is needed concerning institutional co-ordination especially on a multinational level. Examples include analytical tools, design principles, the analysis of management arrangements and of processes of stakeholder involvement. (Compare the results of panel 4 and working groups 2 & 3).

Research Contributions to Improving Policy Implementation

A policy is only as good as its implementation. As with most environmental problems reef degradation is difficult to perceive and this makes it difficult to understand and to address. Policy formulation and implementation can be facilitated through easily manageable indicators. Research can contribute by improving methods for monitoring and evaluating impact in two respects: (i) making methods simpler and thus more cost-effective, and (ii) providing indicators more relevant to new policy formulation. In order to achieve this, researchers from social and natural sciences will have to work together closely with one another as well as with policymakers, implementing organisations and other relevant actors. Some examples mentioned during the workshop are indicators for identifying stress on corals (Schroeder & Mueller, panel 2) the impacts of tourism on reefs (Ammar, panel 2 and Piskurek, panel 1), environmental impact assessment and the monitoring and evaluation of the impacts of MPAs.

The methodologies required should be easy and cheap but sufficiently accurate and robust. Developing data-poor management methods can make important contributions in this respect, especially when supported by participatory research involving the local stakeholders in the reef monitoring process[a]. This challenge would probably best be addressed through a two pronged approach:

a) Promoting the structuring of all basic biodiversity, ecological and environmental knowledge in publicly accessible databases, as already at least partially underway thanks to a series of thematic, regional, or global initiatives, such as ReefBase and FishBase (www.fishbase.org), the Global Taxonomic Initiative and Species2000. These efforts can significantly assist scientists, teachers and managers in countries with a weak S&T infrastructure to access knowledge (see e.g. Feoli and Nauen, 2001[b]), enrich it with their own and participate actively in the emerging global knowledge society, thus increasing the innovation potential of their countries.

b) Developing management methods, which can be legitimately and cost-effectively implemented under the prevailing historical and socio-economic conditions. This implies that they must be sufficiently accurate and robust. Thus, they cannot be dependent exclusively or predominantly on the same extremely data-hungry modelling approaches developed in industrialised temperate countries, except perhaps where much of the data-acquisition can be done cheaply through remote sensing and similar approaches. However, this does not apply for socio-economic information and knowledge, which must underpin any successful management approach. Basing such methods on a combination of scientific principles, which could be supported by the knowledge accumulated under a), but contextualised and deepened by participatory research involving the local stakeholders in the reef monitoring process is likely to fulfil the two key conditions. This also offers a valuable avenue to capture historical trends and go back sufficiently in time to compare present situations with past ones, thus setting an appropriate reference framework (see e.g. Pauly, 2001[c]).

A considerable experience with participatory techniques has been accumulated world-wide and with it a growing sensitivity on where the limits of participatory techniques lie. This is particularly relevant in situations where different groups of stakeholders have uneven command of power. For policy to be able to address such issues, knowledge on mediation as well as the design of property rights can make a significant difference. The same holds for the creation of incentives to improve the situation of groups with little power to make themselves heard in society. Even if current policy makers might not be interested in such changes, NGOs or donors may exercise influence in their more limited range of action. There are many historical examples showing that wealth, opportunities, and power relations within and between societies change over time, drivers being e.g. internal or external pressures and technological change (compare panel 3).

A crucial role for interdisciplinary (natural and social science) research was identified concerning the follow-up of policy implementation. The Philippines constitute a prime example

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[a] The underlying definition of 'data-poor' here is in terms of formal scientific data, while the participatory research mobilises a depth of knowledge few researchers can boast in local situations.

[b] Feoli, E. and C.E. Nauen (eds.), 2001. Proceedings of the INCO-DEV International Workshop on Information Systems for Policy and Technical Support in Fisheries and Aquaculture, Los Baños, Philippines, 5-7 June 2000. Brussels, *ACP-EU Fish.Res.Rep*., (8):135 p.

[c] Pauly, D., 2001. Importance of the historical dimension in policy and management of natural resource systems. pp. 5-10 In Feoli, E. and C.E. Nauen (eds.), 2001 Proceedings of the INCO-DEV International Workshop on Information Systems for Policy and Technical Support in Fisheries and Aquaculture, Los Baños, Philippines, 5-7 June 2000. Brussels, *ACP-EU Fish.Res.Rep*., (8): 5-10.

for this. In the Philippines, the institutional set-up constitutes a good precondition for the information flow between policy, research and implementation, and the country has accumulated many valuable experiences with different policy measures over the past decades (compare Zaragoza *et al*., and Hermes, panel 3). Interestingly, the presenters formulated a need for more follow-up research on the impressive number of experiences that have been made in recent years in order to make it available for the further policy formulation process. Such research could not only allow fine-tuning in the policy formulation in the Philippines, but also serve as highly relevant information for other countries' policy processes (compare panel 3).

The principles and approaches sketched out above, taken together could significantly increase the probability of designing relevant policies for sustainable use while taking into account the specific conditions in each country and locality, but also the international drivers in a globalising world. Thus, strategies could be designed to be more realistically implementable even if from an environmental point of view certain trade-offs might have to be made.

Research for the Transition towards Sustainable Use of Coral Reefs and Associated Ecosystems – Integrating Scales from Local to Global

The discussion concentrated on factors in the direct vicinity of the reefs, the human impact through fisheries and tourism. Important upstream factors for the degradation of reefs and associated ecosystems such as siltation through erosion, pollution through sewage disposal, and the consequences of rapid urban development as well as the recent massive coral bleaching event of 1998 have not been discussed extensively during the workshop. It is however, important to take these factors into account, in order to improve our understanding of the system's functionality and, if relevant, support lobby work for policies to reduce their negative impacts on reefs. Economically speaking, all of the above-mentioned constitute so-called externalities, costs (or benefits[a]) originating from an economic activity, which are borne not by those who originate them, but by others or the society in general. It can be argued that making the value of reefs, especially their income earning potential, more visible will also increase the possibilities to implement policies to protect reefs by internalising the above mentioned externalities. Concepts of integrating efforts at larger than national scales were presented and discussed in Panel 4 and Working group 3.

The workshop concluded that the use of most coral reefs has to be regulated in order to become sustainable, particularly in the face of Global Change. Pertinent questions refer to the institutional set-up, the policy design and instruments used, the level of decision making, the timing and finally the methods of implementing such regulations in order to maximise social return over time. These questions are resolved in each society depending on the political frame conditions, the distribution of power within society as well as on the moral and cultural values. Each society thereby has different preferences, which themselves evolve over time with internal changes within society as well as through external inputs like international initiatives and agreements. The question of how preferences are determined and the question of who decides on priorities in each society constitute the framework within which policies operate. This framework also determines how and to which extent research results feed into policies. Analysing and better understanding these political processes remains an important challenge for (social science) research but with the hope to thereby improve its own impact on policy formulation for sustainable development.

[a] Compare Arthurton (panel 2) for some costs and benefits of upstream factors to reefs and coastline protection.

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Thanks to Cornelia Nauen, Regina Birner, Helge Vogt, Rudi Hermes, Lothar Schillak and Anthony King for kindly reading and commenting on this manuscript and to all workshop participants for their interesting contributions.

Panel I: Economic Valuation of Coral Reefs: Implications for Sustainable Use

In recent years economic valuation of biological resources has gained increasing importance in the policy formation process. Economic valuation is a powerful tool that helps to identify the level of protection, which is most adequate from a macro-economic point of view, thus assisting in the formulation of rational conservation policies. Moreover, the results of economic valuation studies are of considerable strategic use in the policy making process because they provide convincing economic arguments which justify protection goals as compared to exploitation goals.

Panel 1 explores the potentials and constraints of applying economic valuation to coral reef resources in three sections: The first section shows how the economic value of coral reefs can be assessed. The other two sections elaborate on two of the most important uses of coral reefs and coastal ecosystems: fisheries and tourism.

By way of introduction, the first section starts with an overview of the methods applied in economic valuation, to allow coral reef experts without economic background to get familiar with this instrument. The following contribution exemplifies the application of economic valuation methods to marine resources, taking Mauritius as an example. The third presentation shows how the benefits of exploitative uses of coral reefs can be economically assessed. This presentation uses trade with aquarium fish and corals in Mozambique as an example and takes the distribution of benefits among different stakeholders into account.

The first contribution of the second section shows how to obtain marine biological data, which are required as input for the application of economic valuation techniques. The contribution compares the effects of two different conservation measures on the evolution of fish stocks. The second presentation shows how socio-economic consequences of marine conservation efforts can be assessed by focusing on the availability of fish for consumption in rural households. The third presentation illustrates the complex causal relationships responsible for the use of destructive fishing methods.

Focusing on the fast growing tourism industry the third section discusses how the inherent economic value of coral reefs can be turned into an income source and, at the same time, create incentives for protection. The first two papers deal with a small-scale and a large-scale tourism enterprise, respectively. The first presentation analyses how a privately managed and sustained marine protected area can create potentials for small-scale eco-tourism and the second elaborates on the potentials of mass tourism. The last contribution analyses the ecological consciousness of dive tourists and the local population in a recently developing dive site in Indonesia. These contributions will help to identify the conditions under which tourism can enhance conservation of coral reefs and associated ecosystems.

The Economic Importance of Coral Reefs: Methodological Issues[a]

By: Zien-Elabdin Hassan[b]

Introduction

This paper, using clear and non-mathematical language, is aimed, beside economists, at marine biologists, environmental activists and decision-makers working or involved in the field of coral reefs and associated coastal ecosystems.

The richness and diversity of coral reefs defy the imagination. They harbour some of the most biologically diverse and productive systems on earth. By conservative estimates, coral reefs are home to hundreds of thousands of species of plants and animals, less than one tenth of which have been discovered or described. Coral Reefs are live support systems for millions of people who derive their livelihoods from them, benefiting from the multiple services that reefs provide. Reefs are a crucial source of food to coastal populations. There are millions of poor fishers whose livelihood depends on coral reefs. In addition, they provide a wide range of non-food products:

- the use of shells for decoration;
- coral blocks as building materials, which have long been used in houses construction;
- both, coral skeletons and shells can be burnt to make lime;
- aquarium fish, and coral trade;
- ecologically important in wave surge protection, and as food chain;
- tourism and recreation, and human inspiration;
- pharmaceuticals and cosmetics from marine organisms.

Also, this richness in biodiversity has a wider interest for students of evolution and lovers of wildlife. Of more direct and immediate interest to human economies is the role of marine organisms in reefs in the life cycle of fish, the potential value of sea plants and creatures as medicines, and in assimilating waste products.

These are only but examples of the different uses and benefits human beings derive from coral reefs and associated coastal ecosystems. Nevertheless, from the economic point of view coral reefs are one of the most undervalued and least protected ecosystems in the world. A major cause for this state of affairs is that people tend to place values on what they can easily identify or see. In the case of coral reefs, a huge potential of unexplored values and services exists that we don't know about yet or only barely understand. Lost environmental functions of damaged reefs cannot easily be replaced. Raw sewage, industrial waste, and agro-chemicals routinely foul the world's coastal waters, and the costs are borne by fishermen, aquaculturists, swimmers and tourism operators. Sea creatures also suffer. Reefs and beaches

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[a] Paper presented at the EU-Workshop: Policy Options for the sustainable Use of Coral Reefs and Associated coastal Ecosystems; Mombasa, Kenya June 19th – 22nd, 2000

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are lost as a result of dynamiting, pollution, and the excavation of sand for construction purposes.

The market cannot give proper weight to environmental considerations unless the costs of environmental damage or the benefits of environmental improvements are built into the prices charged for goods ad services. Who pays, and who benefits? We need to internalise the environmental and social costs to society of destructive actions that benefit only a few. By doing so, we can create the price signals that will move people in the right direction.

Measures of economic value:

Cost Benefit Analysis (CBA) and Cost Effectiveness Analysis (CEA):

The most common methods of project appraisal are Cost-Benefit and Cost-Effectiveness Analyses. CBA and CEA are used to assess the impacts of projects on the environment. For example, the damage to reef from heavy nutrient loading suggests that the costs of treatment or land-disposal of sewage needs to be weighed against the lost of coral reefs in developing coastal towns and cities.

CBA is used where benefits can be valued, and CEA where the exercise is one of selecting the second best (i.e. lower-cost) alternative. If properly applied, CBA can combine rigour with comprehensiveness in a way that few other techniques can match. The need to balance the cost of an action against its benefits is intuitively appealing, and provides an important discipline with which to approach decisions. CEA comes into its own where benefits cannot be measured. It is applicable in such circumstances as the analysis of reef management and protection. The costs of implementation, operation and maintenance are evaluated against the physical change in the reef ecosystem being managed.

However, application of standard cost-benefit techniques to value Coral Reefs (CRs) has overlooked many of the indirect uses and non-market goods and services provided by CRs, and hence revealed only partial values of the reef resources.

Total Economic Value (TEV)

Is the most appropriate theoretical construct to have a full accounting of the costs and benefits associated with existence and utilisation of the coral reef systems. To operationalise this concept we need to look at a range of contexts to determine the TEV of coral reefs. The first distinction we can make about the value of CRs is whether it has use value or non-use value. Use values are derived from the actual use of the environmental resource - its inherent extrinsic values - while non-use vales are more related to the intrinsic value of the environment. Certain things do have an absolute value that makes them essentially non-quantifiable - life itself, beauty, the diversity of species etc.

Use value can be subdivided into direct and indirect use values, with direct use values further subdivided into consumptive and non-consumptive, in the case of CRs see Fig. 1. The revenue delivered directly into the economy can measure direct use values. In this case, it comes down to the revenue generated by the supply of goods or services from the CRs. Indirect Use Values are a bit more obscure and uncertain to quantify but it essentially refers to the utility that healthy CRs supply. Estimates have been made for some of these values.

Non-use Value is divided into Existence Value, which is purely concerned with the intrinsic values of CRs, and Bequest Value that is the willingness to pay to preserve CRs for the benefit of future generations - it is a potential Use Value for people not yet born. But Bequest Value is also about preserving for the benefit of nature, e.g. retaining biodiversity for habitat preservation and the protection of species in the long term.

A third type of values of CRs is optional value. Optional Value is essentially expressions of preference (willingness to pay) for the conservation of CRs systems on the assumption that an individual will make use of them sometime in the future.

So, TEV of CRs is made up of Use Value (Direct and Indirect), Non-use Value (Existence Value and Bequest Value), and Option Value - in other words:

TEV = UV + EV + BV + OV

Approaches to Valuation

We can talk about two basic approaches to valuation; there are those valuing CRs using a demand curve, and those that do not. I want to quickly review both of them.

Demand curve approaches to valuation of CRs:

These are basically two methods - expressed or stated preference methods (this uses direct survey methods, such as questionnaires, to gather the data) and revealed preference methods (which tap into secondary data sources by examining the way people actually spend their money).

Within the revealed preference methods we can talk about two methods - the travel cost method and the hedonic pricing method. The contingent valuation method is an expressed method.

Travel Cost Method (TCM)

This method is most commonly used in determining the value of recreational sites. It has one underlying assumption - that the incurred costs of visiting a site reflect the recreational value of that site. Income is important, as are any alternative sites that may be available to visitors. Questionnaires are used to ask visitors about why they visit the site, where they've come from, their personal circumstances etc.

Hedonic Pricing Method (HPM)

The HPM tends to be used to evaluate environmental costs rather than benefits. It is most commonly applied to the property market - principally the housing market. Housing prices are affected by a whole range of factors including the size of the house, access to services etc. And, of course, there are environmental factors such as view, aspect, negative externalities etc. We could write an expression for this:

House Price = f (rooms, access, environment)

So we can see from the logic of this expression that if we can control the influence of non-environmental factors then any remaining difference in house prices must be related to the local environment quality.

The existence of a well functioning international market for small, isolated islands gives the possibility to apply this method for valuing indirect uses of CRs e.g. storm surge protection, beside that of valuing environmentally the location of coastal towns or neighbourhoods according to the vicinity to a reef.

TCM and HPM are indirect market methods. The direct questioning method asks households their Willingness-To-Pay (**WTP**) or willingness-to-accept (**WTC**) compensation, and that is the:

Contingent Valuation Method (CVM):

CVM is an 'expressed preference' method so it doesn't have to rely upon individual valuations of environmental goods as revealed by purchases in the market like TCM.

Economists have a distinct definition of value based on the ideals of rationality and consumer sovereignty - an individual consistently knows what he or she wants and needs (rationality) and is best able to make choices that affect his or her own welfare (consumer sovereignty) - if the individual prefers improved coral reef quality to a new truck, rationality requires her to consistently rank coral reef quality over the truck. Based on this foundation of rational choice, individuals are assumed to be able to value changes in environmental services despite their absence from the market. If a change occurs such that the person believes she is better off in some way, she may be willing to pay money to secure this improvement. This Willingness-To-Pay (WTP) reflects her economic valuation of improved environmental services.

Practically, we can formulate the questions in a survey design as the following:

"You are a tourist or diver who comes to this place to enjoy coral reefs, but dynamite fishing is degrading the site; what are you willing to pay so that we can enforce laws against the ill practices and set up a small project for other income generation sources for the poor fishers who depend largely on this bad fishing practices?"

One of the very useful applications of CVM is that it can also be used to determine the value of an environmental resource that may be quite remote from the respondents.

The non-demand curve approach to valuation includes techniques like:

Replacement Cost Technique (RCT)

This technique considers the cost of replacing or restoring a damaged environmental asset and uses this cost as a measure of the benefit of restoration. A good example is the transplantation of corals to reefs damaged by ships, e.g. the work of the University of Essen, Germany in the Red Sea, Egypt (compare also Schillak panel 2). This also will allow valuing the reef ecosystem in general, that in connection with other approaches like Opportunity Costs. Other methods under this approach are, Dose-Response Analysis and Mitigation Behaviour, which all can be used to value CRs ecosystems.

The non-demand curve methods are heuristic in nature, i.e. they don't attempt to represent 'true' valuations, rather they act more as a guide to decision-makers. They are commonly used to inform policy makers and so are often employed by government agencies and departments.

Socio-economic Surveys (SES):

The different techniques of socio-economics (surveys, case studies, RRA and PRA etc.) are indispensable in valuing the economic importance of CRs to local coastal communities, countries and even regions. Obtaining this economic importance will lead to more environmental awareness about CRs, and to incorporating conservation and sustainable uses of these resources in the planning and decision-making processes.

Examples and Concluding Remarks

Using different valuation methods and techniques, the following figures and statistics shed light on some of the aspects of the economic importance of CRs.

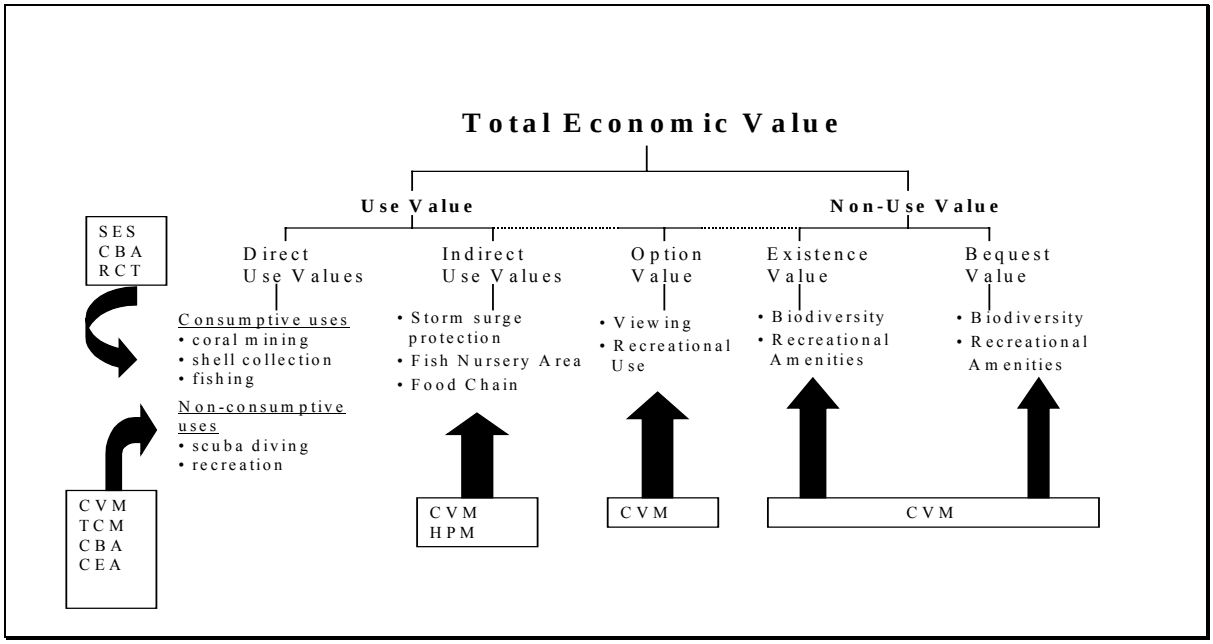
- Costanza et al. (1997, cited in World Bank, 1998), have estimated the global value of coral reefs by taking a per hectare estimate of various use values at approximately $6,075 and multiplying it by the global area of coral reefs, 62 million hectares. The result was a very large estimate of the economic value of the world's coral reefs - a total of $375 billion p.a.
- The coral reef fish catch potential is estimated to be 12% of the world's total. Coral reefs provide up to 25% (Serageldin, cited in World Bank, 1998) of all the fisheries harvested in

developing countries. Thus, coral reefs are not an insignificant aspect of the livelihoods and social welfare of communities.

- In Indonesia, the private benefits to individuals involved in destructive practices are often considerable. However, the costs to society are much larger, up to a factor of 50 times higher in the case of blast fishing in tourist areas (Cesar, cited in World Bank, 1998).

The total sum of the economic benefits derived from coral reefs provides a measure of the total economic contribution of particular reef systems. It is essential, therefore, to include in our valuation as much as we can estimate from the different uses of the CRs ecosystems, e.g. tourism, production data for fisheries, coral mining and trade, and environmental benefits such as biodiversity, etc. This is essential, because in order to defend reefs economically, the marginal costs of reducing stress on reefs must be less than the marginal benefits associated with so doing. Calculating the economic costs of, e.g. treating sewage, not fishing, or not building is fairly straightforward, and has been used for years to support change in policies that are detrimental to reefs. More recently, economic analysis of the benefits associated with maintaining or improving the health of reefs have made important strides. In other words, the economic information contained in a Total Economic Value calculation can be very powerful in making the case to decision-makers and others responsible for allocating financial resources that the benefits of protecting and managing coral reefs in a sustainable manner are substantial.

Figure 1. The Concept of Total Economic Value of Coral Reef Ecosystems and the Available Methods and Techniques for Valuing



Source: TEV Concept from Dixon (World Bank,1998: 158); Economic Valuing Methods and Techniques, Own Presentation.

CBA (cost/benefit analysis); CEA (cost-effectiveness analysis); CVM (contingent valuation method); HPM (hedonic pricing method); RCT (replacement cost method); SES (socio-economic surveys); TCM (travel cost method).

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The Quantifiable Economic Value of Coral Reefs in Mauritius[a]

By: Helge Peter Vogt[b]

Abstract

Coral reefs are a valuable natural resource and an important source of revenue in particular for small island nations. In Mauritius, the reefs and the extensive lagoons of the various islands provide fishing grounds that form the livelihood of many fishermen. Tourists enjoy the beauty of the reefs and international tourism has become a major part of the country's economy. This article summarises the main economic values of coral reefs in Mauritius, and quantifies the benefits in monetary terms wherever possible. The major reef fishing grounds surround the islands of Mauritius (300 km^2), Rodrigues (240 km^2), Cargados Carajos (190 km^2), Agalega and smaller islands. In 1997, about 2,400 artisanal fishermen from the main island of Mauritius contributed 1,246 t or about 10 % of the total fish catches in Mauritius. The financial value of these catches was estimated at € 4.5 million. The overall economic importance of reef fishery on the main island is low compared to other sectors of the economy such as tourism or sugar cane production. However, in Rodrigues reef fishery constitutes a major part of the economy of the island and provides the livelihood of about 2,000 registered fishermen and their families, which account for roughly one third of the islands population. In Mauritius, international tourism has developed into a major economic force. In 2000, about 915,200 arrivals were registered in Mauritius and tourism generated € 605 million as gross receipts. Every year, approximately 50,000 tourists and Mauritians enjoy Scuba diving in the reefs which is estimated to earn Scuba dive tour operators about € 4,180,000/year. The total economic value of reef tourism is considerably higher if costs for travel, accommodation, food as well as other reef activities are included in the overall assessment.

Introduction

Coral reefs world-wide are facing severe threats partly caused by the rapid growth of the coastal populations which puts increasing pressure on the dwindling natural resources in the coastal zone. In many areas, this trend is accelerated by unsustainable fishing and harvest methods and the lack of successful management practices. In addition to this continuous tendency of widespread coral reef degradation, prolonged periods of coral bleaching killed corals and other benthic organisms in many areas of the world. In the Indian Ocean, reefs were most severely affected as coral mortalities reached 50-95 % in many locations (Souter et al. 2000). In many areas, extensive and co-ordinated survey efforts have succeeded to monitor reef health and to provide reefs status information on local, national and regional level. However, whilst these efforts made it possible to produce a global overview of the recent status of the coral reefs of the world (Wilkinson 2000), very little information is available on the economic value of coral reefs on national level and the economic losses caused by the recent reef degradation.

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[a] Paper presented at the EU-Workshop: Policy Options for the sustainable Use of Coral Reefs and Associated coastal Ecosystems; Mombasa, Kenya June 19th – 22nd, 2000

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In analogy to rapid reef surveys, this study may be regarded as a rapid economic reef survey that aims to quantify the economic benefits of reef use on a national level. For this purpose, the monetary value of reef fishery and reef tourism of Mauritius is quantified based on figures published by the relevant ministries in Mauritius and other organisations. This first assessment of the economic values of a nation's coral reefs may be used as a stepping-stone towards a regional and perhaps even global assessment of the total economic values of the world's coral reefs.

The Economic Value of Coral Reefs

The key sectors of Mauritius' economy include the textile and tourism industries as well as the sugar production. Although the nation's exclusive economic zone covers about 1.2 million square kilometres of the Indian Ocean, the value of fishing exports is limited (Fig.1). In Mauritius, white sandy beaches fringed by coral reefs form major a part of the country's tropical image which attracts an increasing number of international, long haul tourists. Coral reefs are also important for dive tour operators who sell trips to both inshore and offshore reefs, and conduct dive training near reefs. On some islands including Rodrigues artisanal reef fishery and related state subsidies form the most important source of income for a considerable number of fisher folk. In Mauritius, most of the coastline is fringed by shallow coral reefs that form natural barriers between the forces of the open ocean and the islands thus shielding coastal developments such as hotels from destruction by the sea.

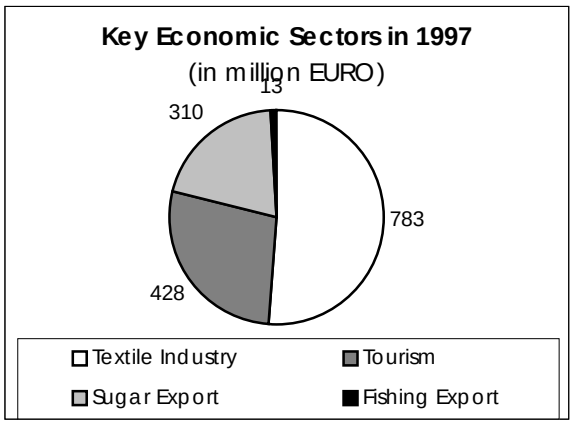

Figure 1: The key economic sectors of Mauritius (source: Ministry of Economic Development, Productivity and Regional Development, 1997)

Reef Related Tourism

In Mauritius, more than 1.2 million people live on islands covering a total area of only 1865 km^2. As a result, the population density of 643 people/km^2 is even higher than in most crowded European countries. As land available for tourism development is very limited, Mauritius established a tourism industry that targets the upper end of the market. The vast majority of holidaymakers have booked a highly priced, luxury vacation. A still increasing number of tourist are attracted by the tropical and exotic image of the island nation and as a result, tourism developed into a key sector of the countries economy, second only to the textile industry (Fig. 1). In the previous decade, the total receipts per stay have steadily increased. In 2000, a tourist on average spend only 10 days in Mauritius during which more than € 900 were spent in the country (Tab. 1). The vast majority of these expenses are not

used for reef related activities but cover the costs for meals, clothing, gifts, sightseeing trips, wedding related expenses and other activities.

Table 1. Tourism statistics covering the previous decade

Hotels and Tourism Statistics	1990	1998	1999	2000
Number of licensed hotels	75	90	92	95
Number of rooms	4,603	7,267	8,255	8,657
Number of bed places	9,572	14,995	16,947	17,776
Room occupancy rate (%)	62	72	71	70
Bed occupancy rate (%)	54	63	62	62
Arrivals ('000)	418.2	778.6	823.1	915.2
Tourist nights ('000)	3,565	5,568	5,800	6,500
Tourist receipts (million €)*	154	506	581	605
Average expend. per tourist (€)*	532	906	1,004	923

Converted from M. rupees to EURO at a rate of 23.51

Sources: Statistical publications by the Ministry of Tourism and Leisure and Ministry of Economic Development and Regional Co-operation (available also on http://ncb.intnet.mu/cso.htm and http://ncb.intnet.mu/medcr.htm)

One of the most economically important activities related to coral reefs in Mauritius involves SCUBA diving, which is primarily undertaken by tourists and only a few Mauritians. All divers who use commercial dive tour operators are obliged to register with the Mauritian SCUBA Divers Association (MSDA). For a nominal fee of approximately € 2 a registration document valid for 6 months is issued. This card is valid at all the registered MSDA dive centres and provides local insurance cover for divers and the Centres, particularly pertaining to access to the recompression chamber at Vacoas. In 2000, an estimated 50,000 divers were registered. The total amount of expenditure for all dives depends on the number of paid dives per diver as well as the average costs per dive. The following estimates are based on the assumption that most paying divers are tourists who spend on average 10 days in Mauritius. Divers are advised not to dive on the arrival and departure date. Thus during the remaining 8 days a diver may dive twice a day resulting in a total maximum number of 16 dives per tourist. However, Mauritius is not amongst the prime destinations for reef dives and it appears that divers enjoy other leisure activities as well, which may account for the low average number of 3 dives per registered diver. At a typical fee of € 27.2 per dive, a diver spends € 81.6 on his dive trips as well as an additional € 2 for his registration document, thus the total amount of direct dive costs generated by 50,000 registered divers is about € 4,180,000 per year. This is less than 1 % of the total gross receipts generated by tourism which accounts for € 605 million.

Reef Fishery

There is considerable fishing pressure in the lagoon of Mauritius thus incentives were proposed which led to a slight reduction of the number of fishing nets. In 1997, the numbers of active fishermen as well as fishing pirogues declined which led to a decrease of fishing effort by 370 t compared to the previous year. In 1997, the total fish catches by the 2,400 artisanal fishermen in the coastal waters of the main island was 1,246 t (Ministry of Agriculture, Fisheries and Co-operatives, 1999) which represents about 10 % of the total fish catches in Mauritius at an estimated value of € 4.5 million. In addition, this industry also provides work to 716 licensed fishmongers.

Artisanal fishermen can receive support by the state which provides various benefits including cheap loans, duty concessions, a non contributory insurance cover, scholarships to kins of fishermen and a compensation package for the voluntary surrender of a large net or a gill net licence (Ministry of Fisheries, 2001). Bad weather and closed season allowances worth a total of € 870,000 provide further sources of income to registered fishermen. These support measures do not add value to the country's economy and are only listed here to present a more complete picture on the income available for artisanal fishermen and to highlight the state's efforts to support and manage nearshore fisheries.

In comparison to fishery in the lagoon of Mauritius, fishing activities at the other islands are less well documented. The nation's second largest island, Rodrigues is located 560 km to the east of Mauritius. Although the island is only 18 km long and 8 km wide, it is surrounded by a large lagoon covering 200 km^2. Reef fishery is the most important source of income for 2,000 registered men and women who catch about 1,500 t of fish per year. Considering an average family size of 6 persons, reef fishery provides the livelihood of roughly one third of the islands 35,000 inhabitants.

The economic value of the aquarium fish trade is not quantified in this study; however, it appears to be of minor importance as only 8 permits were issued. There is no record for permits for shell collection in Mauritius, however, 60 permits for sale of imported shells were issued in 1997 (Ministry of Agriculture, Fisheries and Co-operatives, 1999).

Discussion

The direct economic benefits of reef dive tourism is less than 1 % of the total gross receipts generated by the nation's tourism industry. This may reflect that the majority of tourists travel to Mauritius to enjoy a beach holiday in a tropical, luxury seaside resort. Diving is only of many leisure activities, however, other marine activities such as wind surfing, canoeing, water skiing, snorkelling, boating and swimming are offered in the safety of the reef's extensive lagoon. One of the main attractions which Mauritius offers to the overseas tourists are the extensive, white beaches which were built over time by the nearby coral reefs. All these assets including the tropical image of Mauritius are dependent on coral reefs. These values are not quantifiable in economic terms. However, a Mauritius without sandy beaches, a 'user friendly' lagoon and attractive reefs would undoubtedly attract far fewer tourists. Thus the real economic importance of reefs for the tourism industry is far higher than the direct earnings of the dive industry.

In Mauritius and Rodrigues, more 4,400 registered artisanal fishermen are dependent on reef fishery and related subsidies. The total number of reef fishers in the country may be considerably higher as not all islands are included in the published surveys and not all fishermen and women are fully registered. The economic value of reef fishery is limited if compared to other sectors of the country's economy and on the main island there are only 2,400 artisanal fishermen out of a population of more than 1 million people. However, in Rodrigues, where there are no major industries and only few employment opportunities in the tourism reef fishing and gleaning remain a main source of income for a large parts of the island's population. There seem to be plans to promote alternative employment opportunities such as offshore fishing and an expansion of the tourism facilities. However, the reef fishery including the octopus fishery supported by state subsidies are likely to remain the key source of income for many Rodriguan families.

Coral reefs protect the Mauritian coastline from erosion and shield the considerable investments made in urban developments and hotel complexes from the forces of the surrounding ocean. In principle, the value of this protection function can be estimated by calculating the costs of man-made structures that could perform a similar function. However,

this would result in exceedingly high figures, which would not be affordable to any small island nation, and thus there is no affordable alternative to healthy coral reefs in Mauritius.

In Mauritius, there seems to be an increasing awareness on the long-term benefits of healthy coral reefs. In Blue Bay, plans to build a luxury hotel in close proximity to a nearshore reef of outstanding beauty had to be abandoned. Intense pressure from concerned groups within the country managed to gain sufficient political support to protect the reefs thus giving preference to environmental concerns over commercial investments. Further signs, such as the discontinued sand dredging within the lagoon and financial incentives for the further education of fishermen's kin may indicate a growing will to utilise reefs in a sustainable way. To this end, this paper hopes to contribute a summary of current reef values and use pattern that may be found useful in the ongoing efforts to protect Mauritius' coral reefs.

Acknowledgements

This study was made possible by the generous support of the Shoals of Capricorn Programme, a project of the Royal Geographical Society. I am particularly grateful for the friendly assistance by Mr Ian Watt and Mrs Juliet Burnett. It is also not possible to overestimate the great contributions of the Shoals' staff in Mauritius and Rodrigues who made both my field trips very enjoyable.

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Ornamental Fish and Coral Trade in Mozambique[a]

By: Helena Motta [b]

Introduction

Mozambique is situated on the eastern coast of Southern Africa, between (10°27´ S and 26°52´ S latitude and 30°12´ E and 40°51´ E longitude). The Mozambican coastline, about 2,770 Km long, is the third longest in Africa and is characterised by wide diversity of habitats including sandy beaches, sand dunes, coral reefs, estuarine systems, bays, mangroves and seagrass beds.

The current population of Mozambique is estimated at more than 16.1 million, and expected to grow at an annual average rate of 2.7% (INE, 2000)[c]. A significant percentage of this population, about 42%, lives in the coastal zone and depends on the resources available in this area. Further, with the export of valuable fishery products and a growing industry of coastal tourism, the economy of the country depends largely on the marine and coastal resources.

Between 1985-1997 Mozambique was in the top 10 exporting nations for marine invertebrates in the world, an estimated 1% of the world's total trade. According to CITES (Convention on International Trade of Endangered Species) annual data for 1997, Mozambique exported 35% (by piece) of the world coral skeletons. Despite the scale of the trade, the economic benefits for Mozambique were limited and in no way reflected the importance of the natural resources being exploited. As for the ornamental (aquarium) fish, there have already been reports from local fishermen and tourist operators that the effects of the harvesting activities were having major detrimental effects on the coral reefs of the area. Both corals and ornamental fish were banned from being exported in February 1999, when the Ministry of Agriculture and Fisheries published a nationwide directive ordering an immediate two-year moratorium on their trade.

This paper describes the trade on coral and ornamental fish prior to the banning and the efforts in Mozambique to establish an institutional and legal framework for the management of coral reefs and associated ecosystems.

The Coral Trade in Mozambique

Mozambique used to be an important exporter of coral skeletons. The coral trade was completely banned in February 1999, at least until February 2001. The two-year moratorium was intended to allow some time for studies and establishment of guidelines for future trade. Although no more new licenses are being issued since then, there is certainly still some illegal activity of collecting, processing and exporting corals.

In Mozambique, the coral trade has long had destructive effects on the coral reefs. Most of the private companies involved in this business were operating in the northern part of the country.

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[a] Paper presented at the EU-Workshop: Policy Options for the sustainable Use of Coral Reefs and Associated coastal Ecosystems; Mombasa, Kenya June 19th – 22nd, 2000

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[c] According to the 1997 Census, www.ine.gov.mz

Until very recently, licenses were granted to different private companies but no effective control was undertaken. This can be seen in several CITES bulletins were "Pocilopora Cauliflower", a mighty coral, is given the common name of "shell". Both the identification names and common names are misleading information. This is especially problematic since the staff at the National Directorate for Forestry and Wildlife (DNFFB) is not familiar with coral identification. Furthermore, the relatively large amount of coral being exported – shown in a CITES permit issued in 1997 for 20,000 "units" of *Pocillopora* and *Tubipora* – should represent only the "tip of the iceberg" of what has been collected and selected. As no data on skeleton yields is yet available, it is only possible to speculate how much live and wet coral has been destroyed.

The same should apply when one asks how much corals have been traded before the moratorium. Data available is quite unreliable, as most of it is based on the exporter information when requesting a CITES permit. Table 1 shows the amount of coral exported in the period between 1994 and 1997, according to CITES permits copies available in DNFFB headquarters (Rodrigues & Motta, forthcoming).

Table 1. Quantities (kg) and units of corals exported from Mozambique between 1994 and 1997.

Species	1994		1995		1996		1997	
	Units	Quantities (kg)	Units	Quantities (kg)	Units	Quantities (kg)	Units	Quantities (kg)
Acropora sp. (elkhorn)		30,000						
Acropora sp. (finger)		30,000						
Acropora cervicornis			70,000	40,000		25,000		
Acropora sp.				12,527			1	
Acropora variavilis						5,000	41,000	
Pocillopora sp.			110,000	40		105,000	86,000	
Fungia sp.			20,000					
Lobophyllia sp.			10,000	3,867				
Seriatopora sp.				287				
Stylophora sp.				717				
Tubipora musica			300	3,650				
Total	0	60,000	210,300	61,088	0	135,000	127,001	0

(Source: Rodrigues & Motta, in press, from DNFFB data, 1998)

According to this table, the quantities were considerable and the preferred coral genera included *Acropora, Pocillopora, Seriatopora, Lobophyllia* and *Tubipora.* Corals were exported to several countries including Portugal, Italy, Spain, United States of America and Germany. According to a report from the *International Working Group* (trade sub-group) in a report to the U.S. Coral Reef Task Force, between 1985-1997 Mozambique was in the top 10 exporting nations for marine invertebrates in the world. The majority of these organisms were destined for retail sale in Portugal. According to CITES annual data for 1997, Mozambique exported 35% (by piece) of the world coral skeleton.

It is estimated that Mozambique exported around USD 5 million worth in coral between 1994 and 1997 altogether. Estimates point to an average gain to the collector of less than 1.5 %, i.e., USD 75,000 was the benefit for the fishermen during the same period (Green & Shirley, 1999). Information from the Ministry in charge of regulating the export market in Mozambique (the Ministry of Industry and Commerce) shows that the country gets less than 20% of the prices in the international market (Rodrigues & Motta, forthcoming).

Apart from the coral destruction with nil or little advantage to local fishermen and the country's economy, natural hazards pose an extra stress on the ecosystem. After the ENSO events 1997-1998, a survey on coral bleaching was undertaken in 1999. The study showed

that effects of El Niño bleaching in Mozambique were most extensive on exposed reefs in the north (up to 99%) and this diminished further south except at Inhaca Island where serious recent bleaching (90%) was encountered. Extensive COTS damage was also found at Bazaruto (80%) and Inhambane (95-98%). The COTS outbreaks commenced in 1995-1996 and, as sufficient time has elapsed for reef erosion and collapse to occur, the damage on these reefs was more pronounced (Schleyer *et al*., 1999).

During the second half of 1999, a monitoring programme started in Mozambique. Preliminary results showed that reefs in protected areas are those in much better condition. The fact that nearly no turtles and hardly any large fish were seen on the surveyed reefs provided an important sign of the need for management measures. The growth of tourism and diving in this country must also be taken into consideration. The study recommended the establishment of more protected areas and sanctuaries as shelters for biodiversity and breeding reservoirs (Rodrigues *et al*., 1999)

The Aquarium Fish Trade

Only one fishing company was so far authorized for the aquarium fish. Although this previous commercial operation has been relatively small by international standards, there have already been reports from local fishermen and tourist operators that the activities were having a major detrimental effect on the coral reefs of the area (Whittington *et al*., 2000). These concerns were formalized by the tourism association and led to concerns being expressed at the inter-institutional technical committee for coastal zone management. In response to these concerns, in February 1999, the Ministry of Agriculture and Fisheries published a nationwide directive ordering an immediate two-year moratorium on the trade in corals and ornamental fish.

Mozambique possesses considerable coral reef resources that could, with all probability, support a viable, profitable and environmentally sustainable ornamental fish trade. However, the greatest obstacle to the establishment and long-term success of this trade in Mozambique will be the lack of management and regulatory resources. These would be needed to ensure that the fish collection is undertaken in a way that poses no long-term threat to the reef fish populations or to the integrity of the reef habitat as a whole. This is a situation that faces many of the major ornamental fish exporting countries, which are often developing countries with few resources to manage or police the trade. Consequently, severe habitat damage has occurred to large areas of reefs in these countries through over-exploitation of reef fish and the use of environmentally damaging harvesting techniques.

It is in direct response to this directive that MICOA initiated a study as Phase I of a long-term investigation of the ornamental fish trade in Mozambique; the ultimate aim of which is to ensure the sustainable management of the country's reef fish resources.

The Future Ahead

Coral reefs are under great pressure in Mozambique. It is expected that more site studies will be carried out in the future. On the other hand, education campaigns with the involvement of local communities will be part of the coral reef management programme in Mozambique. Users will be educated on the need for coral conservation and protection since these ecosystems are the basis of several other important economic activities such as tourism and artisanal fisheries, to name a few. The mining of coral reefs should not be considered as a possible use of coral reefs in the near future. Rich importing countries such as EU, France, Italy and Germany should also get involved in this process, assuming that their demand for corals is the actual cause destroying coral reefs in the Mozambique coast, not the poor local collector.

As for the aquarium fish trade, the impacts of the trade on the reef systems elsewhere in the world have been well documented. The effects of harvesting specimens can, in localised areas, be profound and can cause major alterations to the community structure of the reefs. At a time when the coral reefs of Mozambique are under severe stress from the ENSO event, it is crucial that a set of guidelines are designed that will effectively manage any future trade in ornamental fish and invertebrates. This will ensure the long-term protection of this valuable natural resource.

Additionally, in order to ensure that any future commercial development of the trade is established in accordance with sound environmental practices, a set of guidelines for the undertaking of Environmental Impact Assessments (already required under Mozambican law) for fish collecting operations is urgently required. Such a project should involve making use of: existing information on the trade; new research directed at assessing the impacts of the trade; as well as the views of the exporting companies, local communities, commercial concerns and the government. This approach should ensure that the guidelines produced should successfully achieve the management goals required by Mozambique.

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Sustainable Fishing in Coral Reefs: Social Dimensions[a]

By: Sebastian Mathew[b]

Extended summary

Coral reefs have been variously defined as "soul of the sea", "sentinels of the deep", "rainforests of the sea", and "ocean treasure". In spite of the fact that Coral reefs cover only 0.2 per cent of the ocean floor they are believed to be home to 25 per cent of marine species. 10 per cent of global food fish production is believed to come from the coral reefs. Coral reefs are distributed mainly in the tropical belt in the Pacific and the Indian Ocean. The largest concentrations are in East Asia (30 per cent of world's total). 10 per cent of the reefs worldwide are estimated to be already destroyed. 70 per cent are feared to be gone in another 40 years. 25 per cent are at high risk. Coral reefs are subject to various pressures, which are both man-made and natural that lead to their destruction. The man-made factors can be land-based or sea-based.

The land-based factors can have a very important sometimes indirect impact on reefs. Bob Johannes in a paper titled, Reef and Lagoon Resource Management in Western Samoa (1982) has observed that: "Exposure of reefs to brackish, silt-laden water associated with flooding… has probably caused more damage to coral reef communities throughout the tropics than all other forms of human activity combined". Coral bleaching, as a result of the impact of "green house effect" on the seas, is another significant factor that causes damage to coral reefs. This is also believed to be of greater magnitude than the impact of fishing.

There is varying dependence on reef fisheries in different parts of the world. In Mauritius and Seychelles, e.g., only demersal reef fish are consumed. However, there is poor demand for reef bottom fish in Maldives and Laccadive Islands, India, where dependence on the reefs for baitfish for pole-and-line tuna fisheries is high. Greater the dependence on bait fishery, better the protection accorded to coral reefs. Reefs are also important for export-oriented trochus, beche de mer and giant clam, which are gleaned by hand by divers, often women, in several South Pacific islands.

The man-made pressures on the coral reefs arising from fisheries include certain destructive forms of fishing like dynamiting and cyanide fishing. The largest destruction of coral reefs on these accounts is seen in South East Asia. High levels of destruction, for example, have been taking place in countries like the Philippines and Indonesia.

Cyanide fishing is employed to harvest fish for consumption in expensive restaurants by rich businessmen, and to cater to the lucrative trade in ornamental fish. It is perhaps the worst form to kill corals. It also depletes targeted and associated species of fish and it has high negative externalities. Even those fishers who do not practice cyanide fishing, for example, are deprived of fish with implications for food security of poor people in coral reef areas. These are some of the poorest in countries like Indonesia and the Philippines.

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[a] Paper presented at the EU-Workshop: Policy Options for the sustainable Use of Coral Reefs and Associated coastal Ecosystems; Mombasa, Kenya June 19th – 22nd, 2000

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Cyanide fishing has a pervasive effect like that of slash and burn agriculture. It spreads to new frontiers when traditional areas get depleted and carries destruction in its wake. When the coral reefs of the Philippines were depleted, Indonesia became the main centre and now it is moving to the reefs of Papua New Guinea. There are reported conflicts in Papua New Guinea between clans and sub-clans, for example, over payments to fishermen by the live reef fish traders from Hong Kong as well as over the fate of the resources in reefs.

The intensity of dynamite fishing varies considerably between countries. There is rampant dynamiting of fish in countries like the Philippines and Indonesia. Both pelagic and demersal stocks are dynamited in Western Samoa, which has destroyed its reef resources with dynamite fishing. In the Solomon Islands, although dynamiting was used in the past, the practice is decreasing. In Mauritius in recent years dynamiting has disappeared as a result of greater control on the supply of dynamite. There is no blast fishing in the Seychelles and Tonga.

Very often those who are full-time fishers do not resort to dynamiting whereas those who are part time resort to such destructive fishing methods in several archipelagic countries. Blast fishing or dynamite fishing is essentially a function of rural poverty. Landless peasants who have poor purchasing power often undertake it. The costs of fishing operation as well as the price of fish caught using this method are the lowest. The fish caught in dynamite fishing are mostly consumed at the village level or in the municipality where it is harvested. It is either for subsistence or for the local market. There is a farming-fishing interface as far as dynamite fishing is concerned in bigger archipelagos. Landless peasants who are not necessarily skilled as fishers find dynamiting a convenient method to fish. Poor fishermen who have no fishing assets also resort to dynamiting. Poor, relatively unskilled or under-equipped fishermen also practice dynamiting, when there is too much competition.

Taking into consideration the interrelationships mentioned above, the following policy recommendations could contribute to a better protection of coral reefs:

1. Introducing non-destructive fishing techniques for ornamental fish.
2. Recognising the importance of setting up a global fund to provide incentives to fishers to give up dynamiting
3. Recognising the importance of agrarian reforms to help alleviate blast fishing undertaken by landless peasants
4. Granting ownership rights over coral reefs mainly as a means to regulate access could be an effective barrier in preventing excessively dangerous levels of exploitation of vulnerable species. Reefs under the control of the Seventh Day Adventist Church, are apparently well managed in the Solomon Islands. This is, however, no guarantee against destructive practices as exceptions show: In Western Samoa, where the citizens believe that land boundaries extend up to the reefs, the village chiefs—Pule nu'u—themselves encourage dynamiting when there is need for fish for the chief's title ceremony.
5. Minimising the impact of flooding and silt-laden waters on coral reefs.
6. Minimising emissions of green house gases.

Summary of discussion first section of panel 1

Heidi Wittmer

The discussion embarked upon three different areas: Questions concerning research, policy options for enhancing sustainable use and questions on institutional design.

A mayor issue for research is to produce information for decision-making and help to make it available to policy makers. Much of the information generated today is not accessible in the form decision makers require it. This can be due to the fact that research addresses only a part of the issue involved, typically the case with disciplinary research projects, which by their very nature have to focus on single issues. A second problem is that the information is not available at the level (local to national) policy makers need it. Research results are often too aggregated (i.e. produce data at national level) or much too local (as they study specific cases). In most cases the collation of the results from different disciplines and from different sites is a scientific challenge in itself and can hardly be accomplished by policy makers themselves. Methodological questions discussed included for example what methods best to apply for economic valuation of non-use values as well as which criteria should be included in Environmental impact assessments. Two areas for further research were identified: the determination of cumulative effects of different stressors or contaminants such as siltation, pollutants etc. as well as an increased application of user-driven models.

Marine farming and the control of fishing methods were discussed as policy options for enhancing sustainable use. The question was raised how fisheries certification can promote sustainable fisheries and how this can increase the economic benefits to artisanal fishers. The participants considered both improving rehabilitation as well as coral farming to constitute an important potential for a more sustainable use of coral reefs. It was, however, stressed that if farming corals for the aquarium trade is to become economically viable it requires the development of markets for such products where the higher costs of producing corals versus exploiting natural corals will be rewarded. This of course requires the implementation of a certification system and the control of compliance: an institutional challenge not easily met by many countries. Certification (for fish and marine products) can be interpreted as a "technical barrier to trade" by poorer countries that cannot afford the cost of research required for certification. The costs of implementing an institutional and administrative set-up capable of ensuring certification can also be prohibitively high, especially considering that pay-off is only years later. Finally it was stressed, that in many areas the sustainable use of marine and especially coral reef resources couldn’t provide sufficient income options for the coastal population depending on these resources. In these cases promoting alternative income sources constitutes the most viable policy option.

With regard to institutional design the discussants suggested the creation of more specialised institutions for reef management as was presented for the case of Mozambique as an interesting option. The co-ordination of efforts from different institutions involved in coastal management was also considered important and deficient in many countries.

Comparison of closed area and beach seines exclusion on coral reef fish catches[a]

By: T. R. McClanahan and Tim S. Mangi[b]

Abstract

Fish landing data from adjacent the Mombasa Marine National Park (MNP) and seven sites in Diani, a legally gazetted but unprotected marine reserve, were studied over a four-year period to determine the influence of the park and of restrictions of beach seines on fisheries catches.

Data were based on sampling for 3 to 12 days per month from 1995 to 1999, where fish were separated into the major families, the wet weights estimated by a spring balance, and data analysed based on gear, numbers of fishers, and the area from which the fish were caught. In the case of the Mombasa marine reserve, the beach seine exclusion was effected nearly simultaneously with a reduction in the size of the Marine Protected Area. These two factors combined resulted in increased fish catches on a per area and fisher basis. It was, however, difficult to distinguish the effects of the two changes, but the initial pulse in catch is largely due to opening a previously un-fished area to fishing. In Diani the two landings that restricted beach seines for over 20 years had the highest per fisher catches, these being 13% greater than at sites with beach seines (ANOVA, $F = 4.5$). Catch data showed a progressive decline in per man catches in all the sites irrespective of the management in place or the exclusion of the beach seines.

Nevertheless, the site next to the marine reserve had the highest catch per area (5.5 kg/ha) and slowest rate of decline despite having the highest number of fishers per area basis (0.07 ± 0.02 fishers/ha/month).

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[a] Paper presented at the EU-Workshop: Policy Options for the sustainable Use of Coral Reefs and Associated coastal Ecosystems; Mombasa, Kenya June 19th – 22nd, 2000. The paper is published under: McClanahan, T.R., and S. Mangi, 2001. The effect of closed area and beach seine exclusion on coral reef fish catches. *Fisheries Management and Ecology* 8:107-121.

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Socio-economic benefits and sustainability of Marine Protected Areas as a coral reef fisheries management option[a]

By: Delphine Malleret-King[b]

1. Introduction

Marine Protected Areas (MPAs) and No Take Zones (NTZ), where all extractive uses are forbidden, are increasingly advocated as one of the solutions to sustainably manage coral reef fisheries. By protecting part of the fish stocks from exploitation, they are considered as a way to implement the precautionary principle in fisheries management. For decades, MPAs have been established for tourism and environmental conservation. One of their main benefits to the surrounding stakeholders was thought to be the employment provided in tourism (Dixon, 1993). However, MPAs effects on the biomass, diversity, and habitat of the fish species they protect have made scientists think that they could also contribute to improve the surrounding fishing yields and be used as a coral reef fisheries management option. The two main processes of replenishment of the surrounding fisheries are the migration of fish outside the MPAs' boundaries (the spill-over effect) and the increased recruitment due to the protection of a spawning stock and to the improved habitat so important to juveniles' survival.

However, potential benefits of MPAs in terms of fishery can be very long to become apparent, for example an increase of high predatory species outside the MPA in the Philippines was first observed 9 to 11 years after the establishment of the MPA (Russ and Alcala, 1996). Proving these processes is however difficult. There is a lack of historical data, which means that the comparisons are often spatial (inside and outside the MPA) rather than temporal (before and after the establishment of the MPA). Furthermore, numerous uncertainties can affect the efficiency of an MPA in terms of the replenishment of surrounding fisheries such as local eddies, currents, location of the MPA, larvae's' dispersal patterns (Allison *et al*., 1998 and Lauck *et al*., 1998).

Moreover, it has been observed that the lack of involvement of stakeholders in MPAs management and establishment has led to numerous failures (Alder, 1996, Salm & Ngoile, 1998). Thus, it is increasingly accepted that involving stakeholders reduces the enforcement costs and improves the efficiency and the sustainability of MPAs (White, 1994, Borrini-Feyerabend, 1998). If MPAs are set up for fisheries management, long term and good enforcement is paramount for their efficiency.

Coral reef fisheries are mostly located in developing countries and often represent the last resort for coastal communities. Thus, coral reef fisheries' depletion threatens the food security of millions of people who depend on them. However, these communities often cannot afford to lose fishing grounds and wait for fishing yields to improve. This is why the establishment of MPAs can lead to violent reactions.

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[a] Paper presented at the EU-Workshop: Policy Options for the sustainable Use of Coral Reefs and Associated coastal Ecosystems; Mombasa, Kenya June 19th – 22nd, 2000. Presented by A. King.

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Most studies examine the ecological benefits at micro-levels or do cost/benefit analyses at macro-levels while very few investigate MPAs impacts from the point of view of the stakeholders. However, MPAs will be sustainable if stakeholders accept them but stakeholders will only accept them if they see the benefits. The results presented in this paper are the results of a PhD[a] research aimed at investigating the benefits of an MPA (in a coral reef area), on the surrounding stakeholders, from their angle.

For this, measures of household food security understood as "*that state of affairs where all people at all times have physical and economic access to adequate, safe and nutritious food for all household members, without undue risk of losing such access*" (FAO, 1996) were used. The hypothesis tested was that if MPAs (or NTZs) were of benefit to the surrounding fishing communities, their food security would be improved. This paper presents the main findings of the research after having introduced the study site and measures (Malleret-King 2000).

2. The Study Site

The Kisite Marine National Park on the southern coast of Kenya (KMNP), located 5Km offshore from Shimoni (see Fig. 1) was chosen as a case study on the basis that: tourism development is limited, there has been a 20 year relationship between the park and the local communities, communities are distinct, biophysical assessments of the coastal and marine environments are available (Samoilys, 1988, Anon., 1993, Watson, 1996). All extractive activities are forbidden in the park, which is considered as well enforced (Watson, 1996).

The KMNP was established in 1978. However, it has only been enforced fully from 1988 when, after the protests of angry fishers, its boundaries were re-designed and part of the communities' traditional fishing grounds (i.e.: Mpunguti, Fig.1) was returned to them. It was returned in the form of a Marine Reserve where traditional fishing methods are allowed (e.g.: hand lines, traps). The park and reserve cover an area of 39 km² and are managed by the Kenya Wildlife Service[b] (KWS).

In order to study the impact of the KMNP on the surrounding communities, five fishing communities located in the vicinity of the KMNP were selected (see Fig. 1). Four communities (Wasini, Mkwiro on the Wasini Island, Kibuyuni, Kichangani on the mainland) were chosen on the basis that their fishing grounds were located near the park or the reserve and that they were accessible. Anzwani, the fifth community on the mainland was identified as a control population.

Its fishing grounds are not located near the park or the reserve, but fishers use the same offshore locations and they fish in the same kind of ecosystem. The main activity in the study site is artisanal fishing, as 54% of the 210 sampled households depended at least partly on fishing for their livelihood.

[a] From the University of Warwick, UK.

[b] KWS was the local host institution for the research.

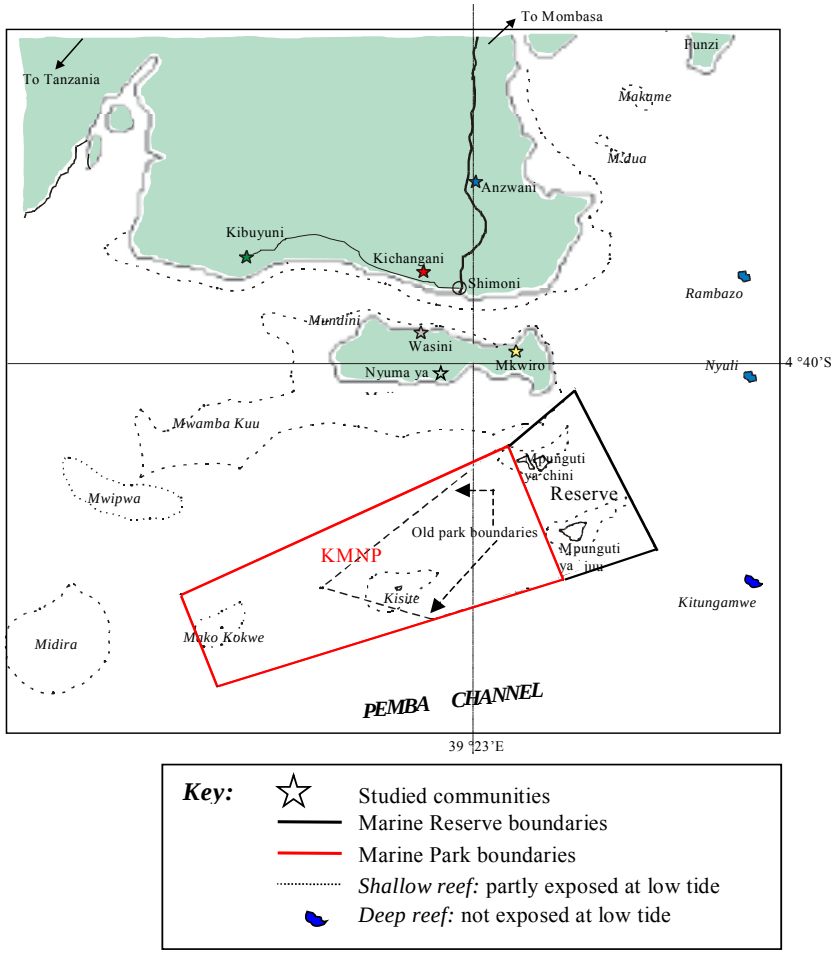

Figure 1: The Study Site

3. Household food security measures

To compare on a quantitative basis the communities' socio-economic situation, a household food security approach was used. It was based on household food coping strategies[a]. In order to provide a good understanding and to detect food crises, the concept of food security has evolved in the last 30 years. Thus, from taking only into account food availability at the macro levels (Maxwell & Frankenberger, 1992) it now encompasses elements of quantity, quality and access to food through food entitlements[b] at the local level (Sen, 1981, Swift, 1989, Maxwell & Frankenberger, 1992, Maxwell, 1996, Maxwell, 1997). Being a more comprehensive concept, food security has become difficult to measure fully. However, if defined cautiously, coping strategies that are indicators for food access can give a good indication of risks of food insufficiency and of households' vulnerability[c] (Nyborg & Haug, 1995, Maxwell, 1996).

[a] Household food coping strategies are defined as: "*short term temporary responses to declining food entitlements*" (Davies, 1993).

[b] Food entitlements represent the ways in which households have access to food such as subsistence productions, assets, income, savings, natural resources and community support (claims).

[c] The vulnerability of households to a crisis depends on the past (previous crisis and strategies used) and on the present (Swift, 1989).

In this research, the food security based quantitative analysis relied on two short term indices, the Food Coping Strategy Index (FCSI) and the Short Term Accumulation Index (STAI) and two long term indices, a Long Term Divestment Index (LTDI) and a Long Term Accumulation Index (LTAI). They were calculated for each of the 210 selected households. The indices reflected the coping capacity as well as the accumulation capacity of the surveyed households and were calculated by using the perceived severity rank of the strategies used by stakeholders and their frequency of use[a] (tab. 1 and tab. 2).

Table 1: Short-term strategies, their perceived severity rank and frequency scale

Coping strategies	**Rank**	**Accum.* Strategies**	**Rank**	**Frequency scale**	**Coping**	**Accum.**
Less food	**1**	Buy more food	**1**	Every day	**1**	**5**
Sell chicken	**2**	Buy *Leso***	**2**	2-5 times a week	**2**	**4**
Skip meal	**3**	Buy meat	**3**	1 to 2 a week	**3**	**3**
Porridge	**4**	Put money in the bank	**4**	1 or 2 a month	**4**	**2**
Feed children in priority	**5**			Never	**5**	**1**
Credit at the shop	**6**					
Borrow from family	**7**					
No food for a day	**8**					

1: least severe, least favoured. 8: Most severe, most favoured.,
**: accum.: accumulation, **: leso, garment worn by Kenyan ladies on the coast.*

Table 2: Long term strategies, perceived severity and frequency scale

Divestment strategies	**Rank**	**Accum*. strategies**	**Rank**	**Frequency**	**Divestment**	**Accum.**
Sell chicken	**1**	Buy chicken	**1**	>1 per year	**1**	**5**
Sell goat	**2**	Buy goat	**2**	1 per year	**2**	**4**
Use savings	**3**	Buy leso	**3**	2-4 times	**3**	**3**
Sell leso	**4**	Buy houseware	**5**	Once	**4**	**2**
Sell gold	**5**	Put money in the bank	**6**	Never	**5**	**1**
Borrow from money lender	**6**	Buy building material	**6**			
Borrow from family	**7**	Invest in activity	**8**			

1: least severe, least favoured. 8: Most severe, most favoured.
**: accum.: accumulation*

Participatory methods were used as much as possible throughout the research process. Strategies and their severity were identified through focus groups and in depth-interviews. For the analysis, households were divided into short-term food security groups (from very low to highly food secure). Table 3 shows an example of scores obtained at the group level.

[a] The scores were calculated by weighting the frequency by the severity ranks: $\mathbf{I= \Sigma_{i=1\ to\ n}\ F(x_i)SR(x_i)}$ With I: index (FCSI, STAI, LTDI or LTAI), x: strategy, i: strategy number, SR: severity rank and F: frequency of use of the strategy.

Table 3: FCSI scores averaged at the short-term food security group level in each village

Groups*	Wasini	Kichangani	Anzwani	Mkwiro	Kibuyuni	All
VL	132.2	114	113.5	122.9	121.6	**119.1**
ML	156.3	129.7	134	146.7	138.9	**141**
MH	172.7	138.2	149.5	158.2	156.8	**158.4**
H	180	162	169.8	170.8	169.7	**173.6**
All	**160.5**	**136.1**	**142.2**	**149. 6**	**145.7**	**147. 9**

**Very Low (VL), Medium Low (ML), Medium High (MH) and High (H)*

The same process was used for the analysis of all four indices. Then, the variability of the scores were analysed and factors that were likely to affect the households' scores were examined (e.g. demographic, geographic, economic...). The following sections present the links identified between the variability of the scores and the presence of the KMNP.

4. Results on the influence of the presence of the KMNP on household food security

4.1 Economic activities

The sampled households mainly depended on 6 economic activities, including fishing and tourism related to the presence of the park (i.e. local small operations or larger tour operators taking visitors snorkelling or diving in the KMNP). It was found that economic activities affected the scores and particularly, that **t**he more households depend on KMNP-related tourism in a group the more food secure the group is. In contrast, the more fishing dependent households, the least food secure the group is.

At the same time, the distance from the main tour operators (KMNP-related) was found to affect the economic structure of the communities. The further away the community is located from the main tour operators, the less households depend on KMNP-related tourism and the more households depend on fishing. Table 4 summarises these results.

Table 4: Relationships between economic activities and food security as well as distance

Activities	Food security	Distance from main tour operator
Fishing	-	+
KMNP-related tourism	+	-

One of the main objectives of the research was to determine whether the effects of MPAs in terms of fishing could be detected from a socio-economic angle. To concentrate on this aspect, the links between the variability of the fishing households' scores and the factors related to the presence of the KMNP were investigated.

4.2 Fishing dependent households

105 households of the 210 sampled were identified as mainly fishing-dependent. Two parameters linked to the presence of the KMNP were thought likely to affect the fishing. These were the distance of the community from the KMNP and the use of powered-boats given as aid. Very few of the fishing households in the study area used powered boats, most

of them fished with non-powered dugout canoes. However, 6 powered boats were given as aid in 1995 by KWS and USAID (United Stated Agency for International Development) to three villages including Kibuyuni and Mkwiro. Fishers have organised themselves into cooperatives and use these boats in shifts. The participation in the shift was thus also considered as a potential factor of variability linked to the park.

The participation in the shift was found to affect positively the situation of the fishing households in the long term. However, the distance of the villages from the KMNP boundaries was not enough to explain the differences amongst fishing households. This confirmed the results of a previous biological study on the effects of the KMNP on the surrounding fishery (Watson, 1996) that could not find evidence of fish migration outside the park. The same study suggested that the patchiness of the reef within the KMNP might have prevented fish from migrating outside it.

To take account of the park's heterogeneity it was decided to explore the potential links between the distance of the villages' main fishing grounds from the nearest protected reefs and the food security scores. It was found that the short-term and the long-term household coping capacities (FCSI and LTDI) were negatively affected by the distances of the fishing zones from the protected reefs. Table 5 summarises these findings.

Table 5: Effects of distance and power boat use on the fishing households' food security

Activities	Food security
Distance from the KMNP	-
Participation in using the power boat	+

The results suggest that the KMNP might have a spillover effect but perceived only by the communities able to fish near protected reefs (mainly Kibuyuni). The KMNP was also found to have an effect on the situation of the fishing households through the aid it brought to the communities (i.e. the gift of boats).

4.3 Households depending on KMNP-related tourism

It was shown that the most food secure households in the short and long term were the ones depending mainly on KMNP-related tourism. Thus, tourism emerged as an important variable to understand the situation of the studied. Tourism is not greatly developed in the area and most of the tourists come for a day trip, which includes lunch and snorkelling in the KMNP. Very few stay overnight, as accommodation is scarce.

In order to investigate the impact of the KMNP through tourism, a qualitative and an economic study were carried out, as there were too few data points to analyse statistically the food security indicators. Questionnaires were given to the tour operators to estimate their economic impact on the area and to 180 tourists were asked to fill in questionnaires to find out why they came for the day trip. The aim was to understand whether the presence of the KMNP was a determinant element in their choice. A previous economic survey by Emerton (1999) was also used.

It was established that KMNP-related tourism created employment but that most of the benefits went to non-local tour operators whilst most of the costs were borne by the local communities. Benefits were also unequally distributed amongst the local communities themselves. This was mainly due to the distance constraints mentioned in section 4.1 (i.e. the

further away from the main tour operators, the less households are likely to be dependent on KMNP-related tourism employment).

Finally, it was shown that only 9% of the tourists interviewed mentioned the Park (or related terms) as a main reason for them to come. Most of them came because of the lunch, the day out of the hotel, the fact that tour operators came to pick them up at the hotels. Although the presence of the tour operators is linked to the presence of the KMNP, it cannot be assumed that tourists on their own will be attracted just because an MPA is established. An MPA could only be a particular attraction to tourists if these are made aware of the differences between the reef inside and the reef outside an MPA. Shimoni (the land base departure point for the KMNP) is very difficult to access thus tourists prefer organised tours to local small private operators which cannot pick them up at their hotel.

It was also found that KMNP-related tourism was seasonal and volatile. The low tourism season corresponds to the hunger period and to the low fishing season on the coast. Thus, it means that households depending on tourism have to be able to accumulate enough income resources during the high tourism season to make it through the lower season. Otherwise, households need to spread the risk and depend on several activities. Thus, they cannot afford to lose their traditional knowledge (e.g. nearshore fishing).

5. Discussion

5.1 Limits of the KMNP benefits

Distance and heterogeneity of the MPA (linked to the patchiness of the coral reef) were a constraint for communities to access the benefits of the presence of the KMNP. In terms of fishing, both these factors affected the potential benefits of the spillover effects of the KMNP to reach all the surrounding stakeholders. Thus, the communities benefiting from the positive effects of the presence of the park are the ones that could fish nearer the protected reefs.

Distance also affected the food security and benefits of the KMNP through its effects on the economic structure of the communities. It was found that economic activities have a role in the variability of the food security scores. Households depending on KMNP-related tourism were the most food secure. However, KMNP-related employment was not equally accessible and it was also shown that the number of households dependent on this activity decreased as the distance from the main tour operators increased.

Because of distances and because of the inaccessibility of the park, it was established that the benefit sharing of KMNP-related tourism is skewed to the detriment of the local communities. Moreover, tourism was shown to be highly volatile. Political events and natural events that occurred during the research led to a direct decrease in the number of tourists visiting the KMNP. Factors leading to variation of the tourism can easily escape local, national and even regional control. The study also found that it could not be assumed MPAs are sufficient to attract tourists if there are no specific advertising policies.

5.2 Implications for management

Through the study, it appeared obvious that it cannot be assumed that all the surrounding fishing communities have access to the benefits. Their location and the heterogeneity of the ecosystem can strongly affect it.

MPAs are not homogeneous entities and thus do not provide obvious benefits to the stakeholders. It is necessary that managers are aware of the disparity of access to the benefits

in terms of fishing as well as in terms of tourism so that conscious decisions are made to compensate or find ways in which to increase the benefits to the surrounding communities.

Similarly, benefits of an MPA through tourism are neither obvious nor homogeneous from the stakeholders' point of view. Tourism should not be considered as the panacea to alleviate pressure on the reefs or as the ultimate source of alternative employment. Although it provides benefits, managers have to be aware of the constraints on these benefits and a political will must be expressed to involve the stakeholders in the benefit sharing of tourism through financial tools, through training (e.g. in safety) but also in terms of defining the type of tourism they are ready to accept in their area. Usually, households use a portfolio of activities in order to reduce risks. It could be important for managers to also look into ways of improving these activities (e.g. farming) to reduce the pressure on the reefs.

5.3 Suggestions for further research

Other elements than coral heads or parts of the ecosystem might have influenced the situation of the fishing households such as sea grass beds, on which several of the commercial fish species depend. Thus, further investigation of the location and characteristics of the fishing grounds used by fishers might reveal more precise effects of the park on the fishing communities' socio-economic situation. Overlaying maps of the characteristics of the fishing grounds and maps of food security scores could give information on a relationship between them. The natural events in the year of the fieldwork (1997) have potentially affected the reefs of the Indian Ocean on a permanent basis by bleaching the coral. Research could concentrate on how this bleaching is going to affect the production system and food security of the KMNP surrounding communities, particularly the fishing households. Finally, further analysis of households dependent on KMNP-related tourism situation could contribute to detecting the conditions that impact on the variability of their food security. This could be done through purposively sampling tourism dependent households and by doing a livelihood analysis.

5.4 Summary

The study showed that a wide range of information could be found through a socio-economic approach of MPAs impacts. From the surrounding fishing communities' point of view the KMNP has benefits through tourism and fishing, however distance and heterogeneity limits the access to these benefits. For MPAs to be a sustainable option to coral reef fisheries management, the factors limiting the access to stakeholders' benefits have to be taken into consideration. Political decisions have to be made towards including the stakeholders in MPA management as well as in the benefit sharing.

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Ecotourism in a private Marine Protected Area: Chumbe Island, Tanzania [a]

By: Sibylle Riedmiller and Eleanor Carter [b]

Abstract

The Chumbe Island Coral Park (CHICOP) in Zanzibar was established in 1991 and is probably the first fully functioning MPA in Tanzania, and the only privately created and managed Marine Park in the world. The project was developed along the lines of a commercial enterprise, but is a non-profit project, with all profits from the tourism operations going into conservation management and free educational island excursions for local schoolchildren. Donor support helped set up several project components, such as nature trails and a visitors' centre that cover about a third of investment costs. There is however, no donor or government support for operations.

Many challenges, particularly severe bureaucratic red-tape and delays, and complications of the ecologically friendly building technology employed on the island, have resulted in much higher investment costs than originally anticipated. However, due to low overheads the management costs of this privately established park are only a fraction of what is normally needed for donor-funded projects through government agencies. As no donor and government support was available for operational costs, income-generating activities are fully developed and successful, thus creating better prospects for sustainability.

Chumbe Island has been developed as a fully functioning protected area, but also as a genuine eco-tourism destination, that offers guided snorkelling and walking nature trails. Accommodation is in not more than seven specially built eco-bungalows that have close to zero impact on the environment. One of the major economic challenges remains the fact that up to the present, the project has to pay the same taxes and licences to Government as any other tourism operation, and no allowance is given for the non-profit and conservation orientation. Meeting bureaucratic and legal demands of, for example, the immigration and labour departments can be enormously cumbersome, both in costs and management time. In the case of Chumbe, a noticeable exception is the efficient co-operation that has evolved with the lead ministry of the project, the Zanzibar Ministry of Agriculture, Livestock and Natural resources.

In addition to the drastically increased investment costs, operational risks for private investors remain high, due to the generally difficult investment climate, lack of long-term security of tenure and legal protection, political insecurity and the volatile tourism market. Because of these risks, and the more noticeable conservation impact on the ground, a case is made for more political and donor support to private initiatives related to the sustainable use and management of marine protected areas.

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1. Introduction

Chumbe Island is situated 8 miles southwest of Zanzibar Town and covers an area of approximately 22 ha. It is an uninhabited island dominated by coral rag forest and bordered, on its western shore, by a shallow fringing coral reef of exceptional biodiversity (Fiebig 1995, Veron pers. comm. 1997). Chumbe Island Coral Park Ltd. (CHICOP) was established in 1991 as a privately funded and managed reef and forest conservation project covering the whole of Chumbe Island and the fringing reef on its western side. This created, to our knowledge, the first and only privately managed MPA in the world. The reserve includes a reef sanctuary and protected forest and has become a rare example of a healthy coral island ecosystem in an otherwise heavily over-exploited area.

Through the initiative of CHICOP, the island was gazetted in 1994 as a protected area by the Government of Zanzibar. Though privately funded (with some donor inputs covering about a third of the investment costs), the project is non-profit-oriented. The objectives of the Chumbe Island Coral Park (CHICOP) project are non-commercial, while operations follow commercial principles. The overall aim of CHICOP is to create a model of sustainable conservation area management where revenue from ecotourism supports conservation and education. Permitted uses of the park include research, education and recreation (swimming, snorkelling, underwater photography). Extractive and destructive activities, such as fishing, anchorage, or collection of specimens (even for research) are not allowed.

2. Establishing and investing in a Privately Managed MPA.

About two thirds of the investment costs of over 1 million US$ were financed privately by the project initiator (a conservationist and former manager of donor-funded aid projects). Several project components, such as the construction of the visitors centre, biological baseline surveys, the Aders' duikers sanctuary, the park rangers patrol boats and nature trails received some funding from donors, e.g. GTZ-GATE, GTZ-EM, the German Tropical Forest Stamp Program, EC-Micro-projects, the Netherlands Embassies in Kenya and Tanzania, the WWF-Tanzania, the International School Schloss Buchhof, Munich, among others.

There is no donor or government support in the running costs of the MPA, and the overall concept of the project was to initiate a self-funding, financially sustainable MPA that was independent of long-term donor reliance.

As is discussed in greater detail in "The Political Challenge of Private Sector Management of Marine Protected Areas" paper (panel 3), the original feasibility study of 1991 suggested an investment of little more than US $200,000 in order to establish the park and to construct a visitors' centre and guest bungalows, with payback of the investment expected to start after three years and with consequent profitable revenue generation being funnelled back into the project to fund the conservation and education components of the project.

However, before the Project could be fully initiated it took a further three years after the establishment of CHICOP before work could begin in negotiating the official gazettement of the island as a protected area, the several management contracts, land lease, licenses and building, research, work and residence permits. Additionally the logistical challenges of construction on an island environment and the experimental nature of the architectural design compounded delays to operations. Thus, the feasibility study had to be updated in 1994 based on an adjusted project design and more realistic conservation costs, resulting in more than three times the original investment. By 1998 (Neckening 1998) the overall investment had risen to nearly 1.2 Million US$, out of which 220.000 US$ were grants from the variety of donors mentioned above. By this stage the start of commercial operations had been revised once more to commence in mid 1998, seven years after CHICOP had been established.

These lengthy delays to operations commencing and the increased investment costs accrued threatened to jeopardize the long-term sustainability of the project. Not only was financial security an issue, but also security of tenure was, and still is, an issue that must be addressed in Tanzania if the Private sector is to be encouraged to invest in conservation. Land tenure in Tanzania and Zanzibar is only available on leasehold, in contrast to other African countries, and while this situation could be offset to a certain degree by legal provisions, such as long-term land lease and management rights, reduction of, or exemption from land rents, licenses, fees and taxes, these are not readily granted (Sterner & Andersson 1998).

Therefore the success of the Chumbe project can in part be accredited to the continued cost-conscious management of revenue and the continuing involvement of volunteer personnel. Even with the delays and increased investment costs as described above, the overall management costs of establishing and running this MPA are a fraction of what is normally needed for donor-funded projects through government agencies. Since the beginning of revenue generating operations, whilst slow to begin, a growing level of occupancy in the eco-lodge can be seen. This growing component of the revenue generation is creating increasingly better prospects for sustainability.

3. Components of the Chumbe Island MPA.

3.1 Project activities from 1991-1999

- The successful gazettement of the Western reef and the island (in 1994) following lobbying from the Project founder since 1991.
- Former fishermen were employed and trained as park rangers by expatriate volunteers from 1993, in interaction with fishers, monitoring techniques and tourist guidance skills.
- Baseline surveys and species lists on the island's flora and fauna were produced with the help of volunteers and some limited donor funds, from 1993.
- Research is coordinated with the Institute of Marine Sciences of the University Dar es Salaam, and an Advisory Committee was established with representatives of the Departments of Fisheries, Forestry and Environment, the Institute of Marine Sciences and village leaders of neighbouring fishing villages.
- A Management Plan 1995-2005 was produced in 1995 to guide project operations thereafter (CHICOP 1995).
- Forest and marine nature trails were established from 1993 together with the production of information material in English and Kiswahili.
- Rats (Rattus rattus) were eradicated in 1997
- A Sanctuary for the highly endangered Ader's duiker (Cephalopus adersi) established from 1997.
- The ruined lighthouse keeper's house was rehabilitated as Park HQ/Visitors' Centre 1998
- Seven visitors' bungalows ("eco-bungalows") and the Visitors' Centre were constructed according to state-of-the-art eco-architecture (rainwater catchment, solar water heating, vegetative filtration of grey water, compost toilets, photovoltaic power generation).

3.1.1 Conservation:

The Chumbe MPA project has secured continued protection of valuable flora and fauna. When the project started in the early nineties, Zanzibar had no marine protected areas and no institutions to manage them. To date Chumbe continues to be the only fully protected coral reef habitat in Zanzibar.

By managing this protected area, locally depleted fisheries have reportedly benefited from greater fisheries yields, and recovery of degraded coral reef ecosystems is promoted. Chumbe island is located upstream of the most important fishing grounds opposite Zanzibar town. The sanctuary provides a protected breeding ground for fish, corals and other species, which are expected to then spread out to recolonise nearby overfished and degraded areas. As the predominant sea current in the Zanzibar channel is northerly, larvae of corals and other sea organisms as well as juvenile and adult fish are likely to migrate to the northern heavily fished reefs. By witnessing the healthy fish yields, co-operation with local communities has been enhanced and continues to be successful. (1)

Chumbe contributes to biodiversity conservation and ecological restoration, by effectively protecting a coral reef, which has at least 90% of the scleractinian coral species ever recorded in East Africa (Veron pers. comm. 1997). The Chumbe Reef Sanctuary has become refuge for several resident hawksbill turtles, and the forest harbours a large population of the rare Coconut Crab *Birgus latro*. In 1994, the undisturbed reef flora and fauna of Chumbe Island allowed successful breeding of rare migrant birds, e.g. the Roseate tern *Sterna dougalli,* (Isles, D. 1995) and the island also offers an ideal breeding sanctuary for the endangered Ader's duiker *Cephalophus adersi* (Kingdon 1997). These can later be re-introduced to Jozani forest or other conservation areas, once they are established and fully managed with the support of neighbouring communities. Particularly after the successful eradication of rats (*Rattus rattus)* in 1997, Chumbe Island is also a safe haven for yet unknown flora and fauna typical of intertidal reef flats and coral rag forests which are little researched and rapidly diminishing elsewhere in Zanzibar and Tanzania (Beentje 1990).

On Chumbe conservation is pro-active. The MPA hosts valuable research opportunities for Tanzanian and foreign research institutions. The Institute of Marine Sciences and other foreign academic institutions linked with the IMS co-operation programs conduct regular long-term research activities that are only possible in protected areas. Shorter-term studies have been carried out by a host of academic institutions involving a varied sector of the scientific community around the world. For this community Chumbe is extremely valuable, as research plots and equipment are safe from theft and tampering in the Chumbe Reef Sanctuary, and conditions are ideal to compare an effectively protected reef with unprotected reefs.

3.1.2 Capacity building and community benefits:

Essential to the closing of the Chumbe Reef Sanctuary to fishing was the close relation and understanding from the local communities concerned. A vital project component has been to provide employment and educational opportunities to Zanzibar people, especially those from the communities near Chumbe. For Chumbe to be an effective MPA a key factor is that it must aim to benefit a wide section of the community, both in the short and long term. If the communities can witness the benefits of the MPA, not only in terms of fisheries, sustainability of the project is more assured.

To this end, since 1992 six former fishermen have been trained in marine park management, marine biology, forest ecology and monitoring techniques for the reef and the forest. They have also learned English and gained the knowledge needed to guide both local and foreign

visitors on the island. The rangers patrol the reef and the island's coral-rag forest habitat, keep daily monitoring records on any observations, assist researchers and guide visitors over the marine and terrestrial nature trails. These rangers are now key people in the project, and as local fishermen themselves their ability to communicate effectively with fellow fishers provides an enormous opportunity.

Approached properly by fellow fishermen trained by the project, fishers from the local community have been able to understand, and after some time see, the direct benefits of conserving the Chumbe reef sanctuary. While coastal communities dependent on fishing possess a wealth of traditional environmental knowledge (Tobisson et al. 1998), reef management is really only just beginning to be seen by communities as a necessity (Scheinman & Mabrook 1996). In some coastal communities corals are still referred to as 'mawe na miamba', stones and rocks. Formal education does also not yet provide environmental information on this important natural resource, as revealed by an analysis of the syllabi of primary and secondary education (Riedmiller 1991, Riedmiller 1995). By the rangers having a direct route through which to disseminate vital information regarding coral biology, ecology, conservation and its direct relation to the long-term utilisation of this resource, Chumbe has been extremely successful at grass roots education.

As the Chumbe Reef Sanctuary is closed to fishing, and the rangers have no policing power, they can only verbally convince fishermen that they should respect the boundaries of the Reef Sanctuary and in ultimately enjoy increased fish harvests in the vicinity. The success of this educational approach is evident in the decline in attempted infringements into the protected area since establishment of the project.

Local fishers also benefit from the Chumbe MPA as assistance is always provided to any fisher in distress. As there is no maritime rescue service available in Tanzania, the assistance given by the Chumbe rangers to fishermen during rough weather, and when boats, engines and sails need fixing, is crucial. They also provide radio communication from the island to anyone in need, and have even been involved in salvage operations for a sunken yacht. Over the many years of project operations there have been hundreds of cases where such help was given. Additionally fishers benefit directly as the Chumbe MPA provides a direct source of income to fishers selling fish and other seafood to the island restaurant.

However, to truly involve the local communities it is essential to involve non-fishers as well as fishers. To this end all employment opportunities on the island are targeted at the local communities, for all aspects of work, including maintenance people, cooks, cleaners, waiters and drivers. Training in all these positions has been provided.

Additionally the project has actively encouraged the employment of women from these coastal communities. In the local Islamic culture, under-educated women from rural communities often find it difficult to find employment, and where employment is found, unless from an educated background, opportunities for female advancement in the workplace can sometimes be limited. On Chumbe equal opportunities are provided to all staff and all staff, be they cooks, waiters, or maintenance, are taught about the ecology of Chumbe and its relation to natural resource utilisation. This is again, a direct route through which to disseminate information to these coastal communities. Environmental education such as this encourages feelings of ownership and responsibility towards a natural resource, and promotes support of the project.

Capacity building even extends to government staff from different departments who have been involved in the Advisory Committee. Over the years, the Committee has dealt with important issues concerning the establishment and management of the reserve, particularly through the discussions preceding the approval of the Management Plan 1995-2005. Chumbe is a training ground for conservation area management, where staff of other conservation

projects and students of Environmental management from both domestic and International institutions have attended classes and undertaken studies.

3.1.3 Education through the schools programme

The Education Centre on the island hosts school visits from schools throughout Zanzibar, through co-ordination with the Marine Education Awareness and Biodiversity Programme (MEAB). These children benefit from learning about the resources upon which many of their families' livelihoods depend, and upon which they may be likely to depend upon themselves in later life. Often Chumbe is the only practical insight school children in Zanzibar have into this environment in the field.

CHICOP has created unique facilities for environmental education for school children and other visitors. Nature trails and educational materials (in Kiswahili and English) have been developed about the forest and the reef. Throughout the year schoolchildren are taken to the island and the Chumbe rangers give them classes in marine biology, conservation and forest ecology. The programme also involves employees of IMS, Department of Fisheries and Department of Environment as they are invited to join in the daytrips and teach on their given subject areas.

From 1994 many excursions of school children were organised with the Department of Environment, then based on the initiative of a VSO-volunteer responsible for environmental clubs in schools. As part of the activities for the International Year of the Reef in Zanzibar, the BBC-Blue Peter Program has on the 17.5.97 filmed such a day excursion of Bububu primary school children to Chumbe. Now, under the current affiliation with MEAB, it is hoped more than 1400 children will have participated in this new scheme during the year 2000 alone.

3.1.4. Historic monuments

An historic lighthouse, built by the British in 1904, is kept functioning by the Chumbe staff in co-operation with the Harbours Authority. Before the Chumbe project began the lighthouse rarely functioned. This lighthouse is an important navigational aid to the traditional dhows that have no modern means of navigation.

A protected historic mosque on the island is cared for and still used daily by the Chumbe staff. This is one of the few mosques of Indian architecture in Zanzibar, built for the Indian lighthouse keepers by their community at the turn of the century. The former lighthouse keepers' house has been carefully restored and converted into the visitors centre that harbours the classroom for the schools programme, the restaurant and exhibits of environmental information about the island reserve for all guests.

4. The revenue: eco-tourism

The running costs of the Chumbe MPA are solely provided from revenue generated through eco-tourism. However, unlike many other tourist ventures, Chumbe is special, as visitors to the island must, by definition of a protected area, have no impact on the environment.

An eco-lodge has been developed with unique eco-bungalows have been in which the guests stay. These eco-bungalows have been specially designed with state of the art eco-architecture and technology, which makes Chumbe a unique example of truly sustainable management of eco-tourism for which the project is receiving International acclaim. Various components contribute towards the innovative bungalow designs.

Firstly, as there is no freshwater source on the island rainwater is collected each rainy season using the large expanse of roof on each eco-bungalow. This water passes through, and is cleaned, by a natural filter located at each side of the bungalow, and is then stored in a large cistern underneath the living room. Water is then hand pumped through a solar water-heating panel, into hot and cold water containers in the roof.

The greywater from the showers and sinks passes through particulate filters, chemical filters, and finally into plant beds located in front of each bungalow. These beds are planted with species that are efficient at taking up the phosphates and nitrates in used water. The beds are completely encased in clay, ensuring that no used water runs into the natural environment.

Sewage is handled by compost toilets. Each eco-toilet has a completely sealed chamber to prevent sewage from seeping into the Marine Park. Compost toilets also economize on water. In each toilet, human waste is quickly decomposed into natural fertilizer through aerobic composting. To work effectively it is essential that compost is added to the toilet and each guests is asked to throw 2 scoops of compost, provided in baskets in the bathrooms, into the toilet after each use. By closing the lid to the toilet after each use any odour is drawn up through specially designed extraction pipes, powered by wind above the bungalows.

The lights in each bungalow are powered by photovoltaic solar electricity, with panels located on the roof of each bungalow. These provide enough environmentally friendly energy for normal usage, and will in the future, power computers and other systems planned in the Education Centre. Finally, the openness of the bungalows, with no walls, and open to the sea, allows for maximum through-draft for cooling of the bungalows; a form of natural air-conditioning.

These technologies are extremely new for this part of the world and the architecture is highly experimental. It is hoped that Chumbe will be a leading example of how hotel infrastructure and the environment can exist in harmony. These bungalows are so revolutionary in the field of eco-design that Chumbe has been chosen to represent Tanzania at the EXPO2000 in Germany, where a bungalow has been re-constructed.

As there are only 7 eco-bungalows numbers of guests are limited; in itself a component to ensure that impact on the island environment is avoided. Visitor numbers are carefully controlled and overnight capacity does not exceed 14 guests per night. No further construction of overnight facilities is planned. During low season when hotel numbers are reduced day visitation to the park is allowed, but numbers are regulated to ensure that between the hotel guests and the day guests, total visitor numbers do not exceed 14.

Tourism is a major, possibly *the* major, driving force in the Zanzibar economy. If unchecked, the impacts of tourism can result in serious degradation to marine environment through activities such as: over-exploitation of the fisheries to provide for increased demand for seafood; lack of suitable waste management of hotel facilities; physical damage to coral reefs in the form of tourist boats anchoring on reefs; diving schools with inexperienced divers directly damaging reefs; etc. Unless managed appropriately, where once there thrived a beautiful tropical marine ecosystem and successful tourism industry there may remain only an irreparably damaged environment and bankrupt tourism businesses. It is hoped that the tourism industry may learn from the experimental developments in the infrastructure of the Chumbe Lodge.

Marketing in the eco-tourism niche markets is primarily through the Internet, with a comprehensive and attractive website. As the Global winners of the British Airways Tourism for Tomorrow Award, and as a laureate of the UNEP Global 500 Roll of honour, the associated publicity that follows such honours has been of immense value in marketing Chumbe to a wide audience. The project does not pay for advertisements and does little marketing in the traditional marketing media, as these have proven little responsive.

5. Conclusions.

The concept of the Chumbe project is that with private investment it is indeed possible to set up a self-funding, sustainable conservation project, where the Project itself generates its own revenue through ecotourism to provide protection and care for the environment into the future. As we enter the new millennium it is increasingly essential that conservation projects approach concepts of sustainability in their own right. As long as conservation initiatives continue to rely on long-term external funding from donors for operational costs, sustainability cannot be achieved.

Chumbe has shown that private management can be considerably less costly and more efficient than government-controlled management bodies set up by externally funded donor projects. The Chumbe project receives no donor or other support and depends entirely on income from ecotourism that fully covers the operational costs.

The inevitable links between access to donor funds and the management of these funds through governmental or NGO channels means that in many cases implementation of active conservation strategy at ground level is inhibited by the multi-layered bureaucratic infra-structure inherent in these institutional systems. The pressures for cost-effective management and the drive for sustainability may be far greater in the Private sector than the donor sector, especially where a long-term reliance on donor support has developed, and recipients of funds may not always provide the level of transparency of accounting for the funds as desired.

However, in order for private investors to be attracted into conservation initiatives a conducive political, legal and institutional environment for investment into environmentally related activities is required. Operational risks for private investors are high due to the generally difficult investment climate, lack of long-term security of tenure and legal protection and political insecurity.

As Chumbe has shown, once the project is established, self-reliance has been successful. However, due to the problems described above, getting the project to an operational level is extremely challenging and costly. One of the major economic challenges remains the fact that up to the present, the project has to pay the same taxes and licences to Government as any other tourism operation, and no allowance is given for the non-profit and conservation orien-tation. Meeting bureaucratic and legal demands of, for example, the immigration and labour departments can be enormously cumbersome, both in costs and management time. In the case of Chumbe, a noticeable exception is the efficient co-operation that has evolved with the lead ministry of the project, the Zanzibar Ministry of Agriculture, Livestock and Natural resources.

With conservation initiatives under the auspices of government regulatory bodies, the very conditions that so inhibit private investment in conservation are bypassed. Governmental bodies managing donor-funds for projects are relieved of many of the tax, permit and licence issues that plague the private investor.

Therefore, one may conclude that a combined effort from donors and the private sector may prove to be successful in overcoming the financial risks of private investors undertaking conservation initiatives alone. For the private sector to take on a conservation initiative, support from a donor organisation would alleviate the many problems associated with the current disincentives for private sector involvement in Marine Protected Area management.

For example, as the Chumbe case shows, now that the project has been established, it is successfully funding all operations of the MPA by the revenue generated by that MPA, and is a superb example of sustainable management of a natural resource. However, due to the delays and increases in investment costs accrued over the developmental phase of the project, the finances contributed by the private individual who founded the project, are unlikely to be regained. What this suggests is that whilst the bureaucratic infrastructure of regulatory bodies

in countries such as Tanzania continue to inhibit private investment in MPAs and other natural resource management, donors still have a vital role to play in the funding and assistance in establishment of projects, which may then be operated under commercial premises for sustainability. A case can be seen for more political and donor support to private initiatives related to the sustainable use and management of marine protected areas.

Eco-tourism can be a revenue generating activity within an MPA, and as can be shown by the Chumbe example, may generate the revenue required for full operations of that MPA. The technologies available today mean that conflicts between the potential impacts of tourism and environmental protection can be overcome as long as effective ground level management is in place. For tourism to be successful, it must attract the bracket of visitors in a financial position suitable to the level of revenue required for sustainable operations. For this to be achieved successfully commercial principles must come into action. As long as the incentive is strong to attract visitors and provide the level of service required for the survival of the project, the drive for sustainability remains. Where external funding must continue to cover the operational costs of an MPA, sustainability of that MPA can never be assured.

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(1) Various meetings and discussions have been held with local communities dependent on the fisheries areas surrounding Chumbe. Rangers regularly communicate with fishers in the region who report increased yields downstream the Chumbe MPA.

Supporting Biodiversity – Take the Benefit of Tourism into Account[a]

By: Wolf M. Iwand[b]

Abstract

Today international tourism is one of the fastest growing sectors of the world economy. According to various forecasts, tourism will become the world's most significant economic activity within the next decade. It is by this dynamic that mass tourism is discussed to be responsible for worldwide environmental pollution, for the loss of species, flora, fauna and landscape diversity and the degradation of coral reefs and the marine environment in general.

In 1990, TUI, the European market leader in organized package holidays, created voluntarily as the world's first tour operator a Corporate Department of Environment to establish a feasible management system in order to reduce the impact of several million clients per year on the environment in holiday regions. Since 1990, we are forcing our contracting partners - destination authorities, tourism boards, hoteliers, transport companies - around the world, to implement procedures to reduce or to avoid waste and sewage, over-consumption of water, energy, land and beaches. We did not opt for the so-called "soft tourism" or "eco-tourism" for the politically correct, and happy few. We opted for an integrated systematic approach of including environmental care in the business processes such as monitoring, product planning, purchasing, training, education, and information to reduce the environmental impact of tourism. The common denominator in our company today is: "Quality Management" - and this includes environmental quality standards, environmental quality controls and environmental quality assurance. Whilst so far concentrating on more or less technical aspects as sewage disposal, waste deposits and solar energy, we have identified a new key issue: the capital asset of tourism that is the beauty and attraction of nature, the diversity of fauna, flora, habitat and landscape, and particularly the coral reefs, e.g. in the Red Sea, the Maldives Islands, East Africa, the Caribbean etc.

Sun-and-Beach-Tourism is the fastest growing economic sector associated with coral reefs and is set to double in the near future. For example, one hundred million tourists visit the Caribbean each year, and scuba diving in the Caribbean alone is projected to generate $ 1,2 billion by the next year. On the other hand, the massive increase of scuba diving and bathing tourism can cause nearly immediate detriment to entire coral reef ecosystems.

Coral reefs are the most spectacular and important of the earth’s tropical marine resources, and it is very much to the tourism industry's own vital interest to support the aims of a global Nature Conservation strategy and the protection of coral reefs! This is not the old platitude about the branch we are perched on which, purportedly, nobody is about to saw off; it is the insight that we must handle our capital investment, capital wealth, our treasures, values, assets more economically and profitably.

Tourism does not need just environmental officers, but asset managers or investment consultants who secure this capital and make more of it and prevent losses at all costs. We

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[a] Paper prepared for the EU-Workshop: Policy Options for the sustainable Use of Coral Reefs and Associated coastal Ecosystems; Mombasa, Kenya June 19th – 22nd, 2000

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commit our company to supporting the protection of biodiversity. We increase our professional competence on how to make good use of nature, but to avoid it being abused by accepting and adopting limits, by codes of best practice and by cooperation with parties involved, e.g. local NGOs, experts, scientists etc.

What about funding the "Strategy"? So far, we do not have experience with financial instruments as eco-pricing, eco-taxes, certificates or debt-for-nature-swaps. There is a brutal price battle on the tourism market. The profit margin averages only around 1%. Eco-Sponsoring is done only for very small-scale projects as reforestation or protection of endangered species. Our real "funding" is by investing year after year into a persistent process of growing eco-efficiency to avoid the loss of biodiversity. At the same time, all our environmental activities contribute by raising the consumer's awareness and aiming at the consumer's willingness to pay for the value of nature; because this is the real gatekeeper of funding biodiversity.

We have one recommendation: Take the ecological benefit potential of tourism into account! There is no other economic sector that depends so much on the value and diversity of nature. Compared to most other industries (agriculture, forestry, manufacturing, raw material, oil, chemicals, energy and traffic) sustainable tourism development safeguards biodiversity whilst creating necessary economic development.

At a WTO Asian-Pacific Minister Conference, at Malé, the President of the Maldives Islands presented a calculation, which gives much food for thought. At the fish market on the Maldives, a fisherman gets about 32 U.S. dollars for a shark; as an attraction for scuba-diving tourists – in the underwater area of Ari Atoll, under protection since 1995 – a shark brings about 33,500 U.S. dollars in revenues per year to the Maldives. A thousand times as much in a single year!

Isn’t this a brilliant example for the economic value of coral reefs?

The common denominator with tourism becomes possible through the economic insight of “protection by use”! Beyond the stage of dialogue, co-operation and partnership can be realised with the “right” experts and the “right” selection of steps for sustainable use of coral reefs. In my view “Protection through sustainable use” is a highly significant concept for the tourism industry and for conservationists. The way to get there could be called public-private partnership: If nature conservationists and marine biologists joined forces with tourism organizations, organized and responsible tourism might be the vanguard of sustainable development in many countries and thus support the lasting existence of coral reefs around the world.

Dive Tourism in Coral Reefs - Impacts and Conditions for Sustainability: A Case Study from Desa Pemuteran (Bali / Indonesia) [a]

By: Nicole Piskurek[b]

Introduction

As scuba diving is a booming segment in the tourism market all over the world (and especially in the tropics) with high annual growth rates, it is a logical consequence that conflicts may occur between the economic value and the conservation of coral reefs on which dive tourism depends.

This case study from Desa Pemuteran investigates dive tourism in coral reefs, its impact and the conditions for sustainability. Pemuteran is a widespread village with about 6000 inhabitants located in the Northwestern part of the Indonesian island Bali. Tourism began in 1992 and still is on a small-scale basis due to the remoteness of the area. During the time of research (September to October 1997) there were only two bungalow resorts and three dive centres in the bay. But more are being built. There are five major dive sites offshore (Napoleon Reef, Close Encounters, Temple Wall, Deep Reef, Lebar), two onshore (Kebun Chris, Kebun Batu) and Menjangan Island that is part of Bali's national park. Next to scuba diving there is not much to do: sunrise - or sunset-cruises, glass bottom boat tours, hiking in the national park, watching Balinese dancing or ceremonies etc.

Method of research and analysis

One point of emphasis are interviews with dive tourists utilizing parts of the multi-attribute approach which helps to find out also about the tourists' demands and the level of satisfaction with recreational activities offered in Pemuteran. The multi-attribute model argues that attitudes are determined by cognitive (= needs / importance) and affective elements (= satisfaction). The original formula is as follows (Steinbach 1994 p. 5ff):

$$A_{oj} = \sum_{i=1}^{n} B_i \, a_{ij}$$

where

A_{oj} = attitude towards attribute o in a tourism destination j

B_i = strength of belief about element i of the attributes o = cognitive influence (needs/ importance)

a_{ij} = special evaluation aspect of belief of one element i in a tourism destination j = affective influence (satisfaction).

n = number of the elements i of all possible attributes o (e.g. recreational activities)

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From this model special characteristics were derived:

- the general importance of an element for all the respondents independent of the fact if one uses an offer or not (mean value of grade from 1=very important to 5=not important at all),
- special importance of one element only for the participants of that specific element,
- the level of participation (percentage),
- satisfaction (mean value, grades from 1=very satisfied to 5=not satisfied at all),
- experience level (= special importance / satisfaction)

The interviewed guests replied to the same lists of variables (representing recreational activities) twice. The first list showed activities offered at any tourism destination including those not offered in Pemuteran. The respondents should indicate its degree of general importance. The second list includes only those activities really offered in Pemuteran, and the tourists were required to value the activities they actually used. A third part of the questionnaire sought basic socio-economic and demographic data, and a last part included specific questions for the scuba divers.

Table 1: List of Priority (own survey)

importance	*Element of activity*	*mean value*
1 = very important	1. Scuba diving	1,12
	2. Snorkelling	1,44
2 = important	3. Opportunities for swimming	1,73
	4. Snorkelling in the national park	2,27
3 = neutral	5. Visiting markets	2,63
	6. Balinese Dancing	2,63
	7. (Temple-) ceremonies	2,75
	8. Sunrise-, Sunset Cruise	2,89
	9. Bush Walking in the national park	2,98
	10. Wildlife Watching in the n p.	2,99
	11. Horse back riding	3,05
	12. Car rental	3,07
	13. Traditional Sailing	3,11
	14. Birds Watching in the n. p.	3,31
	15. Mountain Biking	3,47
4 = not important	16. Child care	3,61
	17. Entertainment for children	3,64
	18. Sailing	3,91
	19. Surfing	3,93
	20. Entertainment program in the hotel	3,99
	21. Discotheque	4,27
	22. Cinema	4,33
5 = not important at all	23. Water skiing	4,67
	24. Parasailing	4,79
	25. Jet-ski	4,82
	26. Motorboat	4,85

Only scuba diving and snorkelling received a general grade 1, which means that those elements are very important for the guests. On the other hand, they did not want or need activities like water skiing and similar possibilities.

By the means of a principal component analysis all those elements correlating a lot were combined to one component or factor. Thus the 26 variables (elements of activities) were reduced to 9 factors. Those factors explain 79,4 % of the variance. 5 of the factors (bundle of wishes/needs) are found in Pemuteran (factor 1, 3, 7, 8, 9). A high positive factor value indicates a high level of agreement by the respondents (a value below 0 means disagreement)

Table 2: Principal component analysis summary

Factor 1: „National Park“	* markets * bird watching in the N. P. * bush walking in the N. P. * wildlife watching in the N. P.
Factor 2: „water sports dependent on power“	* water skiing * jet ski * parasailing * motorboat
Factor 3: „Balinese culture“	* Balinese dancing * (temple-)ceremonies * sunrise-, sunset cruise * traditional sailing * horse back riding
Factor 4: „organized entertainment programs“	* entertainment for children * child care * entertainment program in the hotel
Factor 5: „evening entertainment“	* discotheque * cinema
Factor 6: „water sports dependent on wind“	* sailing * surfing
Factor 7: „snorkelling/swimming“	* snorkelling in the national park * opportunities for swimming * snorkelling * entertainment programs in the hotel (negative!)
Factor 8: „transportation“	* mountain biking * car rental * Balinese dancing (negative!) * (temple-)ceremonies (negative!)
Factor 9: „Scuba diving“	* scuba diving * opportunities of swimming (negative!)

The next analytical approach was to find out how the socio-economic characteristics influence these factors. The statistical method used was variance analysis. ‘Scuba diving’ e.g. is significantly influenced by the characteristic ‘profession’ and ‘home country’. In the first group the mean value assigning the least importance is still higher than 1.4. (Salaried) employees, teachers/scientists and housewives gave 1.0. For those working as a freelance the wish for scuba diving was - compared to the others – least important (1.36). Students value an average 1.2. Although there are slight differences, scuba diving is very important to everybody. Similar conclusions apply to the characteristic ‘home country’: Scuba diving rates an average 1.12. Because of such a rating it is clear that only very „pre-formed“ tourists come to Pemuteran.

Table 3: Influence of the tourists' characteristics

	Characteristics					
„bundle of wishes“	sex	profession	home country	number of inhabitants	travel partner	time when beginning with diving
national park	.	.	.	.	.	.
water sport dependent on power	.	.	.	.	* (0,023)	.
balinese culture	.	.	.	.	.	.
organized entertainment programs	.	.	* (0,018)	.	.	.
evening entertainment	.	.	.	* (0,031)	.	.
water sport dependent on wind	.	** (0,003)	.	.	.	.
snorkeling/swimming	.	.	** (0,004)	.	.	* (0,019)
transportation	* (0,018)	.	.	* (0,024)	.	.
Scuba diving	.	* (0,023)	* (0,013)	.	.	.

Level of significance		**meaning**	**symbol**
$p > 0,05$	=	not significant	.
$p \leq 0,05$	=	significant	*
$p \leq 0,01$	=	very significant	**

Source: Bühl & Zöfel (1998: 111-112)

A good way to show a possible deficit is the value of the ‘experience level’ (=quotient of special importance and satisfaction). An experience level < 1 indicates deficits as the average importance is higher than the average satisfaction and on the other side an experience level > 1 tells that there is no deficit. It is remarkable for Pemuteran that there are only deficits concerning scuba diving and the swimming opportunities. Not because of the dive sites themselves, but because of pricing and old rental gear. Besides recreational activities the respondents were also asked to give marks concerning pricing and hospitality.

Socio-economic impacts

Surveying the socio-economic impacts is very difficult. The planned interviews with locals using a questionnaire couldn’t take place, as they did not like to answer very personal questions. But in personal conversations they were very cooperative and these helped to understand their reasoning. Nevertheless, it can be said that there are hardly any obvious impacts yet. Most of the people still live their traditional lives far away from the tourism taking place at the beach. But even those living right in between the resorts seem to be hardly affected by tourists. All of them were open to get in contact, but would never bother the guests (like it happens at other areas in Bali). Both locals and guests show a very sensitive and respectful attitude towards each other.

Thanks to tourism, Pemuteran, once one of the poorest areas in Bali, became much more self-supporting and independent. Even though the main income goes to the owners of the resorts

etc. there are still direct sources of income for the village and its inhabitants. E.g. the fee of Rp. 5,000 per day per guest (which sums to approx. Rp. 15.5 millions a year) is exclusively for the locals. This money is administered by the LMD and is used to improve the medical health system or school system.

The locals also get the chance to learn as a trainee even without a specific qualification in tourism and can make their way up by learning by doing. Some of them even receive training to become a dive master with an international certificate (PADI). With such a certificate it is very easy to find an employment all over the island. Locals also receive money in form of donations and sponsorships by tourists.

Ecological impacts

The damage caused by scuba divers seems to be very little in comparison to the worldwide pollution, sedimentation, sewage etc. But as the total number of divers grows each year more and more divers may destroy more and more corals. In a study in Florida it was found out that a diver touches corals around seven times during a 30 min. dive (mainly with the fins, pressure gauge or other parts of the equipment). Especially underwater photographers and their models represent a possible danger for the fragile ecosystem (models posing right in between coral blocks or Photographers holding on to corals as they are not neutrally buoyant). While diving underneath an overhang or inside a cave the exhaled air can cause such a big air bubble that marine organism fall dry and die. Equally damaging are those divers walking on top of the reefs during low tide to reach the dive site.(compare Wells & Hanna 1992, pp. 134).

In Pemuteran the reefs were more threatened by local fishermen and their fishing methods than by diving tourists. The traditional way of fishing consists of using big nets very close to the reefs. Dynamite and cyanide are also used. When the locals realized the decrease in fish population they did not understand that it was also their fault. After countless conversations with the locals in the beginning of the tourism development one of the main problems became clear: the locals did not understand why to protect resources for the future if they need to survive today. By the means of underwater videos the locals could experience what a healthy reef looks like and how much fish there could be. Simply by talking, explaining and showing those videos the locals understood and started to protect "their" reefs themselves. So an unofficial marine reserve was born.

There are many other existing programs to protect the environment in Pemuteran:

- The number of divers is limited to a maximum of 10 per reef/per day,

- mooring buoys at the dive sites, so that no anchors destroy the reefs,

- rest stations for snorkelling

- turtle hatchery etc.

Strategies for sustainable development

After all the surveys and analysis it is concluded that the concept of carrying capacities and the critical threshold level is a good basis approach to guarantee a sustainable development. After Prosser the definition of carrying capacities is the:

„level of use...which a natural resource can sustain without an unacceptable degree of deterioration of the character and quality of the resource or the use of that resource" (Prosser 1986, as quoted by Davis & Tisdell 1996)

In a survey conducted in Bonaire Marine Park a critical level of usage above which degradation begins was defined. This critical threshold level was estimated to be 5.000 dives per year per dive site, which means a carrying capacity of 200.000 divers per year (in Bonaire Marine Park). Based upon this experience Dixon developed a simple model of relationship between diver density (number of individual dives) and threshold stress level. It relates a perceived stress threshold on the marine ecosystem to the intensity of diver use.

The following diagram tries to illustrate this concept.

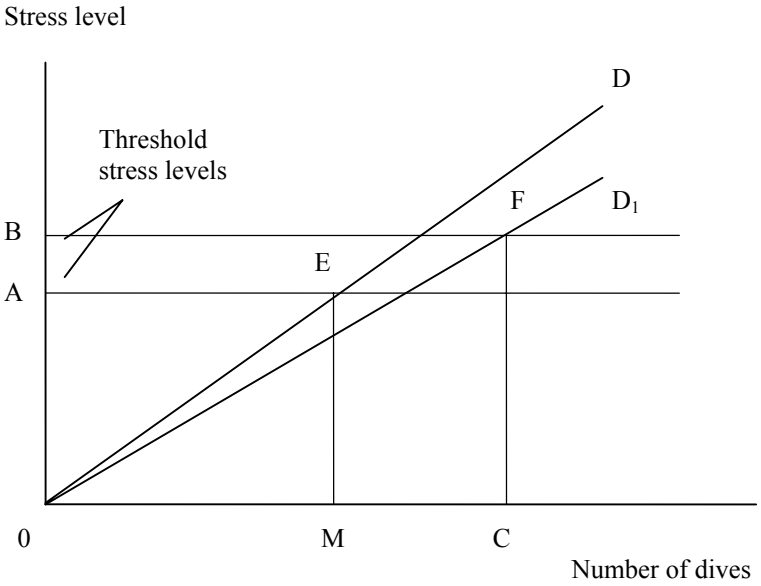

Fig 1: Threshold stress level of dive numbers (after Dixon et al., 1993)

Level A indicates the threshold stress level at which reef degradation becomes obvious. Below that level minimal to no degradation is visible. Above it the coral cover decreases as well as the visibility and species diversity. The graph OD is the damage function that measures the damage caused by scuba divers. In E the number of dives (M) reaches the threshold level. With special management or precautions the threshold level can be raised from A to B with the result of a new damage function OFD_1

Referring to Pemuteran other approximate values than for Bonaire are recommended. At Napoleon reef an estimated 1.026 dives per year took place; at Close Encounters 880, at Kebun Chris 540 and at Pura Tembok 400. In comparison to Bonaire the total number of individual dives was far below the critical level, but as the reefs already show degradation, due to the combination of stress factors, the critical threshold level was defined at 1.500 to a maximum of 2.000 dives per year per dive site. Especially as the guests of the other three existing dive shops in Pemuteran could not be taken into consideration.

Not just the fragile ecosystem will profit from a diver limitation, but also the tourists themselves. Every diver wants to dive in a healthy, unspoiled reef and is happy not to share it with many others at the same time. The scuba diver seeks the ‘wilderness experience’ (Davis & Tisdell 1996, p. 234).

Measures for adhering to the carrying capacities

1. Rotation of dive sites

To avoid an overuse of special reefs like e.g. Napoleon, a rotation of the sites should happen. The problem is that Napoleon is the favourite dive site for nearly everybody. Therefore it might help to make a different pricing for the single reefs. To make others more attractive for

guests a dive at Napoleon could be more expensive compared to dives at Close Encounters. So a rotation in favour of more damaged reefs can be reached. But also within one reef itself the rotation can be applied in the way of different underwater routes in order to avoid typical 'dive roads'.

2. Limitation of access to the dive sites

Divers without a proper dive qualification or showing no sense of responsibility should be excluded. Certification cards and logbooks of any new dive guest need to be checked. In a first check dive under the supervision of an instructor or dive master the divers have to demonstrate their qualifications like the ability of being neutrally buoyant etc.

As soon as a diver touches the corals on purpose he/she should be excluded from all the following sites (a measure already applied at the Great Barrier Reef in Australia).

3. Regulation of underwater photography

Very close to the method of 'limitation' is the mean of regulating the underwater photography. Photographers in particular have relatively many contacts with the corals and are therefore responsible for quite a lot of coral damage; either by holding on to coral blocks in order to be stable or by kicking too close to a sandy bottom so that the silt is stirred. The best would be to have a special check dive for photographers as well where they can demonstrate their skills.

Unfortunately in theory it sounds easy, but in reality the economic factor is often more important than the ecological. By regulation and limitation a dive shop could lose quite an amount of money. The benefits for the environment are not important enough when the profit for the dive shop owner is too low.

4. Search for alternative dive spots including artificial reefs

Besides a limitation of the total number of divers at one reef, new reefs can be developed as dive sites. New dive sites mean a change and improvement for Pemuteran as a dive destination. For example, old wooden fisher boats sunk on the sandy bottom close to the shore are very popular 'easy dives'. Creating artificial reefs offers another very environmentally friendly alternative. The university of Essen developed and tested the procedure of electro-chemical precipitation. (http://www.geologie.uni-stuttgart.de/IYOR/infos/ SCORE.html).

These artificial reefs can become real underwater marine theme parks with different modules like one for photographers, one for practicing diving skills, another for educational purposes etc. A big problem is the financing of such a theme park. If the Indonesian government were interested in developing the dive tourism, then there would be public money. Cooperation with environmental organizations like the WWF Indonesia or maybe PADI AWARE could constitute other opportunities for sponsoring.

An easier way to find alternatives is to offer the guests to participate in exploring dives – this would mean that tourists get the chance to dive for the very first time at a yet unknown reef, which might get developed as an official dive site later on.

5. Improving the divers' education with emphasis on environmental awareness

Even if no certification courses (including specialties like underwater naturalist) can be offered a dive guide can always try to educate and sensitise the diver for environmental awareness.

6. De-marketing

Every interviewed tourist stated that Pemuteran should not change, but stay as it is: Offering diving on a small-scale base in a remote area away from the tourism centres. But this wish is unrealistic as more and more people start to dive and want to experience dive holidays in nice

places. A chance to slow down this development lies in de-marketing. E.g. there is no real promotion for Pemuteran as a dive destination yet (it's even hard to find Pemuteran in dive guides). Most of the tourists learned about this place by accident (passing by and seeing a sign) or by friends' recommendations. The fewer people know about a place the easier it is to develop it on a small-scale base. But tourism operators in Pemuteran are of course not interested in a stagnation of the tourism development.

7. Diversification of the structure of the offered activities for tourists

For the future tourism planning in Pemuteran one should diversify the offered activities to attract other groups of travellers than divers so that the reefs get a rest. A new offer for the tourists is horseback riding in the mountains or along the beach. As experiencing the nature is one of the main goal of the tourists guided walks with locals aside the typical tracks in the national park is another option. To involve even more inhabitants of Pemuteran in tourism activities they could offer cooking or dance courses.

8. Establishment of a MPA

In theory the best for the environment in and around Pemuteran is the status of an official national or marine park, but if you look at the reality it seems to be utopic. The government shows no interest. The organization WWF Indonesia has already tried to achieve official protection of the area for several years without any success. But at least the existence of the unofficial marine reserve works. Maybe even better than an official one due to the fact that in Pemuteran the locals understand why they need to protect their reefs, not just for the benefits of tourism but also for their own. An improvement would be the help of WWF and a better education in environmental protection of the locals.

Summary

Dive tourism is predestined to be developed in a sustainable way, as diving is dependent on an intact environment with healthy reefs. Several millions of people spend their holidays close to coral reefs. For many countries reef tourism is the main source of income. Although tourism can destroy reefs, with the adequate management strategies it can help to preserve the environment. Pemuteran still is a very positive example and other places where tourism just begins can learn from the progress of Pemuteran.

Altogether further surveys and research need to be done in order to better understand this branch of sport tourism and how to turn it into an important sector of a sustainable development. It remains to be hoped that the village itself realizes the importance of a sensible treatment of the environment and continues to integrate tourism in a socially sustainable way. Otherwise the tourism development will destroy not just the reefs but also the Balinese culture and tradition.

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Summary of discussion second section of panel 1

By: Heidi Wittmer

The discussion centred around two main issues: The impact of Marine Protected Areas (MPA) on fisheries and the importance of local communities' participation within coastal resource management.

The effects of marine protection on fish yield were further explored during the discussion. It was positive in the two cases presented. There was a notable catch decline further away from the MPA. It was, however, also noted that as a consequence of establishing the MPA there were now more fishers in smaller areas (i.e. reduced accessible fishing grounds), a situation that can easily increase conflict among fishers. Likewise the distribution of costs in form of income forgone and benefits for example through tourism related activities as a consequence of MPAs within a community is far from equal and requires special attention.

The fact that young people move out of traditional fishing was considered beneficial because it takes stress away from marine resources. Understanding the livelihood systems of coastal communities was therefore considered an important prerequisite for successful policies to address development and overcome poverty in these communities. Questions were raised in how far national policies match the needs of local people. Empowering local communities was discussed as one option to improve their position and to increase the effect of conservation measures.

The need that tourism should operate in favour of conservation was stressed. (The issue of tourism was further debated in panel 3). Finally, participants stressed the importance of analysing the impact of globalisation especially through trade in world markets for reef conservation. This refers to aspects like higher demand for fish products and especially seafood as well as the increasing demand for aquarium fish and live corals.

Panel II: Technical Options for Coral Reef Rehabilitation and their Policy Implications

Contents

Rehabilitation of coral reef areas needs a multisectoral approach. Besides some technical options available at present, there are only a few other tools applicable for the halt and reverse of the decline of coral reef areas, e.g., Marine Protected Areas (MPAs). Rehabilitation of coral reef areas therefore requires integrated coastal zone management in its full extent and equally has to address politicians, scientists, managers, governmental organisations (GO) as well as NGOs. The coastal communities need to be regarded as obligatory, integral part of coral reef restoration processes and in fact represent the socio-economic target group.

At present the international community involved in coral reef rehabilitation faces a combination of two major problems: (i) rehabilitation of coral reefs proves to be a long-term process. Reversal effects that allow a sustainable use of coral reefs seem to occur only after decades or even generations, (ii) on the international level only little experience is available regarding coral reef rehabilitation processes compared to the overwhelming demand for immediate actions from a large number of countries.

The presentations of panel two will reflect on the necessary preconditions for coral reef rehabilitation activities: First, technical options for rehabilitation and the necessary political frame conditions are illustrated using three examples. In the second contribution basic biochemical tools for identification of stressed coral reef areas are presented. The third paper shows the application of a simple Coral Damage Index (CDI) for rapid assessment of impacts on reefs. The fourth contribution will discuss the potentials of aquaculture for 'coral reef management' 'rehabilitation' and 'sustainable use of renewable reef resources'. Finally the interaction between natural processes of beach formation and contamination through human use are analysed in order to derive implications for the integrated management of coastal zones.

Coral Reef Rehabilitation – Technical Options and necessary Political and Socio-economic Frame: Experiences from Jordan, Egypt and Kenya [a]

By. Lothar Schillak[b] Mohammed Shokry Ahmed Ammar[c] and W.E.G. Müller[d]

Transplantation of coral species to electrochemical produced hard substrata: *Stylophora pistillata* (ESPER, 1797) and *Acropora humilis* (DANA, 1846)

Abstract

24 recruits of *Stylophora pistillata* and *Acropora humilis* (12 each) were transplanted to a cathode mesh of a DC electrolytic system (ARCON® technology) in the Middle Reef off Hurghada, Egypt, Red Sea. Fed by solar energy the coral nubbins were embedded into the ARCON® substrate during the precipitation phases. The recruits were distributed across one half of the cathode (0.6 m^2) surface with a mean distance of 9.35 cm to each other.

After 5 month the precipitated substrate showed a maximum thickness of 18 mm with maximum crush strength of 256.0 kg/cm^2. Transparent cuts of the phase limits between the artificial substrate and the coral skeleton showed a direct connection between the molecular lattice of the electro-chemical produced substrate and the molecular lattice of the coral skeleton.

The highest mortality was found for the recruits of *A.humilis* (75.0%). The growth rate of *A.humilis* was measured with 3.2 mm/month. The number of new buds on the surviving recruits of *A.humilis* was counted with a mean of 3,4 buds per recruit within the investigation period of 8 month. The highest number of buds per *A.humilis* recruit was counted with 6.

In contrast the recruits of *S.pistillata* survived to 83.4 % with a growth rate of 3.6 mm/month. The productivity of the *S.pistillata* recruits during the investigation period was considerably high: a mean of 14.2 new buds per recruit was counted for the *S.pistillata* nubbins. The highest number of buds per recruit was counted with 27.

After 8 months the tissue of transplanted *S.pistillata* nubbins did not contain any heat shock protein (HSP 90 / HSP 70). In contrast HSP 90 was found in the tissue of *S.pistillata* colonies from reef areas in close vicinity of the ARCON® unit.

The results are discussed for the suitability and applicability of the ARCON® technology within the frame of coral reef rehabilitation.

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Introduction

The present study for the transplantation of coral nubbins has been conducted in the year 2000. The project area, the 'Middle Reef', is situated in the sublittoral off the Marine Biological Station in Hurghada, Egypt, Red Sea. The experiments were run for 8 months including 2 monitoring phases after 5 and 8 months.

Materials and Methods

Electrochemical Substrate

The substrate for the transplantation of stony coral species is produced by the aid of the ARCON® technology (**A**rtificial **R**eef **CON**struction). The ARCON® technology uses the principle of electrolysis in seawater with a low voltage DC regime. Installed in the sublittoral of the project area the anode-cathode system is fed by an external, land based energy supply. The underwater cathode represents the basic material for the precipitation of the substrate.

The principal installations of the ARCON® technology are shown in figure 1.

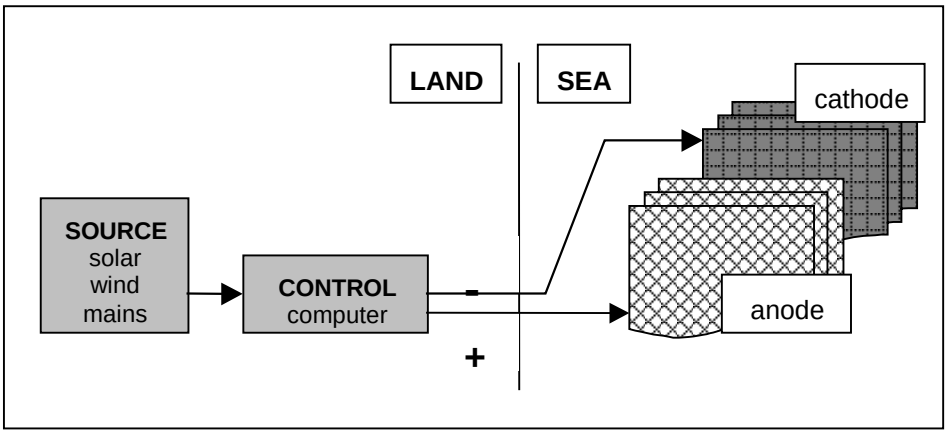


Figure 1: Principal scheme of the ARCON® technology

For this study a single solar panel, type SIEMENS SM 110 L (mono-crystalline system), was taken as source of energy. The unoccupied voltage is given as 21.75 V, the occupied voltage as 12.35 V mpp (maximum power point) and the occupied current as 5.91 A mpp. The active solar area is 0.75 m^2 (1135x66cm).

A smaller ARCON® unit with a total extension of 0.6 m^2 cathode surface was installed in the Middle Reef. An iron mesh (mesh size 0.5x0.5 cm, wire 0.7 mm) was taken as material for the cathode whereas the anode was formed by a special Titanium (Ti) mesh (mesh size 4.5x4.5 cm, lozenge) coated with a mixture of metal oxides (Cerid=O_2-RR) to ensure the necessary optimal conductivity in the system. The anode mesh kept a distance of approximately 16.0 cm to the cathode to allow the transplantation of coral nubbins and their growth.

The ARCON® unit was fixed horizontally to a sandy patch in the reef flat of the Middle Reef at a water depth of 2.0 m. It was connected by electric underwater cables to the solar panel, which was installed on the roof of the nearby laboratory of the Marine Biological Station in Hurghada.

After 5 months samples of the precipitated substrate were analyzed for the flexural strength and the crush strength. The samples were cut into cubes with an approximate volume of 1000.0 mm^3. Each of the cubes was then weighted until the destruction of the cube.

Additional samples were taken for the analysis (x-ray diffraction) of the major substrate compounds.

For the investigation of the interactions between the coral skeleton and the artificial ARCON® substrate at the phase limits of the two different molecular lattices, a sample of the substrate with a coral nubbin was embedded into an artificial resin which allowed for the production of a transparent cut. The sample was analyzed with polarized light (microscope).

Transplantation of Coral Nubbins

12 recruits each of *Acropora humilis* and *Stylophora pistillata* were implanted into the cathode mesh without any glue. Since the recruits are embedded by the substrate during precipitation no glue for fixation was necessary. The height as well as the number of branches for each recruit was determined as well as the distance between the recruits.

The other half of the cathode was not implanted with coral recruits in order to investigate the settlement and colonization by free swimming larvae of different other marine organisms.

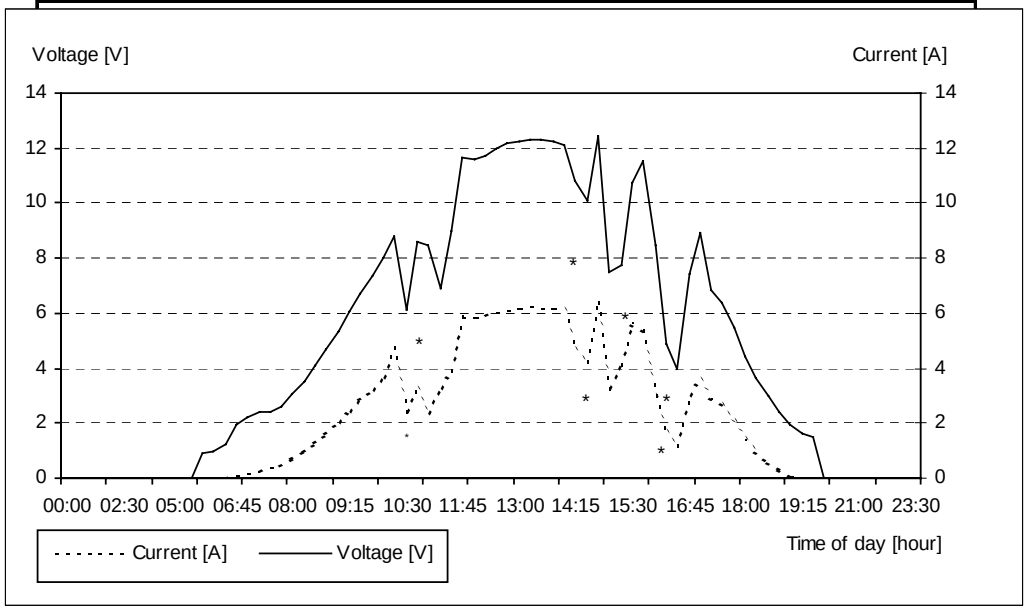
Predation of the recruits and other marine settlers by larger fish species (e.g. parrotfish) was excluded since the anode mesh (mesh size 4.5x4.5 cm, rhombic) was wrapped around the cathode mesh.

After 5 and after 8 months the ARCON® unit described above was monitored for (i) the functionality of the DC current system, (ii) the thickness of the precipitated substrate, (iii) the vitality and growth of the implanted coral recruits, and (iv) the abundance of other marine organisms on the substrate.

Biochemical Analysis

The tissue from transplanted recruits of *S.pistillata* as well as tissue from *S.pistillata* colonies in close vicinity of the experimental area in the Middle Reef were analyzed for their content of stress proteins as described before (Wiens et al. 2000). In brief, tissue samples of the coral nubbins was extracted in 0.1 M Tris (pH 6.8) and kept below 4.0 °C. The extracts were centrifuged for 15 minutes at 850 x g and 4.0 °C to separate the zooxanthellae from the coral tissue. The supernatant (i.e. the coral tissue) was then centrifuged for 15 minutes at 12,000 x g and 20.0°C to separate cellular debris and larger organelles (Ford and Graham, 1991). The supernatant was then frozen for analysis of the determination of HSP proteins. After centrifugation the supernatants were collected and protein content was determined (Lane, 1957).

The protein samples (approximately 15 µg/slot) were subjected to electrophoresis in polyacrylamide gels containing 0.1% $NaDodSO_4$ (PAGE) as described by Laemmli (1970). For Western-blotting experiments the proteins were electro-transferred to PVDF-Immobilon P membranes using a semi-dry blotting apparatus (Wiens *et al*. 1998). The membranes were incubated with monoclonal antibody against HSP90 (McAb-HSP90; 1: 500 dilution) for 1.5 hrs at room temperature, followed by incubation with peroxidase-conjugated anti-mouse IgG and CSPD; the blots were evaluated using a Model GS 525 Molecular Imager (Bio-Rad) (Stanley and Kricka, 1990). The monoclonal antibody directed against the old *Ashley ambisexualis* HSP90, which also cross-reacts with vertebrate and plant HSP90s (H1775) was used and purchased from Sigma (Deisenhofen, Germany). In parallel, the blots were incubated with monoclonal antibody against heat-shock protein-70 [anti-HSP70 antibody



(bovine); H 5147; Sigma] as described (Schröder *et al*. 2000). The immunocomplexes were visualised using the labelled secondary anti-mouse IgG.

Results

DC regime and substrate precipitation

Figure 2 shows the DC characteristic of the ARCON® unit triggered by the solar energy. The diagram represents the situation of a day when the sky was temporarily covered by clouds subsequently leading to considerable drops in voltage and current.

(* = drop of solar energy due to cloud cover)

Fig. 2: DC characteristic of ARCON® unit

Coral recruits

Figure 5 presents the implantation scheme of the relevant cathode surface with distances given in cm.

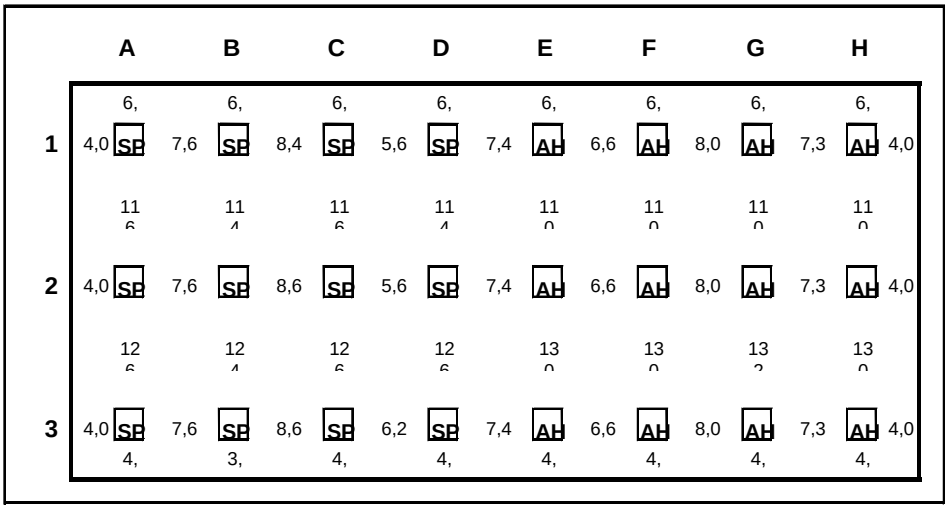


Fig. 5: Implantation scheme of *A.humilis* (AH) and *S.pistillata* (SP) recruits on the cathode mesh; figures indicate distances in centimeters

The mean distance between the recruits was 9.35 cm ± 2.51 (n=37, max: 13.2, min: 5.6). Prior to substrate precipitation the transplanted coral recruits showed a mean height of 5.38 cm ± 1.33 (n=24, max: 9, min: 3). The mean number of branches (i.e. bifurcations longer than 5.0 mm) was 4 ± 2 (n=24, max: 9, min: 0). Five months after the system was connected to the solar panel all of the recruits were still in place, tightly locked to the cathode and cemented by the precipitated substrate.

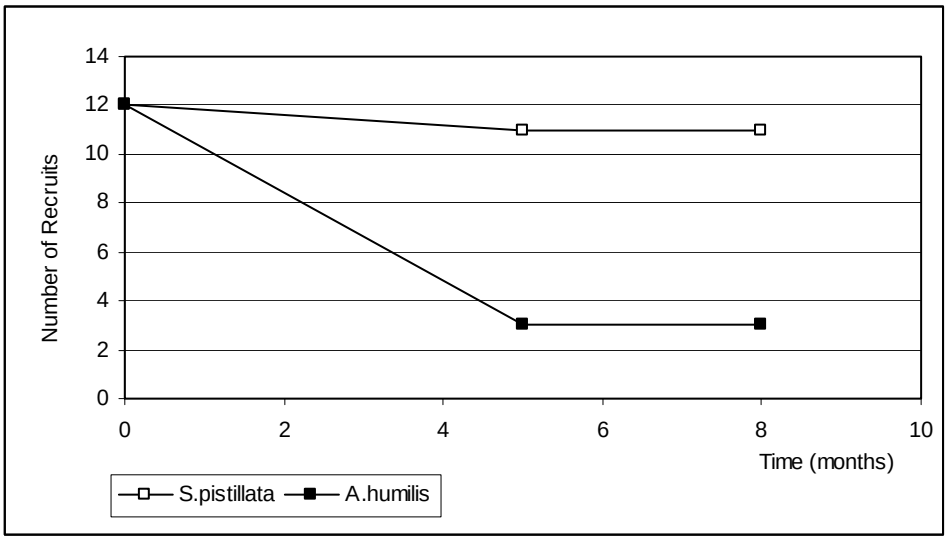


Fig. 6: Survival of recruits

Nine recruits (75.0%) of *A.humilis* were found dead, 2 recruits showed partial mortality (16.7%) and only 1 recruit (8.3%) was still alive. The recruits of *S.pistillata* on the contrary survived to 83.4% (10 recruits). Only 1 recruit (8.3%) showed partial mortality and 1 recruit

(8.3%) was found dead. During the second monitoring mission at the end of the pilot study, 8 months after the start of the substrate precipitation no additional mortality was found. During the investigation period of 8 months the height of the transplanted *S.pistillata* recruits increased by a mean of 2.9 cm (± 1.19, n = 9, max.: 5.3 cm, min.: 0.6 cm). The recruits of *A.humilis* increased in height with a mean of 2.6 cm (± 0.17, n=3, max.: 2.7 , min.: 2.4).

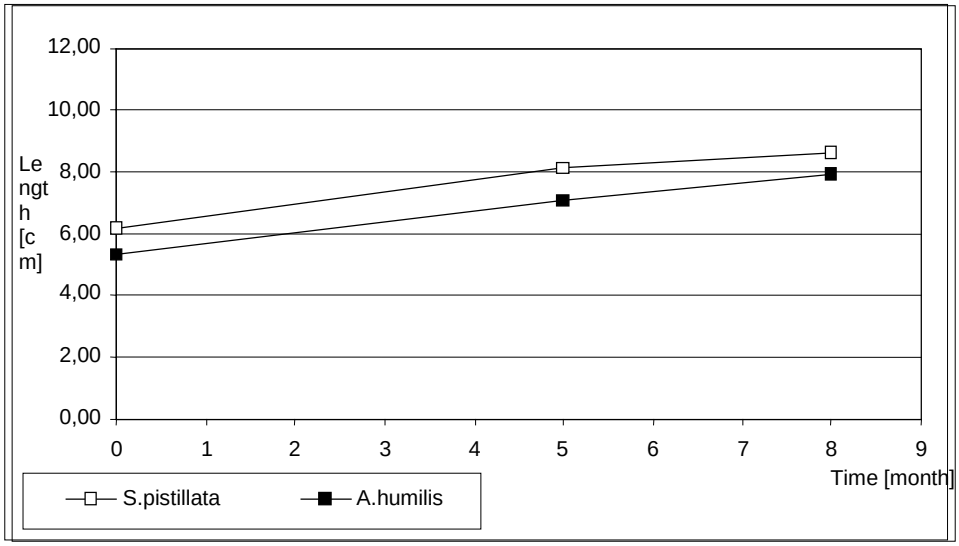


Fig. 7: Growth of recruits of *Stylophora pistillata* and *Acropora humilis* (mean values)

The mean growth rate during the period of 8 months for *S.pistillata* was 3.4 mm per month. *A.humilis* grew at a rate of 3.3 mm per month. The recruits of both species showed a rapid increase in height during the first 5 months of the investigation period i.e. during the precipitation phase. *S.pistillata* recruits grew with a mean of 2.1 cm (4.2 mm per month) and *A.humilis* recruits grew with a mean of 1.7 cm (3.4 mm per month).

Figure 8 displays the growth rates as mm increase per month.

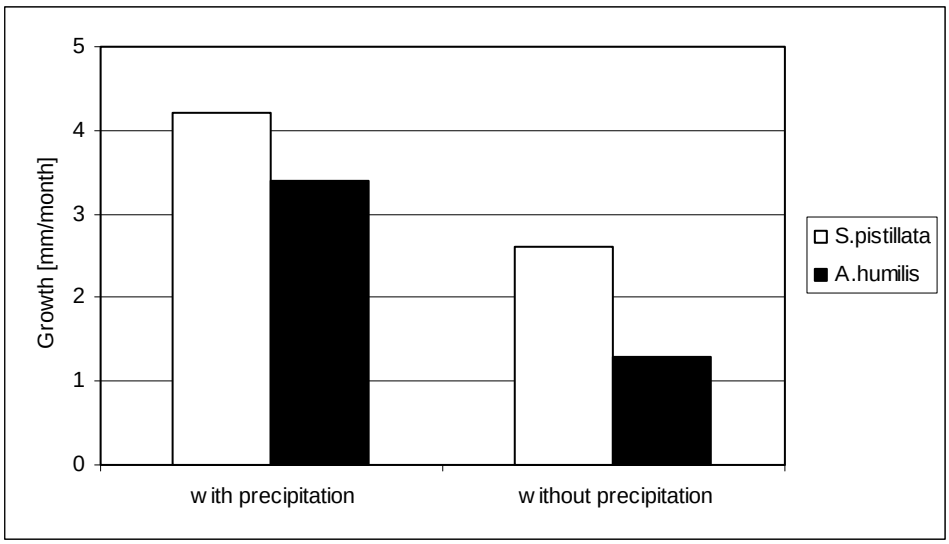


Fig. 8: Mean growth rate [mm/month] of *Stylophora pistillata* and *Acropora humilis* recruits with (months 0 to 5) and without (months 5 to 8) precipitation

The increase in height significantly slowed down during the last months (5. to 8. month) of the investigation period i.e. after the precipitation phase: *S.pistillata* grew with a mean of 0.8 cm (2.6 mm per month) and *A.humilis* with a mean of 0.4 cm (1.3 mm per month).

During the precipitation phase of 5 months the length of the recruits increased by 37.3 % for *S.pistillata* and 36.1 % for *A.humilis*. After the precipitation of the ARCON® substrate was stopped (months 5 to 8) the increase in length slowed down to 12.1 % for *S.pistillata* and 6.6 % for *A.humilis*.

After 8 months the number of new buds produced by the surviving coral nubbins on the ARCON® substrate was counted.

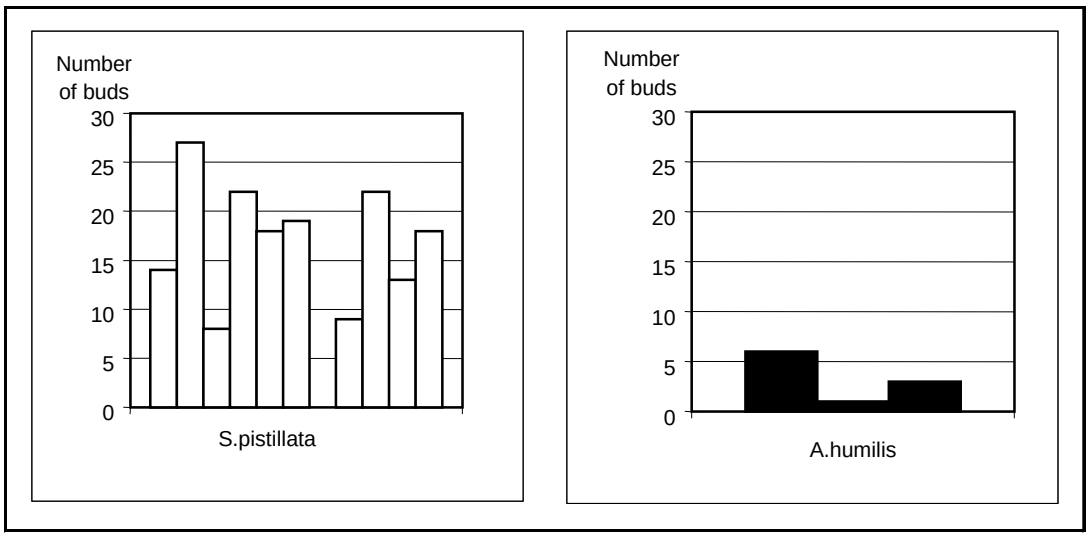


Fig. 9: Number of buds on coral recruits embedded in ARCON® substrate

The mean number of new produced buds in *S.pistillata* recruits is 15.5 ± 7.7 (n=11, max.: 27, min.: 0). *A.humilis* recruits, in contrast, only produced a mean of 3.3 ± 2.5 (n=3, max.: 6, min.: 1) new buds.

The detection of the interactions between the crystal lattice of electrochemical produced ARCON® substrate and the crystal lattice of the coral skeleton (recruit of *S.pistillata*) revealed that both crystal systems are able to closely connect its lattice to the other system.

Transparent cuts (approx. 2,6 cm^2 large) analyzed under polarized light display several (>20) connection points where artificial lattice (ARCON®) and natural lattice (from coral skeleton) and directly stuck to eachother.

Expression of the heat shock protein HSP 90

In a previous report it was documented that the octocoral *Dendronephthya klunzingeri* express the heat shock protein (HSP) with a M_r 90 kDa in response to environmental stress (Wiens et al. 2000). In the present study the level of expression of HSP 90 was successfully determined using the hexacoral *S.pistillata* in dependence of the exposure either to the natural or to the ARCON® substrate. In the first series of experiments it was attempted to resolve the protein pattern from extracts of this coral species.

However, this approach failed (Fig. 10A); both the extract obtained from *S.pistillata* specimens obtained from the field (lane a) and from the ARCON® substrate (lane b) resolved no bands. Applying the technique of Western blotting the proteins from tissue samples of

S.pistillata from the field and from animals, grown on the ARCON® substrate, were subjected after PAGE to Western blotting using antibodies against HSP 70 and HSP 90. The blotting experiments revealed that no signal could be obtained using antibodies against HSP 70 (Fig. 10B), irrespectively of the origin of the animals which were taken for extraction of the proteins (lanes a and b). However, if the blots were treated with anti-HSP 90 antibodies the protein samples from *S.pistillata* taken from the field gave a bright signal (lane a), while the extract from a specimen grown onto the ARCON® substrate did not contain measurable HSP 90 (lane b).

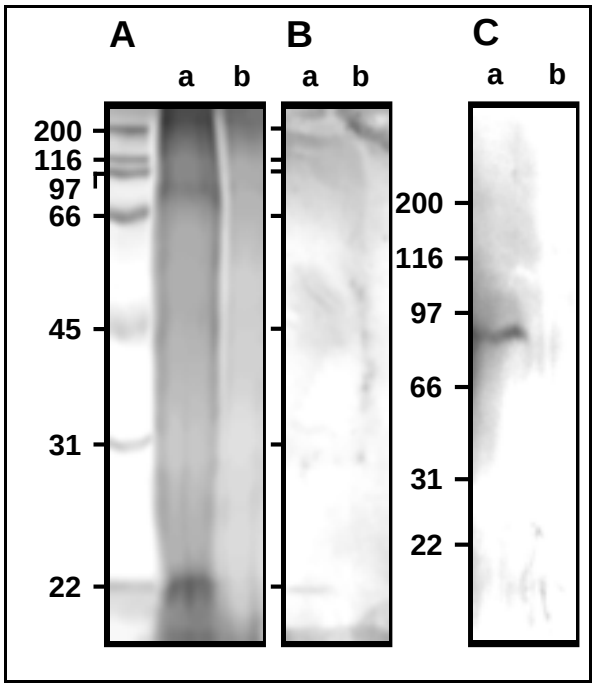


Fig. 10: SDS gel electrophoresis (A) and Western blots (B and C) were performed to detect either HSP 70 (B) or HSP 90 in *Stylophora pistillata* tissue (C).

The extracts from animals from the field (lanes a) or from specimens which grew on the ARCON® substrate (lanes b) were separated and either stained for protein using with Coomassie brilliant blue (A) or were blot-transferred and reacted with anti-HSP 70 (B) or anti-HSP 90 (C). The protein size markers are given at the margins. The percentage of the polyacrylamide gels were as follows: A and B: 12% (continuous concentration); C: 4-20% (gradient).

Other marine organisms

In total there are 20 records of different marine organisms on the ARCON® unit distributed to 7 major taxa (phyla). Besides the Algae sessile faunal elements have been found with the Annelida (Polychaeta, Sedentaria), the Cnidaria (Octocorallia) and the Porifera. The Rhizopoda (Foraminifera) are defined as semi-sessile since they are capable to move within a restricted range. Mobile faunal elements are represented with Mollusca (Bivalvia, Gastropoda), Crustacea (Decapoda, Ostracoda) and Hemichordata (Enteropneusta).

Tab. 1: Other marine organisms on the ARCON® substrate; "recruits": part of the cathode implanted with coral nubbins, "empty": part of the cathode left free

Pos.	Taxonomic Group	Genus	Species	Records	
				recruits	empty
1	Algae, Chlorophyta	*Halimeda*	*tuna*	+	-
2		Indet.		-	+
3	Annelida, Polychaeta	Indet.		-	+
4	Crustacea, Decapoda	*Alpheus*	*sp.*	-	+
5		*Lysmata*	*kükenthali*	-	+
6	Crustacea, Ostracoda	Indet.		-	+
7	Cnidaria, Octocorallia	*Tubipora*	*musica*	-	+
8	Rhizopoda, Foraminifera	*Amphisorus*	*sp.*	-	+
9		*Hauerina*	*sp.*	-	+
10		*Peneroplis*	*planatus*	-	+
11		*Peneroplis*	*sp.*	-	+
12		*Quinqueloculina*	*sp.*	-	+
13		*Sorites*	*sp.*	+	+
14		*Triloculina*	*sp.*	-	+
15		*Textularia*	*sp.*	-	+
16	Hemichordata, Enteropneusta	Indet.		-	+
17	Mollusca, Bivalvia	*Trapezium*	*oblongum*	-	+
18	Mollusca, Gastropoda	*Barbatia*	*lacerta*	-	+
19		*Strombus*	*lentiginosus*	-	+
20	Porifera	*Stylostellay*	*auranthum*	+	+

Further observations of the ARCON® unit in the Middle Reef, Hurghada, also prove the acceptance of the substrate by fish. The unit was fixed to a sandy patch leaving a considerably large space between the sandy surface and the cathode mesh. After precipitation of the substrate this crevice was occupied by two individuals of *Pomacentrus taeniurus* Bleeker 1856, which were able to also patrol through the anode mesh. During the second monitoring phase after 8 months, when substrate samples were taken for the examination of marine settlers on the substrate, these individuals showed a very aggressive behavior towards approaching divers.

The examination of the substrate revealed the reason for this behavior. On the substrate surface orientated towards the crevice a clutch was found, obviously hatched by the aggressive individual observed when the sample was taken. The number of eggs was estimated to range between 300 and 500 on an area of 675.5 cm².

Discussion

Physical characteristics of the ARCON® substrate

The precipitation rate of the ARCON® substrate within the predefined conditions of (i) the DC regime, (ii) the area of the cathode and anode as well as (iii) the distance between cathode and anode is considerably high. Detailed data from other scientific experiments with the ARCON® technology do not exist. Since the substrate is produced in the natural environment there are large variations in the thickness of the precipitated substrate layer. These variations are as well reflected in the crush strength of the substrate. Especially Hilbertz 1979 report similar results from the Carribean Sea. These ARCON® substrates showed a very high crush strength ranging from 3720.0 P.S.I. (257.0 kg/cm^2) to 5350.0 P.S.I. (368.0 kg/cm^2) with a high variability, however. The maximum crush strength found in the Red Sea substrates (256.0 kg/cm²) is in the range of concrete property class B 25 with crush strength of 250.0 kg/cm². This class of concrete is used for buildings. Even the average crush strength of the substrate (185.0 kg/cm²) is higher than of the concrete property class B 15 (150.0 kg/cm²). Concrete used for offshore installations belong to the group B II with the property classes B 35 to B 55 with a crush strength of 350.0 to 550.0 kg/cm². Due to the considerable variations of the mechanical characteristics the applicability of ARCON® substrate for larger installations seems to be rather limited.

The crush strength of the ARCON® substrate is directly connected to the chemical composition of the substrate. Although detailed analysis of most of the substrates presented in figure 4 regarding their crush strength was impossible due to the reduced thickness, the samples of B2, M6, M7 could not be destroyed by hand. Compared to the samples R1 and R2 it seems obvious that the Aragonite as major chemical compound finally triggers the crush strength of the ARCON® substrate.

Chemical characteristics of the ARCON® substrate

Results of the chemical analysis (X-Ray-Diffractrometry) of hardsubstrata produced with this technology in various other marine climates (cf. Fig. 4) revealed the uniform composition of these materials independent from the resident oceanographic characteristics of the relevant seawater such as mean water temperature, salinity and conductivity (Bubner *et al*. 1988, Schuhmacher & Schillak 1994, Schillak *et al*. 1999, Meyer & Schillak 2000). In all samples substances other than Calciumcarbonate and Magnesiumhydroxid ranged below the sensitivity range of the analytical method (< 1% by volume) except Siliciumdioxide, which was introduced by Diatomea as primary settlers on the substrates produced in boreal marine climates (e.g. Baltic Sea, Schillak *et al*. 1999). The uniform composition of the substrate independent from the marine environment is due to the basic principle of the ARCON® technology i.e. electrolysis of seawater. Although detailed data about the physical preconditions of the substrate precipitation in past experiments are absent, the percentage of volume for $Mg(OH)_2$ and $CaCO_3$ as major substrate compounds is triggered, among others, by the predefined DC regime with voltage, length of cables, cathode area and anode area. Menzel 1988 and Menzel 1995 investigated the electrolysis of seawater in detail in the laboratory and found Mg^{++} - Ca^{++} ratios depending on the DC regime. Under natural conditions, however, and especially in the sublittoral many other abiotic and biotic factors impact on the precipitation conditions of the substrate to a large extent. Any change in the oceanographic characteristic of the seawater (e.g. intrusion of water bodies with different salinity and temperature) will definitely alter the precipitation of the major compounds.

Coral nubbins

The survival rates obtained for *S.pistillata* correspond with data published by van Treeck & Schuhmacher 1997, who used the same technology for the transplantation of scleractinian coral species in the Gulf of Aqaba, Kingdom of Jordan, Red Sea. The obtained survival rates for nubbins of 5 species of scleractinian corals ranged from 36-100%.

The relatively high mortality of the *A.humilis* recruits in the experiment described above has also been reported by Ammar et al. 2000, who suggested that *A.humilis* is sensitive to mechanical impacts. Ammar also reported, that the mortality of transplanted *S.pistillata* nubbins increases over time. The increasing mortality of *S.pistillata* has also been found by van Treeck & Schuhmacher 1997.

Although there is a wide spectrum of publications on transplantation experiments with scleractinian corals (Auberson 1982, Plucer-Rosario & Randall 1987, Harriott & Fisk 1988, Yap *et al*. 1992, Clark & Edwards 1995, Rinkevich 1995) none of the authors used the electrochemical produced substrate.

The growth rate of the *S.pistillata* nubbins give evidence that neither the DC regime nor the process of being embedded by the precipitating substrate impacts negatively on the implanted nubbins.

Goreau & Hilbertz 1996 give the only available data on scleractinian corals growing on similar produced hard substrata. This publication, however, gives neither indications on survival/growth rates nor on dominance, but only lists a total of 14 scleractinian coral species as settlers on the substrate.

The high number of buds produced by the surviving *S.pistillata* and *A.humilis* transplants demonstrates the considerably high vitality of the recruits on the ARCON® substrate. The absence of the stress proteins HSP 70 and HSP 90 in the tissue of the *S.pistillata* transplants on the ARCON® substrate, too, indicates a high vitality of the coral nubbins.

The use of the heat shock protein HSP as a biomarker to indicate the environmental stress in corals is a recent approach. Black et al. 1995 separated seven heat shock proteins of different molecular weights (95, 90, 78, 74, 33, 28 and 27 KDa), by thermally stressing the reef coral *Montastrea faveolata*. The same author separated heat shock proteins from another zooxanthellate species (*Aiptasia pallida*) with different molecular weights (82, 72, 68, and 48 KDa). Fang *et al*. 1997 found that high temperature induces the synthesis of heat shock proteins and the elevation of intracellular calcium in the reef coral *Acropora grandis*. Transplantation of *Goniopora djiboutiensis* from the subtidal habitat to the intertidal habitat for 16 and 32 days resulted in elevated constitutive levels of HSP 70 compared to the control colonies (Sharp *et al*. 1997). Meehan and Ostrander 1997 assumed that molecular mechanisms may play a role in coral bleaching. Gates and Edmunds 1999 explored the relationship between protein turnover, metabolic rate, growth rate, and acclimatization capacity of reef corals to survive changes that are predicted in the global environment. A small alpha-crystalline heat shock protein was identified in the scleractinian coral *Madracis mirabilis* (Branton *et al.* 1999). Wiens *et al.* 2000 studied the induction of heat shock (stress-) protein gene expression by selected natural and anthropogenic changes in the octocoral *Dendronephthya klunzingeri*. Ammar *et al*. 2000 approached a rational strategy for restoration of coral reefs by application of molecular biological tools to select sites for rehabilitation by asexual recruits.

A wide range of publications address the necessity of hard, fixed materials as optimal substrate for the settlement and growth of coral colonies. Brown and Dunne 1988 discuss the necessity of hard, fixed substrate for the recovery of reef areas destroyed by human impacts (e.g. coral mining). Clark and Edwards 1992(1) and Clark and Edwards 1994, too, state that

coral transplantation on rubble will not result in a rehabilitation of degraded reef areas. Although rubble represents a natural substrate, it moves under hydrodynamic impact. In their experiments Clark and Edwards used metal structures for the fixation of the rubble in reef areas degraded by coral mining. In this respect the similarity of the chemical composition of the ARCON® substrate and the coral skeleton, which results in a direct and very tight connection of the two crystal lattices, favors the vitality and growth of the transplanted *S.pistillata* and *A.humilis* recruits.

The increased growth rates of the recruits during the precipitation of the ARCON® substrate might possibly be an indication that the DC regime and its electric field and lines of electric flux positively impact on the growth and vitality of the coral nubbins transplanted to the substrate. As it applies for the presence of stress proteins in coral transplants, their vitality after transplantation and their reaction within electric fields no detailed data have ever been published.

Other marine organisms

Data on other marine organisms settling on similar hard substrata produced in the Red Sea environment to be compared with the results of the presented experiments are not available. Goreau & Hilbertz 1996 recorded 89 species distributed to 14 higher taxa on similar produced hard substrata from the Caribbean Sea. In the Mediterranean Sea Spieß 1991 recorded 64 species distributed to 7 higher taxa and Schillak *et al*. 1999 found 20 species distributed to 7 higher taxa in the Baltic Sea on similar produced hard substrata. All of these investigations have been conducted after at least 1 year of exposure and prove the acceptance of the substrate by a broad spectrum of different autotroph and heterotroph, sessile and mobile, marine organisms.

Investigations of ARCON® substrate from the Mediterranean Sea regarding the acceptance of the substrate by marine organisms revealed that even during the precipitation phase the colonization of the substrate takes place almost continuously. Transparent cuts of ARCON® substrates from the Mediterranean Sea show the intercalation of sessile organisms into the substrate. However, it has to be assumed, that the colonization of the substrate takes place during the period, when no electrical current is running through the system, since the normal pH of seawater (pH 8.0 to 8.2) is shifted to pH 11.0 within a 250 µm thin layer above the substrate during precipitation phases.

Compared to the data sets from other marine climates, the results obtained from the Middle Reef in Hurghada give reasons to assume that the community of settling organisms found on the substrate after 5 months (20 species, 7 higher taxa) represents an intermediate development stage prior to the climax stage of a benthic community.

Coral reef rehabilitation

The technology of producing hardsubstrata directly from the sea for the revitalization of degraded reef areas represents an adequate tool for rehabilitation activities in coral reef areas (Schuhmacher & Schillak 1994, Meyer & Schillak 2000). The technique uses renewable energy resources (solar, wind) and does not impact on the marine environment by introducing excotoxic materials into subtidal zones. Moreover the substrate proves to be an adequate colonization matrix for a large number of marine settlers other than scleractinian corals and thus contributes to a broader revitalization of degraded subtidal areas not only directed to the reintroduction of coral species. In addition the acceptance of the substrate by fish for reproduction (fixing of eggs directly to the substrate) proves the suitability for coral reef rehabilitation.

Although the technology seems to allow for the installation of large sized units there are clear limitations in its applicability. To restore a stretch of coral reef several hundreds of meters long and several tens of meters deep would require an enormous effort regarding the necessary energy supply. Substrate units larger than 1.0 m^2 have been planned and designed for a larger project in the Baltic Sea to deploy artificial reef installations within a sea area of 2.5 km^2 (Schillak *et al*. 1999).

For the application of this technology within coral reef rehabilitation activities, however, it seems advisable to consider small units ($\leq$ 8.0 m^2) to be deployed in reef locations. Experiences from other, recently started coral reef rehabilitation projects in the Indian Ocean (Kenya) using the ARCON® technology, show that there is a limit in handling large transplantation units (unpublished data by Schillak).

Deployed ARCON® rehabilitation units should therefore be regarded as spawning nuclei from which the re-colonization of the entire reef may take place rather than as "architectural repair units". The implantation of nubbins from autochthonous scleractinian coral species also seems to be advisable since this will presumingly accelerate the rehabilitation process considerably. In addition the deployment of single units in different morphological locations of the reef like reef flat, reef crest or reef slope integrates the possibility to use the ecoforms of these morphological reef locations for transplantation: massive (*Porites*) or thick branched genera, (*Acropora*) for the reef flat or fragile forms (*Seriatopora*) for the reef slope.

The application of the technology even for remote coral reef areas is realistic. The Kenyan coral reef rehabilitation project uses pontoon systems as carrier for the solar panels. These pontoon systems are directly installed above the coral reef in the open sea (unpublished data by Schillak).

In areas with high human impact leading to deteriorated water quality or high sedimentation rate as described by Ammar 1998, the technology will only be successful if accompanied by adequate land based measures which help to eliminate these impacts (e.g. improvement of wastewater discharge patterns, halt of landfill activities).

In addition, the installation of several re-colonization units (sized as described above) in coral reef areas with integrated coral nubbin transplantation will subsequently require a considerably large number of nubbins. This could represent a major threat for the remaining coral colonies in the wider range of the deployment area. Therefore, it should seriously be discussed to combine or even precede larger transplantation activities by adequate fringing projects for marine farming of scleractinian coral species (Harrison & Wallace 1990, Richmond & Hunter 1990, Yates & Carlson 1992, Ammar *et al*. 2000, Jaubert *et al*. 2000).

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Induction of heat-shock (stress) protein gene expression by selected natural and anthropogenic disturbances in the octocoral (*Dendronephthya klunzingeri*)[a]

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Abstract

Until now biomarkers for the assessment of the health of coral reefs have not yet been reported. Recently we published that heat-shock proteins (HSP) are suitable markers in sponges to monitor the degree of environmental stress on these animals. In the present study the HSP with a molecular weight of 90 kDa has been selected to prove its potential usefulness as biomarker under controlled laboratory conditions and in the field. The studies have been performed with the octocoral *Dendronephthya klunzingeri* from which the cDNA coding for HSP90 was cloned first. The cDNA, termed *HS9DEKL*, obtained was 2558 nt in length and contained a potential open reading frame coding for 733 aa; the complete size of the cDNA (2.7 kb) was confirmed by Northern blot analysis. The deduced M_r of the putative coral HSP90, HS9_DEKL, is 86,309. Homology searches revealed that the *D. klunzingeri* HSP90 is grouped together with the related metazoan polypeptides. The evolutionary rate of the coral HSP90 is low (k_{aa}-value of 0.158×10^{-9}). The expression of the HSP90 gene is up-regulated by thermal stress; treatment of the animals for 2 hr at 4ºC below or above the ambient temperature resulted in a >4.5-fold higher steady-state level of the respective mRNA. Also animals taken from stressed locations in the field showed an increased expression. On translational level the amount of HSP90 protein in *D. klunzingeri* was found to be strongly increased under thermal stress, exposure to the polychlorinated biphenyl (congener 118), but not after treatment with cadmium. Field studies revealed that samples taken from a nonstressed area have a low level of HSP90, but those collected from locations at which the corals are under physical stress (destruction through storm or landfilling) show a high expression of HSP90. It is concluded that the chaperone HSP90 is a suitable biomarker to monitor environmental stress on corals.

Introduction

Coral reefs are fragile ecosystems that are highly vulnerable to environmental stress (Johannes 1975, Loya 1976, Loya and Rinkevich 1980). Both natural, such as storm-generated waves (Stoddart 1963, Hernandez-Avila *et al*. 1977) or population explosions of the crown-of-thorn starfish *Acanthaster planci* (Chesher 1969, Pearson 1981) and anthropogenic disturbances, e.g. sedimentation (Sheppard 1980), sewage and eutrophication (Pastorek and Bilyard 1985), oil (Loya and Rinkevich 1980) and thermal stress (Johannes 1975) affect the growth and ecology of the coral in the reefs. An effective management of the health state of

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coral reefs requires regulation of human activities based on a rational monitoring of the extent of stress in a given coral reef. One suitable way to assess sub-lethal effects of stressors on growth and metabolism of corals is to quantify the physiological responses of corals to those influences. Therefore, biomarker(s) for a biological monitoring program are needed. A biomarker is defined as "a xenobiotically-induced variation in cellular or biochemical components or processes, structures, or functions that are measurable in a biological system or sample" (NRC 1989).

Our earlier findings revealed that sponges [Porifera] react to environmental stress with an increased expression of the heat-shock protein(s) (HSPs) (Koziol *et al*. 1996, Koziol *et al*. 1997a, and reviewed in: Koziol *et al*. 1997b). The response to stressors occurred in sponges not only under controlled conditions in the aquarium, but also in animals collected from the field (Müller *et al*. 1998). In the present study we investigated for the first time if corals also react to anthropogenic stress with an over-expression of the gene coding for a selected HSP. Five families of stress proteins are found in eukaryotes; four of them are grouped according to their molecular weights as HSP90, HSP70, HSP58-60 and HSP20-30 whereas the fifth HSP is termed ubiquitin (Schlesinger *et al*. 1982). The HSPs are known to be essential cell components, most of them being involved in the formation of transient protein complexes (Nover 1991). They may also play key roles during cell cycle and development. As an example, members of the HSP90 family, which might possess ATPase activity (Nadeau *et al*. 1993), are involved in the folding of nascent and denatured proteins or protein complexes [and hence act as molecular chaperons] (Miyata and Yahara 1992, Wiech *et al*. 1992). The HSP90s are characterized by their high level of specificity in associating with particular proteins; they form in most cases long-lived complexes and acquire important regulatory features (Pratt *et al*. 1992, Xu and Lindquist 1993).

In the present study we determined for the first time if also in corals the level of expression of HSPs can be used as a marker for environmental stress. HSP90 was selected because it was previously found that this chaperone is up-regulated by cadmium (Barque *et al.* 1996), is stress-inducible (Ali *et al*. 1996) and binds to the oestrogen receptor by which it is - in turn - regulated in its activity (Sabbah *et al.* 1996). The latter property could qualify the HSP90 polypeptide as a marker for xenoestrogens in the future (Soto *et al.* 1995).

The experiments have been performed with the octocoral *Dendronephthya klunzingeri* that is abundantly found in coral reefs at the Red Sea (M. Eisinger, unpublished); in addition this species does not contain zooxanthellae (unpublished) like *Dendronephthya hemprichi* (Fabricius *et al.* 1995). As stressors, the heavy metal cadmium (Cd) and the polychlorinated biphenyl (PCB) congener 118 were selected and tested on the response of this coral under controled aquarium conditions. Furthermore, the effects of stressors in the field, destruction of the biotope by storm or by landfilling, were analysed. The data revealed that the selected chaperone HSP90 is a biomarker that is useful to assess the extent of stress on the coral *D. klunzingeri*.

Materials and Methods

The materials and methods used have been described elsewhere (Wiens *et al.* 2000).

Results and Discussion

PCR cloning and sequencing of the cDNA HS9DEKL

One degenerate oligonucleotide primer, corresponding to a nucleotide sequence of the region in human *HSP90* cDNA was used to identify the corresponding cDNA from the coral cDNA library, as described under Materials and Methods. The cDNA obtained, *HS9DEKL*, encodes the putative HS9_DEKL protein.

The largest cDNA obtained was 2558 nt [excluding the poly(A) tail; accession number Y15421] in length and contained a potential open reading frame [ORF], extending from nt 74 to 2272 and coding for 733 aa. At the 3'-terminus the cDNA has a poly(A) tail, with the polyadenylation signal AAUAAA (nt_{2540} to nt_{2545} [Gil and Proudfoot 1987]). The putative AUG initiation site (nt_{74} to nt_{76}) displays a strong consensus sequence A_{-3}/T_{+4} (Kozak 1991) and reads AAAATGT [the putative translation initiation site is underlined].

Northern blot analysis was performed with the sponge *HS9DEKL*-clone as a probe. One band of approximately 2.7 kb was obtained, confirming that the full length cDNA was isolated (Fig. 1). In comparison, the size of the human *HSP90* cDNA is 2906 nt long with an ORF of 2190 nt (Yamazaki *et al.* 1989).

Amino acid sequence analysis and phylogenetic analysis of coral HSP90

The *HS9DEKL* cDNA encodes a 733 aa long putative HSP90, HS9_DEKL. The deduced M_r is 86,309 with a pI of 4.53 (PC/GENE 1995). According to the instability index, the sponge HS9_DEKL has to be classified as an unstable molecule with a predicted half-life of 5.5 hr (PC/GENE [Physchem] 1995). The HSP90 protein family signature NKEIFL (aa_{38} to aa_{43}) is present (Lindquist and Craig 1988). The stretch aa_9 to aa_{16} shows characteristics of the α component of HSP90s (Lees-Miller and Anderson 1989a). Furthermore the repeats Glu-Lys (Moore *et al.* 1989) are found in the coral sequence within the segments aa_{222} to aa_{282}. The potential phosphorylation site at serine aa_{229} for the casein kinase, which is also present in vertebrate HSP90 sequences (Lees-Miller and Anderson 1989b), is found in the coral sequence.

Homology searches (BLAST and FASTA) with HS9_DEKL revealed highest similarity to metazoan HSP90 proteins. The coral protein sequence shares ≈75% of identical aa and ≈90% of similar aa with other corresponding molecules.

Already earlier studies revealed that the class of HSP90 proteins, including members of vertebrates and higher invertebrate phyla, are phylogenetically highly related (Moore *et al.* 1989). Here we show that within an unrooted tree, which has been constructed from HSP90 sequences from *(i)* Metazoa, including the vertebrates human, chicken and zebrafish sequences as well as the invertebrates *Drosophila melanogaster* and *Caenorhabditis elegans*, *(ii)* unicellular eukaryotes (*Trypanosoma cruzi* and *Plasmodium falciparum*), *(ii)* the slime mold *Dictyostelium discoideum*, *(iii)* Fungi (Ascomycota) and (iv) viridiplantae (*Arabidopsis thaliana*), the coral HSP90 sequence from *D. klunzingeri* groups together with the invertebrates.

Evolutionary rate of coral HSP90

Until now, an evolutionary rate of a coral protein has not yet been determined. An estimation, based on the number of point mutations per 100 aa within a deduced polypeptide, which might reflect the time of divergence of the corals from the other metazoan phyla can be calculated. The evolutionary rates - expressed as k_{aa}-values - vary between different proteins (Zuckerkandl and Pauling 1965, Kimura 1983, Li *et al.* 1987). As shown by Kimura (1983), k_{aa}-values vary from 8.3×10^{-9} for fibrinopeptides (reflecting a value of 8.3 aa substitutions per site per 10^9 years) to 0.01×10^{-9} for histon H4, with an average k_{aa}-value of 1×10^{-9}, meaning 1 aa substitution per site in 10^9 years. In a previous study it was calculated that the galectin protein from the sponge *Geodia cydonium* (Pfeifer *et al.* 1993) has a k_{aa}-value of 1.7×10^{-9} (Hirabayashi and Kasai 1993), while a k_{aa}-value of 1.24×10^{-9} was calculated for the receptor tyrosine kinase (Schäcke *et al.* 1994) from the same animal. In contrast, the Hsp70s from sponges have a comparably low evolutionary rate with k_{aa}-values between 0.125×10^{-9} for *G. cydonium* [Demospongiae] and *Rhabdocalyptus dawsoni* [Hexactinellida] and 0.087×10^{-9} for *Sycon raphanus* [Calcarea] (Koziol *et al.* 1997c). A similarly low rate is now calculated for the coral HSP90 with a k_{aa}-value of 0.158×10^{-9}, which indicates the slow rates of evolution of HSP90 molecules and reflects the strong functional constraints placed upon this polypeptide.

Expression of HSP90 on transcriptional level

Northern blot experiments have been performed to determine the level of *HS9DEKL* gene expression. The level of the 2.7 KB long transcript in a control animal was arbitrarily set to 1-fold (Fig. 1; lane b). If animals are treated for 2 hr at 4ºC below the ambient temperature (lane a) or 4ºC above the ambient temperature (lane c) the mRNA level of *HS9DEKL* reaches a value of 5.6-fold and 4.5-fold, respectively. One sample from the field was collected from a biotope which is stressed by land filling; the mRNA level in this animal is 2.7-fold higher than in the control coral (lane d).

Expression of HSP90 on translational level

The level of HSP90 protein in *D. klunzingeri* was determined by Western blotting (Fig. 2). Protein extracts were prepared, size separated and reacted with a McAb-HSP90. The size of the main band visualized corresponds to an M_r of 86,000 (lane b), which is identical to the one of the deduced aa sequence from the *HS9DEKL* cDNA. Minor bands of a size around 45 kDa are visible which are attributed to similar proteins, as reported before (Kelley and Schlesinger 1982). For this experiment, a tissue sample was used from a specimen, which had been collected from a site stressed by land filling (from "Got‘a Torfa"; Ammar 1998). In parallel to the Western blot, the gel stained by Coomassie Brilliant Blue is shown (lane a). In one control experiment 100 µl of the McAb-HSP90 was adsorbed to 50 µg of HSP90 prior to its use. This antibody preparation did not reacted with any coral sample (not shown).

Effect of thermal stress on the level of HSP90

A shift of the incubation temperature resulted in an increased synthesis of HSP90 protein in the corals. While in the control specimens, which were kept for more than two weeks in the aquarium, only occasionally a distinct band, corresponding to a size of 86,000 is seen (Fig. 4A

lane b), a strong increase in the level is measured after incubation of the animals at 4ºC or 8ºC above the ambient temperature. These animals show a 4.8- to 8.3-fold higher level of HSP90 (Fig. 4A lanes c and d). Reduction of the ambient temperature by 4ºC likewise resulted in an increase of HSP90 (Fig. 4A lane a).

Effect of cadmium and PCB 118

Cadmium exposure at a concentration of 100 ng/ml or of 300 ng/ml did not cause a change of the steady state level of HSP90 with respect to the controls (Fig. 4B lanes b and c versus lane a). In contrast treatment of the animals with PCB 118 causes a 3.5-fold increase of HSP90 (data not shown).

Interesting is the finding that a pre-incubation of the animals at 4ºC above the ambient temperature and a subsequent incubation with Cd resulted in a strong increase of HSP90 expression. This chaperone is synthesized in tissue from animals treated first by an elevated temperature and subsequently with 100 or 300 ng/ml of Cd at a 1.8- and 4.6-fold higher level (Fig. 4C lanes c and d), if compared with animals treated by a 4ºC higher temperature only (Fig. 4C lanes a).

Field study

First field experiments have been performed to monitor the level of HSP90 in animals from non-stressed and stressed biotopes. As a non-stressed location the "Big Giftun" site has been selected. *D. klunzingeri* specimens from this area show only a low level of HSP90 (Fig. 4D lanes a and b). In contrast, if animals were analyzed which had been collected from sites affected by destruction through storm, "El-Fanadir" (Fig. 4E lanes a and b), or by land filling, "Got'a Torfa" location (Fig. 4E lanes d and e), the level of HSP90 is more than 2-fold higher than the one measure in tissue from corals kept at 8ºC above the ambient temperature (Fig. 4E lane c).

Conclusion

Until now molecular biomarkers to assess stress factors in corals have not yet been studied. Based on our earlier experience that heat-shock proteins are suitable biomarkers in the lowest metazoan phylum, the Porifera, it was studied if the expression of the HSP species HSP90 can serve as a reliable parameter for stress response in corals. HSP90 is of special interest and importance, because its expression results in a modulation of the activity of the estrogen receptor, the hydrocarbon receptor and it is also involved in signal transduction systems(s), mediated by oncogenic tyrosine kinases (see: Sabbah *et al.* 1996). In addition, this protein has been found to be inducible in unicellular- and multicellular organisms and systems (Yonehara *et al.* 1996). It was also reported that HSP90 is up-regulated after treatment of rats with pesticides (Bagchi et al. 1996). Hence, based on these data a systematic survey on the role of HSP90 in one coral species appeared to be promising and was therefore performed.

The cDNA encoding the HSP90 was cloned from the coral *D. klunzingeri* and found to belong to form α of HSP90s. The deduced aa sequence contained all those elements which are characteristic for the family of HSP90s.

The expression of HSP90 was determined on transcriptional and translational level. On transcriptional level it was found that within 2 hrs the steady-state level of the 2.7 kb long HSP90 mRNA increases by >3-fold after treatment of the animals by heat or cold shock.

For a more comprehensive elucidation if also on the functional, the translational, level HSP90 is regulated in quantity under different stress conditions, studies both under controlled

aquarium conditions and in the field have been performed. A monoclonal antibody that recognized *D. klunzingeri*, anti-HSP90, was used to quantify the steady-state level of the HSP90 protein. The experiments revealed that this chaperone is strongly up-regulated if the animals are exposed to thermal stress. Even the short exposure time of 2 hrs and at a temperature shift of 4ºC, resulted in a drastic up-regulation of HSP90. In contrast, exposure of the coral to Cd at concentrations of 100 or 300 ng/ml displayed no effect on HSP90 expression. In earlier studies it was found that marine sponges undergo in response to those Cd concentrations apoptotic DNA fragmentation (Wagner et al. 1998). This finding could indicate that Cd is under those conditions toxic for *D. klunzingeri*. Therefore, the result, that shows that after pre-treatment of the animals by thermal stress and a subsequent exposure to Cd the HSP90 protein level is highly increased, suggest that HSP90 protects the corals against Cd if the expression of this chaperone is induced prior to the influence of this heavy metal. This result is in agreement with an earlier study in which it was demonstrated that the freshwater sponge *Ephydatia fluviatilis* reacts with an increased expression of the stress protein HSP70 if it had been pre-treated by a short temperature stress prior to the exposure to environmental xenobiotics (Müller et al. 1995).

It has been suggested that polychlorinated hydrocarbons might affect corals (Chesher 1969). Polychlorinated biphenyls (PCB) are widely distributed as environmental pollutants in both terrestrial and aquatic ecosystems (Safe 1993, Clark 1997). The toxic effects caused by PCBs have been well investigated (Kimbrough 1985, Silberhorn et al. 1990). In sponges it was recently reported that PCBs cause besides DNA damage also an induction of HSP70 (Schröder et al. 1998). In addition, a novel sensitive marker for PCB load to sponges was found by the demonstration that the chaperone 14-3-3 is highly expressed in response to this class of xenobiotics (Wiens et al. 1998). Here, we tested if one model compound, the nonplanar mono-*ortho* PCB congener 118, displayed an effect of the expression of HSP90. As reported in sponges also in the *D. klunzingeri* system the expression of heat-shock protein is up-regulated after PCB 118 treatment.

In a last series of experiments it was analysed if also *D. klunzingeri* reacts in the field, at known environmental loads with a change of the intracellular level of HSP90. Animals from one site which appeared to be non-polluted and those from locations which show a characteristic stressed environment, destruction by storm "El-Fanadir" or by land filling, were analysed. Again, it was found that the chaperone HSP90 is highly up-regulated in animals, taken from stressed areas.

In conclusion, the data reported in this study show that the chaperone HSP90 is a suitable biomarker for monitoring environmental stress on corals (here *D. klunzingeri*), especially if the animals were taken from areas stressed by natural disturbance and by selected anthropogenic chemicals, here PCB 118. In future studies it will be determined, if besides molecular biological and biochemical markers, which have been used here, also immunological marker(s) could be chosen to estimate environmental stress on corals, e. g. on the basis of the strength of histoincompatibility reactions as in the hydrocoral *Millepora dichotoma* or the scleractinian coral *Stylophora pistillata* (Müller et al. 1983, Müller et al. 1984).

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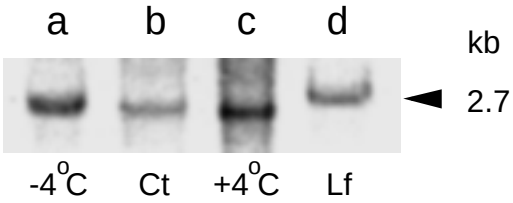

Fig. 1. Northern blot analysis to determine the size of the transcripts of the mRNA encoding the coral HSP90; 2.7 kb. RNA was prepared from coral tissue and 1 µg each was subjected to analysis. The following samples were analysed; control [Ct] (lane b), thermal stressed animals either cold shocked at 4ºC below the ambient temperature [<4ºC] (lane a) or heat shocked 4ºC above the ambient temperature [>4ºC] (lane c) and one sample from the field, collected from a biotope, stressed by land filling [lf] (lane d).

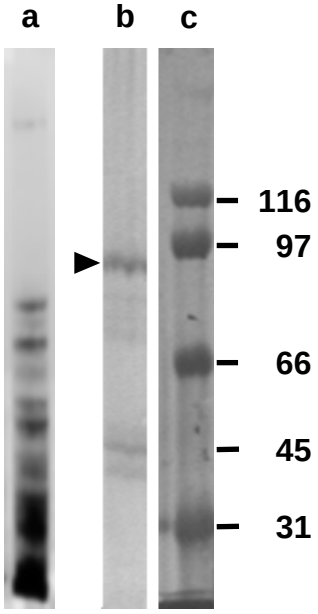

Fig. 2. Expression of heat shock protein HSP90 in *D. klunzingeri*. In this experiment, an animal from one site that was stressed by land filling procedure (from "Got'a Torfa") was analysed. Proteins were extracted as described in Materials and Methods, and size-separated by polyacrylamide gel electrophoresis. An amount of 40 µg of protein was applied to each slot. The gel was either stained by Coomassie Brilliant Blue (lane a) or analysed for the presence of HSP90 by Western blotting technique using McAb-HSP90 (lane b). The position of migration of the HSP90 is indicated [arrow head]. The molecular masses of marker proteins, which were run in parallel (lane c), are given in kDa.

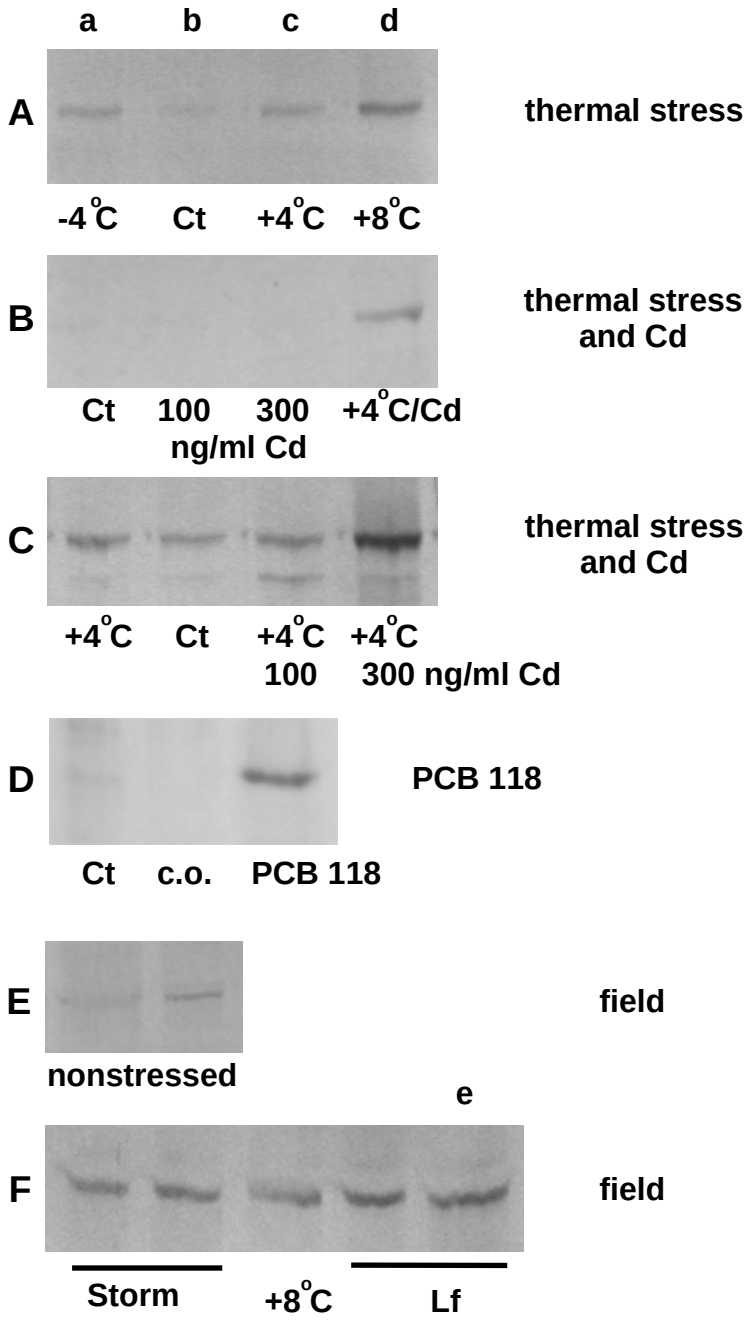

Fig. 3. Expression of the HSP90 protein in *D. klunzingeri* exposed to different stressors; the analysis was performed by Western blotting. **A.** Thermal stress: Tissue from a control [Ct] animal, or samples from thermal stressed animals either cold shocked at 4ºC below the ambient temperature [<4ºC] or heat treated 4ºC or 8ºC above the ambient temperature [>4ºC; >8ºC]. **B.** Cadmium (Cd) exposure: Effect of 100 ng/ml or 300 ng/ml of Cd [100 ng/ml or 300 ng/ml], or of 100 ng/ml of Cd after a pre-treatment by a temperature shift of + 4ºC [>4ºC/Cd], and the control [Ct]. **C.** Thermal stress and cadmium: The specimens were treated first by elevated temperature for 2 hr at 26°C and subsequently with 100 ng/ml or 300 ng/ml of Cd for 2 days [>4ºC/100 or 300 ng/ml Cd]; in parallel one control [Ct] animal and one animal treated 4ºC above the ambient temperature [>4ºC] were analyzed. **D.** Field samples: Two specimens from the non-stressed site "Big Giftun" have been analysed [non-stressed]. **E.** Field samples: Corals (two samples each) collected from sites affected by destruction through storm "El-Fanadir" [Storm] or by land filling "Got'a Torfa" [Lf] have been analysed for HSP90 level. As a reference, a sample from an animal kept under heat-stressed condition in the aquarium for 2 hr at 30°C [>8ºC] was run in parallel.

Impacts of Recreational Dives and the Application of a Coral Damage Index (CDI) along the Egyptian Coast of the Red Sea[a]

By: Dr. Mohammed Shokry Ahmed Ammar [b]

Abstract

Impacts of recreational dives were rapidly assessed in 27 diving sites at Hurghada and 16 diving sites at Safaga, Egypt, Red Sea. A coral damage index (CDI) was provided to screen the sites to obtain a perspective of the extent and severity of physical damage to corals in five sites (four heavily visited and one control site). Around Hurghada sites, Abu-Hashish West has the highest percent of cover with stony corals and the lowest level of human impacts. El-Fanus, in contrary, shows the lowest percent of cover with stony corals but is considerably impacted by human activities. Among Safaga sites, Panorama reef East has the highest percent of cover with stony corals although it encounters a considerable amount of anchors, divers and snorklers. The reef area is very large and relevant dive sites are located within a restricted area. Dynamite fishing seems to be the main reason for a very high amount of rubbles at both El-Fanus and Abu-Kafan reefs. High sedimentation rates at Abu-Hashish Island subsequently lead to a high die off of corals at this site. For the sites screened by the CDI, 40% of all reef areas of the four heavily visited sites investigated by transects have been identified as ”hot spots”, which require immediate management action. Thirty-one percent of the 16 ”hot-spot” transects were identified by the broken corals and the rubble criteria, whereas 25% were identified by broken coral criterion and 44% by rubble criterion of the CDI. These relations indicate that recent breakage of corals seems to be the reason for the observed damage. Sixty-three percent of the ”hot-spot” transects were located at 4.0m water depth and 37% of the transects were located at 8.0m water depth. Most of the damage is likely to be generated by anchors dragged across shallow reef areas. The CDI can be used globally to gauge the severity and extent of damage in coral reef areas and help managers to focus on areas that need immediate action such as mooring buoys. It also provides a starting point for assessment and coral reef restoration programs.

Introduction

Unless a greater amount of information is available on the response of coral reef ecosystem to human activity and impacts, further recommendations can’t be stated. Proclaiming an area as a coral reef preserve often attracts the attention of divers, fishermen, boats and others wishing to visit the area for recreation. In addition, the impact of human activity on coral reefs is much less understood than for terrestrial environments.

Effect of tourism on coral reefs has been studied by several authors e.g. Hughes 1992, Hawkins & Roberts 1992, 1993, 1994 and Wells 1995, Medio et al. 1997, Nickerson-Tietze 2000. Weins et al. 2000 used the induction of heat shock protein expression in the octocoral Dendronephthea klunzingeri as an indicator of environmental and anthropogenic changes, however, Ammar et al. (2000) introduced one rational strategy for restoration of coral reefs by

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application of a molecular biological parameter for selection of sites for rehabilitation using asexual recruits.

Recreational diving can damage reefs both directly and indirectly (Rogers 1988). Divers damage reefs in a number of ways, this is usually accidental and can result from kicking, trampling, holding, kneeling or standing on benthic organisms. Re-suspension of sediments may also stress organisms (Rogers 1990). Diver carrying capacities, usually expressed as the number of dives per site per year, is a measure of the number of divers a reef can tolerate without becoming significantly degraded, and also plays an important role in the management of physical damage on a coral reef. Sal (1986a, b) introduced the concept of diver carrying capacity. In the Bonaire Marine Park, Dixon et al. (1994) found that most divers seldom venture further than 300m in one direction and that there was a decreasing physical impact on reef communities with increasing distance from a mooring buoy. Analysing coral cover, they estimate that the diver carrying capacity threshold for the Bonaire Marine Park is between 4000 and 6000 dives per site per year. Surveying the percent of damaged coral colonies in the Red Sea Ras Mohammed National Park, Hawkins and Roberts (1997) suggest 5000 to 6000 dives per site per year as a good role of thumb in the absence of site-specific data. Sampling a suite of invertebrates (hard corals, soft corals, sea fans, branching hydrocorals, and erect sponges), Chadwick-Furman (1996) found the threshold for diving sites in US Virgin Islands to be only 500 dives per site per year and attributed this significantly lower estimate to the fragility of the various organisms in the study area. Effective diver education programs can allow coral reef managers to increase carrying capacities (Medio et al. 1997).

Mooring buoys and the management of the number of vessels using mooring buoys with respect to time and location are other effective tools coral reef managers use in reducing the anchor and diver damage to coral reefs. A large number of diving vessels and active dive centres operating in the Hurghada and Safaga areas have had free reign to operate unsupervised until 1997 when a ranger enforcement unit was established out of Hurghada by EEAA with support from the United States Agency for International Development). This has caused considerable physical damage to coral reefs (Jameson and Smith 1997).

Objectives of the study

1- To rapidly assess the coral reef environment of the diving sites of each of Hurghada and Safaga coral reefs. Besides, human impacts by the effect of boats, anchors, divers and snorklers will be studied.

2- To use the coral damage index (CDI, Table 1), to screen five diving sites to obtain a perspective on the extent and severity of physical damage to coral (not the cause of damage). The CDI also provides managers with an understanding of which sites need mooring buoys and associated dive site management programs, and provides a starting point from which to focus more detailed coral reef assessment and restoration programs.

Materials and Methods

Rapid assessment survey

Twenty-seven diving sites at Hurghada and 16 diving sites at Safaga were rapidly assessed in September, October and November, 1996. These sites are indicated in Tables.(3,4). A quadrate of 2m X 2m was designed and used in this study. Five to ten quadrates were surveyed at 5 m depth, 5m intervals at each site. Each quadrate was surveyed for the percentage cover of hard corals, soft corals, rocks, rubbles, sediments, macro algae, algal turf,

coralline algae and other benthic organisms. Percentage cover was calculated from the formula:

$$\text{Percentage cover} = \frac{\text{Area occupied by coral or other category}}{\text{Area}^2} \times 100$$

The number of clams, *Diadema* and sea cucumbers were counted in each quadrate. Data concerning number of boats, number of anchors, number of divers, number of snorklers, signs of dynamite fishing or other stress were also recorded.

The coral damage index (CDI)

Broken coral and coral rubble are the life forms used for the CDI (Tables 1 and 2) because they best represent past (rubble) and more recent (broken coral) physical damage to coral on reefs. The CDI criteria are justified from the data of minimally impaired sites, collected in (1987) by Riegl and Velimirov (1991), (1994), provided a baseline perspective for breakage and rubble formation that was minimally affected by anthropogenic impacts or natural disasters.

Table 1. Coral damage index. Sites are listed as 'hot spots' (candidates for further monitoring, assessment and/or restoration) if they fail any one of the criteria for any transect

Coral damage index
The percent of broken coral colonies is greater than or equal 4%,
or the percent cover of coral rubble is greater than or equal to 3%.

Table 2. Life form categories used in the coral damage index and sampled for at five diving sites in the Egyptian Red Sea

Life form category	**Characteristics**
Broken coral. Expressed as percent broken coral colonies (BCC). By using percentages rather than numbers we factor out the potential confounding effect caused by differences in coral cover which exist among sites (Hawkins and Roberts, 1997).	Broken (any part) or overturned live coral colony with no extensive regeneration or callus formation. Non-attached but otherwise live colonies were classified as broken if there was visible evidence that the stem had been broken off (Riegl and Velimirov 1991, Hawkins and Roberts 1997).
Coral Rubble (CR). Expressed as percent cover of coral rubble	Unconsolidated dead coral fragments (English et al. 1997).

Survey methods for the dive sites screened by CDI

Four sites were selected in areas frequented by diving vessels in the Hurghada (Got'a Abu Ramada, Gaftun Segir, El Fanus) and Safaga (Ras Abu Soma) areas (Table 5). The global coral reef monitoring line intercept transect method (English et al. 1997) was used to sample the damage in 1996. At each site, five 20 m long replicate transects were placed haphazardly

along the reef slope at 4 and 8 m depth. A 10 m transect length was determined as adequate using a species-transect length curve. However, a 20 m transect length was actually used to be consistent with Global Coral Reef Monitoring Network protocols (English et al. 1997). All beginning and endpoints of transects were marked with steel rods. For easy identification and relocation, yellow tags denoting 'Park Study Site' were attached to transect rods and white cable ties were attached to the substrate near the rod. Gaftun Canal, a minimally impaired site that is relatively unknown by divers, was used as the control, thus, a total of 4 heavily visited sites and one control site were screened by the CDI. Because of the extensive amount of diving occurring in the study area, it was impossible to find a perfect control site with no impacts occurring. Daily observations were made of the number of boats, number of anchors on the reef, number of divers and number of snorklers (Table 6).

Table 3 List of diving sites surveyed at Hurghada.

Sites	*Abu-Ramada (west)		Abu-Ramada (south)	Sha'ab Talata (Megawish)	Sha'ab Eshta (Petra reef)	Eruk Magawish	Umm-Gam'ar (west)
Latitudes (N)	27º09.319`		27º09.262`	29º08.485`	27º08.991`	27º09.016`	27º21.219`
Longitudes (E)	003º58.709`		003º57.903`	003º53.016`	003º53.636`	033º53.378`	330º54.451`
Sites	Eruk-Gaftun	Gaftun Kebir	Shabror Umm-Gam'ar	Carless reef	#El-Erg 1	#El-Erg 2	*#El-Fanus1
Latitudes (N)	27º10.058`	27º11.063`	27º19.97`	27º18.67`	27º18.67`	27º18.67`	27º16.066`
Longitudes (E)	033º57.032`	033º57.843`	033º55.025`	033º56.416`	033º56.416`	033º56.416`	033º53.234`
Sites	#El-Fanus 2	El-Fanadir	#Sha'ab Sabina	#Erg Sabina	#Sha'ab Disha Maalak	#Sha'ab Disha (Middle point)	#Sha'ab Disha (Tower)
Latitudes (N)	27º15.867`	27º17.708`	27º12.856`	27º12.966`	27º03.551`	27º02.974`	27º02.476`
Longitudes (E)	033º52.925`	033º49.867`	033º57.191`	033º57.277`	033º54.077`	33º54.299`	033º54.362`
Sites	#Got'a Torfa (East)	#Got'a Torfa (South west)	#Sha'ab Torfa	El-Erg 3	#Abu-Nugar	Abu-Hashish West (Crescent)	Abu-Hashish Island
Latitudes (N)	27º13.428`	27º13.428`	27º13.372`	27º32.787`	27º28.744`	27º00.617`	27º00.617`
Longitudes (E)	033º57.094	033º57.094`	033º57.252`	033º52.777`	033º5o.357`	033º54.596`	033º54.596`

Table 4 List of diving sites surveyed at Safaga.

Sites	$ Abu-Makhadeg	Sharm El-Arab	Gamul Kebir	Gamul Soraya (Gamul Segir)	Tobia Hamra	Tobia Baida (Sandy island)	Tobia Kebir
Latitudes (N)	26º59.821`	26º58.044`	28º46.941`	26º47.111`	26º49.824`	26º48.909`	26º48.531`
Longitudes (E)	033º54.555`	033º55.318`	033º59.185`	033º59.260`	033º59.160`	033º58.782`	033º59.767`
Sites	Tobia Soraya (Tobia Segir)	#Sha'ab Sheer (Salem)	Sha'ab Sheer (Abd-Allah)	Tobia Arba	Panorama reef (East)	Middle reef (Umm Halhal)	Sha'ab Sheer
Latitudes (N)	26º48.206`	26º38.341`	26º38.600`	26º50.170`	26º44.931`	26º42.284`	26º39.516`
Longitudes (E)	033º59.640`	034º03.745`	034º02.878`	033º59.500`	034º05.084`	034º06.028`	034º03.457`

Sites	#Abu-Kafan (East)	#Sharm El-Naga
Latitudes (N)	26º39.182`	26º53.894`
Longitudes (E)	034º06.519`	033º557.789`

Sites having dynamite fishing, * Sites having iron chains, $ Sites having plastic bags

Results

Sites surveyed by rapid assessment

Different tools of recreational activities impacting different diving sites of Hurghada are indicated in Fig. (3a). Number of boats ranges from 1 at Sha'ab Disha (middle point) to 9 at Shabror Umm-Gamar and Sha'ab Sabina. Number of anchors ranges from 0 at Sha'ab Disha (middle point) to 18 at each of Shabror Umm-Gamar and Sha'ab Sabina. Number of divers ranges from 2 at each of El-Fanadir and El-Erg 3 to 107 at Sha'ab Torfa. Number of snorklers ranges from 0 at many sites to 100 at Gaftun Kebir, so, Gaftun Kebir has the highest

anumber of snorklers while Sha'ab Torfa has the highest amount of divers among all sites. Signs of dynamite fishing were observed at 12 sites, which are El-Erg 1, El-Erg 2, El-Fanus 1, El-Fanus 2, Sha'ab Sabina, Erg Sabina, Sha'ab Disha (Maalak), Sha'ab Disha (Tower), Gota Torfa (south east), Sha'ab Torfa and Abu Nugar. Iorn chains were observed at two sites only, which are Abu-Ramada West and El-Fanus 1. The number of existing buoys ranges from 0 at several sites to 3 at Sha'ab Torfa.

Different tools of recreational activities impacting different diving sites of safaga are shown in Fig.(4a). Number of boats ranges from 1 at Gamul Kebir to 5 at many sites. Number of anchors ranges from 0 at Tobia Arba to 10 at Gamul Soraya and Tobia Baida (Sandy island). Minimum number of divers (2) was recorded at Gamul Kebir while the maximum number (80) was recorded at Sha'ab Sheer (Salem). The minimum number of snorklers (0) was recorded at Gamul Kebir while the maximum number (100) was recorded at Sharm El-Naga. Plastic bags were recorded in a large amount only in Abu-Makhadeg. Signs of dynamite fishing were recorded at 5 sites. The number of existing buoys ranges from 0 at several sites to 3 at Tobia Arba.

Percent cover of corals, other organisms, and other substrata as well as the number of clams, *Diadema* and sea cocumbers at each of Hurghada and Safaga diving sites are shown in Figs. (3&4). Percent cover of hard corals at Hurghada ranges from 11.89 at El-Fanus 1 to 51.13 at Abu-Hashish West while soft corals recorded its minimum percent cover at Sha'ab Disha (Maalak) while the maximum value was found at Sha'ab Disha (Tower). On the other hand, hard coral cover at Safaga ranges from 20.33 at Gamul Soraya to 71.71 at Panorama reef East while soft coral cover ranges from 1.13 at Sharm El-Naga to 33.75 at Tobia Arba. Among Hurghada sites, Gota Torfa recorded the highest amount of rock while at Safaga, the highest amount of rock was recorded at Sha'ab Sheer.

Rubbles in general were recorded at many sites but the highest recorded values at Hurghada were found at El-Fanus 1, El-Fanus 2 and Sha'ab Talata while at Safaga, the highest value was recorded at Abu-Kafan East followed by Gamul Soraya. Values of the percent cover of rubbles are higher at Hurghada than at Safaga diving sites. Similarly, new broken clonies are higher at Hurghada than at Safaga. Among Hurghada sites, Abu-Hashish island has the highest amount of newly broken colonies while among Safaga sites, Gamul Soraya has the highest value.

Percent cover of dead corals at Hurghada ranges from 0 at many sites to 26.6 at El-Erg 2 while at Safaga, it ranges from 0 at Sha'ab Sheer (Abd-Allah) to 12 at Gamul Kebir. Hurghada sites have higher values of dead corals than Safaga sites. Sediments in general were recorded at many sites but it was maximally recorded at Abu-Hashish island, Hurghada and Sharm El-Arab, Safaga.

Algal turf was recorded in a larger number of sites in Hurghada than in Safaga but the maximum value (10.25) was recorded at Abu-Makhadeg, Safaga, conversely, the macro algae are scarce at the diving sites of each of Hurghada and Safaga, the results also indicate that values of the percent cover of macroalgae are higher in Hurghada than in Safaga. At Hurghada, coralline algae were recorded in one site only (Shabror Umm-Gamar) while at Safaga, they were recorded in more than one site. Values of percent cover of coralline algae are higher in Safaga than in Hurghada.

Among Hurghada sites, number of *Diadema* ranges from 0 at many sites to a maximum value of 1.8 at Sha'ab Disha (Tower) while in Safaga, they were recorded maximally at the Middle reef having a mean value of 34.13. Number of clams in the studied sites has values similar in both Hurghada and Safaga and it recorded a maximum value of 0.75 at Gaftun. Kebir

Sponges were recorded at a fewer number of sites at both Hurghada and Safaga areas. where it was recorded at 7 sites only at Hurghada and 5 sites at Safaga. Values of the percentage

cover of sponge are closer to each other for both Hurghada and Safaga areas. Sea cucumbers aren't recorded in Eruk Magawish, Hurghada only but they aren't recorded in the surveyed quadrates at Safaga. Sea grasses aren't recorded in the surveyed quadrates of Hurghada diving sites but they are recorded at 2 diving sites in Safaga having a maximum percent cover of 11.11 at Gamul Soraya.

Sites screened by the coral damage index (CDI)

The extent of coral damage was high in all the four heavily visited diving sites (Table 5). Forty percent of all the transects of the four heavily visited sites were "hot spots" that required management action. Ras Abu Soma and Gaftun Segir were the most damaged sites (five "hot spots" each), followed by El-Fanus (four "hot spots"), and Got'a Abu Ramada (two "hot spots"). Thirty-one percent of the 16 "hot spot" transects were identified by both broken coral and rubble criteria, 25 % by only broken coral criterion and 44 % by only coral rubble criterion of the CDI. Number of daily observations of number of boats, number of anchors on the reef, number of divers with means (SE)/estimated dives per year (DPY-assuming two dives per diver and 300 days per year) and number of snorklers for the five sites screened by the CDI are indicated in Table 6. All these daily observations were maximum in Gaftun Segir and minimum in the control site Gaftun canal.

Table 5 Extent of coral damage at 5 diving sites in the Egyptian Red Sea expressed as percent of broken coral colonies (BCC) and percent cover of coral rubble (CR). Transects were located at 4 and 8m depths. T = transect number, CS = control site, * = ''hot spot'' (i.e BCC values of 4% or greater, CR values of 3 % or greater)

Dive Site/Location	T1 BCC/CR	T2 BCC/CR	T3 BCC/CR	T4 BCC/CR	T5 BCC/CR
El-Fanus/27°16.06`N, 33°53.20`E					
4m	0/0	0/5*	0/0	0/0	4*/7*
8m	0/0	17*/0	5*/1	0/0	0/0
Got'a Abu Ramada/27°09.26`N, 33°57.90`E					
4m	3/4*	0/8*	0/0	0/0	0/0
8m	3/0	0/0	0/0	0/0	0/0
Ras Abu Soma/26°50.29`N, 33°59.80`E					
4m	2/9*	0/0	2/2	4*/2	2/6*
8m	0/0	0/0	0/0	4*/4*	1/8*
Gaftun Segir/27°10.15N, 33°50.85`E					
4m	0/0	0/0	8*/10*	7*/0	8*/13*
8m	0/0	0/0	3/6*	0/0	4*/15*
CS Gaftun Canal/27°10.02N,33°50.07`E					
4m	0/0	3/2	0/0	0/0	0/0
8m	0/0	0/0	0/0	3/2	0/0

Table 6 Number of daily observations, with means (SE), of number of boats (Boats), number of anchors on the reef (Anchors), number of divers (Divers)/estimated dives per year (DPY - assuming two dives per diver and diving 300 days per year), and number of snorklers (Snorklers) for the five sites surveyed off Hurghada and Safaga, Egypt, Red Sea. CS = control site, * = Hawkins and Roberts (1997) recommended carrying capacity of 6000 dives per year exceeded

Dive site/date	Boats	Anchors	Divers/DPY	Snorkelers
El Fanus				
03 Oct. 1996	7	14	57	30
11 Oct. 1996	9	18	87	45
Mean(SE)	8(1)	16(2)	72(15)/43,200*	37.5(7.5)
Got'a Abu Ramada				
12 Sep. 1996	7	10	35	15
13 Sep. 1996	3	6	8	8
Mean (SE)	5(2)	8(2)	21.5(13.5)/12,900*	11.5(3.5)
Ras Abu Soma				
5 Nov. 1996	6	12	72	30
6 Nov. 1996	6	12	80	35
Mean(SE)	6(0)	12(0)	76(4)/45,600*	32.5(2.5)
Gaftun Segir				
15 Sep. 1996	7	14	74	38
16 Sep. 1996	27	54	330	160
Mean(SE)	17(10)	34(20)	202(128)/121,200*	99(61)
CS Gaftun Canal				
15 Oct. 1996	2	4	14	0
16 Oct. 1996	1	0	2	0
17 Oct. 1996	1	2	2	0
Mean(SE)	1.3(0.5)	2.7(1.9)	6(5.7)3,600	0(0)

Discussion

Regarding Hurghada sites, the highest percent cover of hard corals at Abu-Hashish West is associated with a minimum amount of human impacts while the lowest percent cover of hard corals at El-Fanus 1 is associated with higher values of human impacts and other stresses like dynamite fishing and iron chains. Among Safaga sites, Panorama reef East has the highest amount of hard corals although it contains a considerable amount of anchors, divers and snorklers because it is a big reef area and the boats anchor in a restricted area. Excessive boating pressure has adverse effect on the reef (Bell et al., 1989).

Among Hurghada sites, Abu-Nugar contains the highest amount of soft corals while Tobia Arba contains the highest value among Safaga sites and both sites contain a lower amount of hard corals. Soft corals compete for space with true stony corals and cause their death (Maragos 1974; Benayahu & Loya 1981). The higher amount of rocks at both Got'a Torfa SW, Hurghada and Sharm El-Arab, Safaga is associated with a considerably higher amount of boats and divers at both sites. Coral damage accompanying diving activities may be the result of anchors or tourist related activities such as spear fishing or coral gathering (McManus et al. 1981) or coral breakage caused by diver fins (Turch & Turch 1982). Hurghada sites in general

contain higher amount of rocks than in Safaga sites because captains of boats of Safaga take more care dealing with the reef and anchor away from the reef as far as they can (personal observation).

It seems that dynamite fishing is the main reason for the highest amount of rubbles at each of El-Fanus 1, El-Fanus 2 and Abu-Kafan East. Broken abraded tissue of corals is likely to be more susceptible to invasion by pathogens, possibly increasing mortality (Hawkins & Roberts 1992). El-Fanadir is among the sites having very low amount of rubbles since it is an exposed site having high waves and strong currents making it difficult to anchor boats. Corals in exposed sites can have denser skeletons and hence may be more resistant to breakage than those in more sheltered sites (Brown et al., 1985). The highest value of new broken colonies at Abu-Hashish island indicates that this site is the most recent site suffering damage as a result of recreational activities in contrast to most other sites in which corals suffered damage in the past which might have changed to rubbles.

Among all the studied diving sites, El-Erg 2 recorded the highest amount of dead corals and this is associated with higher numbers of snorklers and divers as well as with dynamite fishing. Kay and Liddle (1989) showed that the tissue of some species of corals can be damaged by trampling even though the tissue is not broken. Sediments have the highest percent cover at Abu-Hashish and this is accompanied by the high value of dead corals at this site. Sediments can cause the death of corals when they are heavily coated or buried (Loya 1976, Sheppard 1982 and Hudgson & Carpenter 1995). Sedimentation limits the abundance of reef framework corals (Woesik & Done 1997). The highest number of divers at Sha'ab Sabina is because it is sheltered by a barrier reef making it a suitable site for teaching diving. Sediments covering the substrate of most sites may be the result of land filling which is a general phenomenon at Hurghada. Hawkins and Roberts (1994) indicated that land filling may damage the reef both directly from construction and indirectly through the effect of sedimentation by smothering, reducing their growth rate and the ability to settle. The algae which are found in considerable amounts in most reefs may be the result of eutrophication. Nutrient enrichment of coastal waters enables algae to thrive, overgrow and kill corals (Walker and Ormond 1982).

Diadema is higher in Hurghada diving sites than in Safaga diving sites indicating that it grows well on corals suffering more stress at Hurghada. Grazers specially *Diadema setosum* compete for space with true stony corals causing their death (Eakin 1996). Littler and Littler (1995) found that the intimate association between a selective herbivore and its prey results in increased biomass and accretion of the algae affecting the reef-building system and this is a reason for the high level of algal turf in Hurghada than in Safaga.

Unless restrictions are swiftly imposed to slow down the accelerating pace of tourist development in the northern Red Sea and to cap its ultimate growth, the future of the regions of reefs will remain in doubt (Hawkins & Roberts 1994).

The focus of screening by CDI was to gauge the extent and severity of physical coral damage at 5 diving sites (4 heavily visited and one control site). There was no way to accurately determine the exact cause(s) of the physical coral damage. In this study, results may be confounded by natural physical damage i.e., breakage by other marine organisms, predation, natural disease, or bio erosion. Riegel and Velimirov (1991) mentioned the problem of accurately interpreting the causes of observed physical damage and found it difficult in many cases to differentiate between natural and man-made damage. More recently, dynamite-related damage patterns in the Red Sea were described by Riegel and Luke 1998 who showed that specific types of user damage created distinct damage patterns, which allowed them to extrapolate causes. Quantitative surveys of the study area (Tables 5 and 6) as well as qualitative observations by experienced divers and boat skippers operating in the study area since 1985 strongly suggest the damage described in this paper is overwhelmingly anchor and

diver-related. The higher amount of "hot spot" transects being identified by the coral rubble criterion than that by broken coral criterion suggests that past breakage was responsible for most of the observed damage. Sixty-three percent of the "hot spot" transects were at 4m depth versus 37% at 8m depth, suggesting that most of the damage was caused by anchors dragging across the reef in shallow water (Table 5).

The severity of coral damage (Table 7), reflected by CR, was the greatest at Gaftun Segir in transect 5 at 4m depths (333% over the CDI criterion value). Transect 3 at Gaftun Segir in 4m depth also experienced considerable damage reflected by a CR value of 233%. El Fanus experienced a severe degree of broken coral damage (BCC value 325% over the CDI criterion value) at 8m depths along transect 2. Damage percentages, relative to CDI values, for other "hot spots" are shown in Table 7.

While the estimates of the number of dives per year in Table 6, showing diving carrying capacities for El Fanus, Got'a Abu Ramada, Ras Abu Soma and Gaftun Segir are being exceeded by large amounts (and this doesn't include the damage caused by snorklers), although it is an estimate based on limited sampling, it should nevertheless be of major concern to coral reef managers.

Table 7 Severity of coral damage in "hot spots" represented as the percentage increase of broken coral colonies (BCC) and coral rubble (CR) over the CDI criteria values of 4% (BCC) and 3% (CR) for diving sites in the Egyptian Red Sea. Transects were located at 4 and 8m depths. T = transect number, * = "hot spots"

Dive site	T1 BCC/CR	T2 BCC/CR	T3 BCC/CR	T4 BCC7CR	T5 BCC/CR
El Fanus					
4m	0/0	0/76*	0/0	0/0	1*/133*
8m	0/0	325*/0	25*/1	0/0	0/0
Got'a Abu Ramada					
4m	3/33*	0/167*	0/0	0/0	0/0
8m	3/0	0/0	0/0	0/0	0/0
Ras Abu Soma					
4m	2/200*	0/0	2/2	1*/2	2/100*
8m	0/0	0/0	0/0	1*/33*	1/176*
Gaftun Segir					
4m	0/0	0/0	100*/233*	75*/0	100*/333*
8m	0/0	0/0	3/100*	0/0	1*/67*

Recommendations

1. To fix a sufficient number of buoys for each reef.
2. To construct tourist villages, hotels and other buildings at a considerable distance from the shore.
3. To limit the number of divers & snorklers per site to the limit of diver carrying capacity with continuous presence of inspectors in waters to prevent any hurt to corals by divers & snorklers.
4. To prevent absolutely coral gathering or any fishing technique in the coral community.
5. To make pathways through the reef flat to make it easy to reach deep water without damaging the reef flat.

6. Introduction of more rangers who may be authorized for immediate punishment to anyone who anchors on the reef, collects corals, walks on the reef, engages in spear fishing or any other behaviour that might be detrimental to the reef.
7. Application of restoration strategies by transplanting both sexual and asexual recruits into the ”hot spots” in synchronization with a powerful management action because just declaring an area as a protected area will attract the attention of visitors
8. Destructive fishing techniques are very dangerous to coral community (Christie et al. 1994) and have to be stopped.

Management action

In early 1997, using the results of this study, the Hurghada Environmental Protection and Conservation Association (HEPCA) with financial assistance from the United States Agency for International Development and with the participation of EEAA's Protectorates Division, installed over 250 mooring buoys (including reef top pins) at popular local diving sites within the Hurghada/Safaga area. More mooring buoys are planned for installation south of Hurghada/Safaga. HEPCA is also responsible for maintaining these buoys/pins. More rangers have been assigned to the area, and work is underway to establish a zoning and a dive site management plan.

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Coral Reef Crustacean Fisheries – Options for Management, Enhancement and Aquaculture[a]

By: Richard G. Hartnoll[b]

Abstract

It is concluded that palinurid lobsters are the only crustaceans of importance on coral reefs, and the paper reviews the exploitation of reef lobsters in the western Indian Ocean. The fisheries are predominantly artisanal, and appear generally overexploited, though stock and catch data are both inadequate. Effective management will need more data, better enforcement of regulations, and improved catching and marketing methods.

Possibilities for enhancement are reviewed. Aquaculture opportunities are limited to the grow-out of wild caught juveniles, the collection of which could impact natural stocks. Stock enhancement is not an option due to problems of larval rearing. Habitat enhancement, by the introduction of artificial habitats, is a possibility: however the ecological implications require careful study.

Introduction

This paper will concentrate on the situation in the Western Indian Ocean, though where available, appropriate examples and experience from other areas will be introduced. Three groups of decapod crustaceans are of general fisheries importance - prawns, lobsters and crabs, but they have very different significance in the coral reef context. Penaeid prawns are important in associated ecosystems such as mangroves and sea grass beds, but not in coral reefs themselves. Some caridean prawns are fished on reefs for the aquarium trade, including members of the genera *Hymenoceros, Lysmata, Periclimenes, Rynchocintes* and *Stenopus.* However, in common with the collection of reef fish for the aquarium trade, this is potentially damaging and is to be discouraged. Aquaculture is a preferred option (Strynchuk 1990). Crabs are similarly of limited commercial importance on reefs. Again some are collected for the aquarium trade, such as the Caribbean arrow crab, *Stenorhynchus.* However, here also aquaculture is a preferred option (Giwojna 1991). A few larger crabs are fished on reefs, such as the large Caribbean spider crab *Mithrax spinosissimus,* but never as major fisheries. There have been proposals for the aquaculture of this species (Cresswell et al. 1989). The reef crab *Carpilus maculatus* is collected and eaten in Madagascar and Mauritius (Guinot, 1967). On the other hand lobsters do support important fisheries in coral reefs worldwide, and the rest of this paper will concentrate on the status and sustainability of these fisheries.

Not all lobsters are of similar importance on coral reefs. The Nephropidae or 'clawed' lobsters, which includes *Homarus* and *Nephrops* as important temperate genera, are not fished on reefs. The Scyllaridae or 'slipper' lobsters occur on reefs, but are of limited value, and are usually taken incidental to other fisheries. However the Palinuridae, comprised of the 'spiny'

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or ‘rock’ lobsters, support important reef fisheries. Within this family the genera *Jasus, Linuparus* and *Palinurus* tend to occur in warm temperate areas and/or in deep water, but not on coral reefs. They support important fisheries that are often heavily mechanised. Thus there is a major fishery for *Jasus lalandei* off south and west Africa (Bergh & Johnston 1992), and a deep-water fishery for *Palinurus delagoae* off southeast Africa, southern Mozambique and Madagascar (Fischer & Bianchi 1984). There has been limited deep-water fishing for *Linuparus somniosus* off Tanzania (Ivanov & Krylov 1980). However, on coral reefs the important commercial species all belong to the genus *Panulirus,* and all species of this genus are fished.

Five species of *Panulirus* are widespread over the western Indian Ocean.

P. homarus (Linnaeus)

*P. longipes (*A. Milne Edwards)

P. ornatus (Fabricius)

P. penicillatus (Olivier)

P. versicolor (Latreille)

A sixth species, *P. polyphagus* (Herbst) is limited to the coasts of Pakistan and India, and to locations further eastwards. It will be discussed below how the data available provide a poor indication of the respective importance of these species in different areas.

There is limited information on the detailed ecology of the species, and further studies are needed. They are all predominantly nocturnal, and during the day shelter in caves in the reef and under overhangs, where they can be gregarious. There are some poorly documented habitat preferences. Thus *P. homarus* and *P. ornatus* tend to favour sheltered inshore areas, whilst *P. penicillatus* and *P. versicolor* favour offshore reefs with clear water and high wave action (George 1974, Fischer & Bianchi 1984). They all have similar and unusual larval life histories. The eggs are incubated by the females, and hatch into a distinctive pelagic phyllosoma larva. This phyllosoma stage can pass through up to twenty or more instars and spend a year in the plankton (Booth & Phillips 1994, Kittaka 1994, Kittaka et al. 1997), before moulting into the single puerulus instar which settles on the bottom. This very lengthy larval life has implications for both aquaculture and for stock discrimination.

As well as their economic importance, spiny lobsters are top predators and potential ‘keystone’ species in the reef ecosystem. As such they can exert major influence on the population structure of their invertebrate prey (Griffiths & Seiderer 1980, Tegner & Levin 1983, Edgar 1990), and may have direct or indirect effect upon the community structure. Their removal may have unpredicted effects upon the ecosystem.

The fisheries

The fisheries for *Panulirus*, in the western Indian Ocean at least, are entirely artisanal, and require little capital investment. Fishermen operate by wading or by diving from small boats, predominantly at night when the lobsters emerge from their refuges to forage. They may be captured by hand, or more commonly by spearing, and the latter method imposes constraints on the storage and marketing of the catch. It is unusual for such a high value target species to be limited to an artisanal fishery, and consequently it is of substantial direct value to the local fishing communities (unlike industrial fisheries where most of the benefit goes elsewhere), who will suffer if the fishery declines.

There is a strong and growing demand for spiny lobsters throughout the western Indian Ocean, driven in part by the growth in tourism and hotel development. Fishermen in most

coastal areas now have a ready and often unsatisfied local market for their catch. In consequence all species are heavily exploited throughout most of their range, and are generally considered as seriously overexploited. The evidence for this overexploitation is largely anecdotal, but generally emphasises reduced stocks, reduced catch per effort, and smaller size composition. The fisheries records are deficient in various respects, and provide a poor basis for evaluating the status. The following factors are relevant.

1. Records do not distinguish between species, so an increased catch of one species could mask a decline in others.
2. Catch records present only the total weight of lobsters, or the total number. There are no data on the size composition. So the catch could be being maintained by targeting smaller size classes.
3. Total effort is not recorded, so CPUE cannot be calculated. With increased demand and higher prices total catch may be maintained by increased effort and the exploitation of more distant reefs. This is not a sustainable option.
4. Records are often far from complete. The scattered nature of the fishery, often with direct sale by the fishermen to the hotels or other users, makes collection of comprehensive landing data difficult.
5. Data on total stock size, spawning stock size, and recruitment rates are all lacking. All of these are very difficult to assess in spiny lobsters. Stock size is hard to evaluate due to their coral reef environment and nocturnal habits, and recruitment because the juveniles are extremely cryptic and very rarely seen.

Effective management is going to require much better information on the biology of the lobsters, and the status of the stocks and fisheries, in order to frame viable regulations. This will require a considerable research effort, preferably with common protocols to collect the data from different areas. An additional complication is that little is known of stock boundaries and of the dispersal of larvae and adults in the western Indian Ocean. A plank tonic larval life of a year provides enormous potential for dispersal (see Pollock 1990), and presents the prospect that recruitment to a fishery may be dependent upon a very distant spawning stock in another country over which no control can be exercised. The only effective way to determine the levels of stock separation is by molecular genetic techniques (Booth et al. 1990, Silberman & Walsh 1994).

Despite this paucity of sound data there are fishery regulations in force in most of the western Indian Ocean countries. There is generally a minimum landing size and a ban on landing ovigerous females, fishing licences may be required (e.g. Mozambique), and there may be close seasons (e.g. Seychelles). However, enforcement of these regulations in a widely dispersed artisanal fishery is difficult. It is probably more effective on the island states than in mainland states with much more extensive coastlines. In the present circumstances it is not possible to assess whether these regulations are appropriate, and effective in sustaining the fishery. However, a primary aim must be to sustain and improve the utilisation of the natural stocks, which will require.

Better knowledge of basic biology.

- Comprehensive fishery statistics.
- Formulation and enforcement of sound regulations.
- Development of improved fishing and marketing methods – e.g. trapping rather than spearing; trammel nets.

Possibilities for enhancement

Whilst the exploitation of the natural stocks in a sustainable or preferably an improved fashion must be the primary aim, alternative strategies to enhance the lobster yield must be examined. Other potential strategies to improve the lobster yield are aquaculture, stock enhancement, and habitat enhancement.

Aquaculture

The standard approach to aquaculture involves 'closing the circle', namely the concept of rearing brood stock and then raising the offspring, via the larval stages, to marketable size. The technical feasibility of this has been demonstrated in clawed lobsters, although the commercial viability has yet to be proven. A major problem is their solitary habit, and their aggressive and cannibalistic nature. The gregarious habit of palinurid lobsters favours their potential for culture, but the major block is their extended larval life (see above). Although some species have been reared through the larval stages in captivity (e.g. Kittaka et al. 1997), the protocol has been complex, the duration approaching one year, and survival to the first juvenile little over 1%. It is currently impossible to transfer this to a commercial level, especially in the developing countries where the need exists.

An alternative approach is to capture either the settling postlarvae, or to collect juveniles from the wild, and then to rear these in captivity to a marketable size. The ongrowing of undersized spiny lobsters in captivity has been successfully carried out in parts of India (Radhakrishnan & Vijayakumaran 1988), and there are not major technical constraints (the economic position, however, may be a different matter depending on local circumstances). Elevated temperatures increase the growth rate, and in *P. homarus* eyestalk ablation also promotes faster growth (Radhakrishnan & Vijayakumaran 1984, Vijayakumaran & Radhakrishnan 1984). More contentious is the source of young lobsters for the exercise. There are a variety of methods for collecting postlarval settlement stages from the wild using settlement devices (e.g. Lellis 1990, Bannerot et al. 1991, Phillips et al. 1991, Guzman et al. 1996, Eggleston et al. 1998). Whilst these may collect substantial numbers at times, the supply is not dependable, and the method has yet to support a commercial enterprise. An additional problem is the complex protocol and time span of several years needed to rear the very small postlarvae through to commercial size, which would be a disincentive in an artisanal environment. The other approach is to start with larger undersized lobsters (as in the Indian programme cited above). This offers practical advantages, but there is potential environmental damage. A demand for undersized lobsters could stimulate the retention of this size class, with depletion of the natural stock as a result. Aquaculture would then be at the cost of the capture fishery. Perhaps even more worrying there could be a target fishery developed for undersized lobsters, using destructive methods to remove them from their cryptic habitats. The costs and benefits will need to be carefully evaluated.

Stock enhancement

Stock enhancement has been widely implemented in homarid lobsters, and has been based on large scale hatchery rearing of larvae that are then released to the natural environment at an advanced post-larval stage (Bannister & Addison 1998). As discussed above, this is not a practicable option for palinurid lobsters due to their quite different larval life history. It may be possible to generate a degree of stock enhancement by altering the environment though, and this is discussed below.

Habitat enhancement

Habitat enhancement is a form of stock enhancement, but the aim is to extend the available habitat, and thus the environmental carrying capacity, rather than to merely increase the number recruiting to the existing habitat (though this may be an additional effect of the programme).

There are two basic formats, which can be combined. One is to deploy devices to encourage the settlement of post-larvae from the plankton (see above). The other is to provide artificial shelters/reefs that will support the growth of lobsters additional to those stocking the natural reefs. They can act as aggregation devices to concentrate existing stocks, and indeed allow lobsters to be harvested with minimal effort and without damage. However, the aim is also to increase the availability of habitat and thus the carrying capacity of the environment. There is considerable experience on the deployment of artificial habitats ('pesqueros' or 'casitas') in the Caribbean which may be designed for juvenile (Mintz et al. 1994, Arce et al. 1997) or for the grow-out stages (Briones-Fourzán et al. 2000, Cruz & Phillips 2000, Sosa-Cordero et al. 1998).

It is necessary to be clear as to the aims of a habitat enhancement programme. One aim can be to provide additional habitat for the postlarval and juvenile lobsters during their early vulnerable stages, so that they can subsequently migrate to the natural reef areas and supplement the fishery stock. There are indications that this can increase recruitment (Butler & Herrnkind 1997). The practical benefits would depend firstly on recruitment being a limiting factor, and secondly on appropriate fishery management procedures to allow the recruits to be effectively exploited.

An alternative aim is to provide additional habitat through from settlement to harvest, possibly in areas remote from natural reefs. Appropriate refuges do attract and accommodate lobsters to commercial size, and are a major component of the fishery in parts of the Caribbean (Cuba and Mexico). However, spiny lobsters can be extremely mobile animals, and it may be hard to discriminate the stock enhancement and attraction components of the activity (Bohnsack 1989). The former could mitigate the effects of habitat loss or overfishing, whilst the latter could lead to overexploitation and collapse. There is, furthermore, the consideration that recruitment to large areas of artificial habitat may detract from recruitment to the natural reefs.

The conclusions in relation to enhancement are:

- The only practicable form of aquaculture is the ongrowing of large juveniles. These should be taken from artificial habitats, not natural reefs.
- Artificial habitats might serve to enhance recruitment of juveniles to nearby reefs.
- Artificial habitats can support lobsters to commercial size.
- The economic viability of all the above requires evaluation for specific areas and circumstances.

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Interaction of Natural Beach Formation and Degradation Through Human Activity: Implications for Coastal Zone Management[a]

By: Russell Arthurton [b]

Abstract

Sediments play key roles in the development of coral reef related coastal ecosystems. Some of these sediments are formed by a combination of biological and physical processes within the ecosystems themselves. Others are sourced from river basins or the erosion of coastal hinterland and transported to the reef related ecosystems by coastal water currents and, in some cases, wind.

The relative importance of these sources varies from place to place, depending, for example, on the proximity of the reef site to significant river discharges. It also varies over time, for example, as the direction of long-shore sediment transport on beaches reflects the changing wind patterns of the monsoon seasons through changing wave impacts. The natural processes of sediment production, transportation and deposition are affected in various ways by human intervention, whether within the ecosystems themselves or externally, even remotely.

The production of sediment in the reef related environment, other than the reworking of pre-existing sediments, depends on the maintenance of the biota that form calcium carbonate from seawater. Any human activities that adversely affect the health of these primary sediment producers should be discouraged. At the local level, these include the use of explosives in fisheries, uncontrolled ecotourism, and the indiscriminate discharge of waste waters including sewage, swimming pool flushing and industrial effluents to back-reef environments. At the regional level, the main concern for the health of these biota is the impact of waters with high levels of suspended sediment and, in some cases, high levels of nutrients and/or pesticides derived from river discharge. In such circumstances policies for coastal management need to embrace the development interests within the wider river basin catchment.

Despite its negative impacts, the discharge of sediment from rivers to the coastal environment has resource benefits that need to be safeguarded. Quartz grains derived from the hinterland form most of the white sand beaches, beach plain deposits and associated dunes of the eastern African shore. Only in a few places are present-day beaches composed of calcium carbonate sand. Whatever their origins and composition, beach sands represent a valuable resource, whether for tourism, recreation or simply for sea defence. In many cases beaches are subject to natural erosion. This may be part of a seasonal fluctuation or progressive wasting over the long-term. Where human activities such as sand mining or the construction of coastal defences contribute to beach erosion they should be regulated where possible. Access to alternative sources of construction materials should be considered. The scope of 'protection' in protected areas should extend to the non-living as well as the living resources.

The effects on the reef-related ecosystems of eastern Africa of possible relative sea-level rise over the short term are speculative. A fundamental question is whether upward accretion of

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fringing and patch reefs would keep pace with sea-level rise. Assuming such a capability for fringing reefs, it is suggested that lagoonal conditions with calcareous algae and coral mounds would become widespread, though existing beach deposits might become progressively vulnerable to erosion, posing a threat to some tourism investment.

Introduction

Contemporary coral reef related ecosystems are closely associated with sediments. Fore-reef aprons are strewn with them, reef bars are constructed from them, lagoons are lined with them, back-reef platforms are veneered with them and beaches depend on them – no sediments, no beaches. 'No beaches' means less recreation, less coastal tourism and less natural coastal protection.

In addition to their contributions to present-day ecosystems, sediments have been the main building materials of the characteristic, reef-associated coastal geomorphology that forms the ecosystem substrates. The limestone that support the patch reefs and form the rock platforms, and their associated undercut cliffs and terraces, are lithified sediments accreted mostly in back-reef environments during the last Pleistocene sea level high stand.

Thus, sediments play, and have long played, key roles in the development of reef related ecosystems. Some of these sediments are formed within the ecosystems themselves by a combination of biological and physical processes. Others are sourced in the hinterland, either discharged from rivers or eroded from beachheads, including the temporary coastal sand stores of dunes and beach plains. The relative importance of these sources varies from place to place, depending, for example, on the proximity of the reef site to significant river discharges. It also varies over time, for example, as the sediment transport regimes reflect the wind patterns of the monsoon seasons through changing wave impacts.

Increasingly, the natural processes of sediment supply are affected by human interventions. Such interventions may be local, for example schemes for protecting coastal land from wave erosion, or external, even remote – such as changes in agricultural practice within hinterland basins that significantly affect coastal waters through changes in the nature of sediment discharge from river mouths.

This paper reviews the supply and fate of sediment within coral reef related ecosystems due to natural processes in the eastern African situation. It assesses negative impacts and any possible benefits of human activity on sediment budgets both in local and regional perspectives. Finally it discusses possible remedial actions that might be considered either by coastal management or, more regionally, in a river basin context.

Sediment produced by reef-related ecosystems

Today's reef geomorphology is the product of biologically influenced sediment and rock accretion and the episodic erosion of the accreted material over geological time. Relative sea-level changes through the Quaternary period impacting the eastern African continental margin have provided repeated opportunities for the biosphere to significantly shape the form of the boundary between land and ocean. Key agents in this shaping have been the biota that have thrived in the turbulent wave conditions at the ocean margin, constructing the rigid frameworks or banks that define the outer edges of today's fringing reef, and patch reef, coasts. The persistent line of such a bank is discernable over hundreds of kilometres in the bathymetry of Kenyan and Tanzanian coastal waters.

The constructive geomorphologic elements reflect the capacity of certain biota to form calcium carbonate from seawater. Some of these biota build rigid frameworks, some encrust

or otherwise colonize substrates formed by such frameworks and their derived debris, while others – both plants and animals –deposit carbonate in their tissues that becomes translated on withering or ingestion into detrital sediment, itself a host for a carbonate shelly fauna.

Some of the sedimentary debris produced by the periodic erosion of fore-reef carbonate material by extreme wave forcing is 'lost' to deep water down the reef apron. Much of the debris, which may include blocks a metre or more across, is transported landwards, in the case of fringing reefs onto the reef bar. Here sediment may become entrapped and enveloped by a tough algal mat that is resistant to wave erosion, thus raising the surface of the bar. Some sand and fines may cross the bar and contribute to the sediment budget of the back-reef platform or lagoon, if present. In some places the reef bar is itself the victim of wave erosion, with gullies scoured on its seaward side.

Where back-reef platforms are extensive, as along much of Kenya's fringing reef coast, they may support the calcareous alga *Halimeda*, an important contributor to the platform budget (Arthurton et al. 1999, UNEP 1999). Carbonate flakes derived from the alga, which thrives in low intertidal to shallow subtidal conditions, may be the dominant component of some platform sediments, and may form the substrate to low- to mid-inter-tidal seagrass meadows (Arthurton et al. 1999). It is interesting to note that *Halimeda* flakes have also been reported as abundant in some of the Pleistocene back-reef limestone that characterise many of these coasts (Crame 1980).

Beach sediments near to the beach toe usually contain conspicuous debris of a shelly fauna, mainly bivalves and gastropods, derived from the platform. In some island situations, notably where the discharge of terrigenous sediments is remote or non-existent and the coastal hinterland is formed of terraced Pleistocene limestone, the beach may be formed almost exclusively of biogenic calcium carbonate sand. Examples occur on the eastern coasts of Zanzibar's islands (Mohamed & Betlem 1996).

Sediment from external sources

Land-sourced sediments affecting coral reef related ecosystems are of two main types. These are water-suspended fine-grained sediments, such as those forming turbidity plumes extending from river mouths, particularly during periods of spate; and bed-load sediments, transported mainly as beach sands by wave-induced currents and perhaps locally on beach backshores by wind. One further type is worth a mention, marine transported flotsam, which includes pumice pebbles (Arthurton et al. 1999), transported from distant volcanic locations, and, increasingly, plastic waste detritus.

Turbidity plumes pose a significant problem in coastal management, particularly in respect of their impact on coral health. Over geological time, such plumes have probably been a major determinant in the distribution of coral reefs. The poor development of reefs in Ungwana Bay in Kenya, for example, reflects the discharge from the seasonally sediment-laden Tana River. The potential for serious impact depends on the nature of the current regime in coastal waters – a regime that may change according to the monsoon seasons.

The beaches of the mainland fringing reef and patch reef coasts, and some of those of the larger islands where older rocks crop out, are usually formed mainly of quartz sand. Most of this sand is derived directly or indirectly from rivers and streams discharging (perhaps remotely) at the coast and transported along the coast by the processes of long-shore drift and wind deflation. Sand is also introduced to the beach budget through the erosion (and recession) of beachheads by extreme wave impacts. The beach head material being eroded may be soft or weathered sandy rock, or, more likely, the temporary 'banks' of unlithified sand represented by beach plain deposits, or, in a few locations, dunes.

Quartz sand and carbonate sand tend to be mutually exclusive on beaches. While there may be some mixing of coarse carbonate material at the toe of a quartz sand beach, the upper parts of such beaches are usually exclusively of quartz, except for the scattered debris of crab shell. While the sediments on the platforms are generally of carbonate, the occurrence of quartz grains increases in the vicinity of the beach toe, where, incidentally, the sediments may be unusually muddy.

Sand may be lost from beaches in several ways (CIRIA 1996). One common apparent loss is actually only a cross-shore redistribution of sand in response to alternating periods of high and low incident wave energy. In stormy conditions, sand is drawn down from the upper part of the beach to prograde over the platform. The reverse process occurs in calmer conditions, sand banking against the former draw-down scarp. The process of long-shore drift may result in a net loss or a net gain of sand from a specified beach sector. Again, this may be a seasonal change, or it may indicate a more fundamental long-term change, perhaps reflecting a shift in the balance of monsoons, or the incidence of human activities in an up-drift direction.

Impacts of human activities on primary sediment production

Any human activities that adversely affect the health of the primary carbonate sediment producers are likely to impact negatively on the sediment budgets of the reef and platform ecosystems, and on carbonate sand beaches, where these occur. Taking a long-term view, and particularly if the predicted global sea-level rise (IPCC 1990) affects the eastern African coasts, there is a need to ensure the capacity of the fore-reef to supply sediment to the reef bar. It is this supply that adds height to the bar, thus maintaining the standard of protection that it affords to the back-reef and the beach.

The introduction of contaminants from coastal groundwater is another concern. The raised fossil reef limestone that forms the coastal outcrop over hundreds of kilometres of the eastern African continental margin provides an important aquifer for the coastal region. Contemporary groundwater discharge from the aquifer occurs on the intertidal rock platforms. Coastal groundwater is a valuable and underdeveloped resource, but it is prone to contamination, especially in urban and industrial zones and in areas of intensive tourism development. Groundwater management in the vicinity of marine protected areas is thus seen as a priority activity (Arthurton 1998a), particularly where there is a danger of contaminated discharge impacting the coastal ecosystem.

At the regional level, the main concern for the health of this sediment-producing biota is the impact of waters with high levels of suspended sediment and, in some cases, high levels of nutrients and/or pesticides derived from river discharge. In such circumstances policies for coastal management need to embrace the development interests within the wider river basin catchment (see UNEP/MAP/PAP 1999).

Impacts of human activities on beach integrity

Whatever their origins and composition, beach sands represent a valuable resource, whether for tourism, recreation or simply for sea defence. While in many cases beaches are subject to natural erosion either seasonally or progressively, human activities such as sand mining and the construction of coastal defences may contribute to the erosion (see CIRIA 1996 and Cambers 1998).

Beach sands have long been used as construction materials in coastal areas. Where these sands have been exploited on a small scale and intermittently there may have been little effect on the beach sand budget, with any losses being made good by natural renourishment processes. Increasingly, and particularly in the vicinity of urban areas, a greater demand for

sand means that beach mining may now cause significant sand depletion and consequent beach degradation. The extraction of sand from riverbeds in the lower reaches of rivers, especially near their mouths, is similarly an increasing practice that will impact on coastal sediment budgets, and thus beach health, over the long term.

Coastal engineering, including construction and dredging schemes, can seriously interfere with established processes of sand transport in the beach environment, leading to the depletion of sand on adjoining shores (CIRIA 1996). While seawalls may be installed to provide protection to vulnerable beachheads, unsuitable designs may exacerbate erosion of the adjacent beachhead in the down-drift direction. Protection schemes that promote the accretion of sand on beaches rather than attempting to defend against direct wave attack may be more effective. Such approaches include the installation of groynes, constructed of timber or rock blocks, and detached breakwaters. These schemes are expensive, however, and may detract from the visual amenity of the beach.

The long-term implications of land-use changes in the hinterland river basins on the delivery of sediment to the coastal zone are difficult to assess. The widespread impoundment of water in many river basins for irrigation or hydropower means that river systems are becoming less effective as transporters of sediment. Despite this constraint, it has been noted that widespread changes in agricultural practice such as deep tillage have led to an increase in soil loss and in some cases, e.g. the Tana River in Kenya, an increase in sediment flux to the sea (Hatziolos et al. 1994). Despite the negative impacts of turbidity plumes, the discharge of sediment from rivers to the coastal environment has resource benefits that need to be safeguarded. Quartz grains derived from the hinterland form most of the white sand beaches, beach plain deposits and associated dunes of the eastern African shore, all key non-living assets in the sustainable development of eastern African coastal communities.

At the global scale, the extent to which human activities are the cause of contemporary global warming and consequent sea-level rise is yet unclear. Whatever the cause, the effects on the reef-related ecosystems of eastern Africa of a relative sea-level rise over the next 50-100 years are speculative. A fundamental question is whether the upward accretion of fringing and patch reefs would keep pace with sea-level rise. Assuming such a capability for fringing reefs, it has been suggested that lagoon conditions with calcareous algae and coral mounds would become widespread across existing platform areas (Arthurton et al. 1999). With greater water depths over the platform areas beaches and weak beach head materials are likely to become increasingly vulnerable to wave erosion, posing a threat to tourism investment, particularly that sited on beach plains.

Implications for coastal zone management

The scope of ‘protection’ of marine protected areas should extend to the non-living, as well as the living, resources.

Any human activities at the local level that impair the capacity of the sediment-producing biota on the fore-reef and on the back-reef platform should be avoided. Such activities include the use of explosives in fisheries and uncontrolled ecotourism. A particular concern is the indiscriminate discharge of waste waters including sewage, swimming pool flushing and industrial effluents to back-reef environments.

Groundwater management in the vicinity of marine protected areas is seen as a priority activity where there is a danger of contaminated discharge impacting the coastal ecosystems.

Depending on the resources at risk from beach and beachhead erosion, taking no action may be sensible – the ‘do nothing’ option. In situations where communities are vulnerable, however, or, where infrastructure is threatened, there is generally a need for intervention.

Possible interventions at the local scale include planning, regulation and physical control involving engineering (see Arthurton 1998b).

Planning and regulation with the aim of reducing vulnerability may include the relocation of people and development or redevelopment, perhaps using 'setback' policies involving the restriction of development of certain types within a prescribed distance from the shoreline. Regulation may also cover practices that lead to beach- and beachhead erosion, including sand mining from beaches and adjoining river courses, the construction of inappropriate sea defences, and the indiscriminate dredging of sand in inshore areas. Access to alternative sources of construction materials in lieu of beach sand should be considered.

If valuable investment is at risk, the physical control of wave impact and/or the sediment budget on beaches may be justified. This may involve the construction of suitably designed sea walls, groynes and detached breakwaters (bearing in mind possible negative impacts), or by beach re-nourishment (see Davison et al. 1992). Beach re-nourishment is a remedial option where, for example, an important recreational beach has suffered severe sand loss. The recycling of beach sand against the direction of net long-shore drift might be considered.

Any controls on the rates of sand and suspended sediment discharge from rivers – a significant concern in the coastal environment – are beyond the scope of local intervention and call for a regional, river basin management approach (UNEP/MAP/PAP 1999).

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Discussion of Panel II

By. Lothar Schillak

The contributions of panel 2 clearly described the urgent need for a multi-sectoral, interdisciplinary approach to coral reef rehabilitation. In the discussion it was stressed that coral reef rehabilitation cannot and must not be based solely on the conservation of reef areas. Reefs are not only exploited for their stocks of fish but also for other marine biota of economic significance such as crustaceans (contribution Hartnoll). The excavation of coral rock, too, represents an important impact on the reefs (contribution Arthurton). Coral reef rehabilitation needs adequate techniques (contribution Schillak) but cannot go nor without basic research regarding imposed ecological stress on corals (contribution Schröder) neither with the definition of the actual stage of degradation via adequate tools such as the CDI-Coral Damage Index (contribution Ammar).

The problem was discussed that rehabilitation with corals taken from reefs can present a potential threat to these reefs, similarly it is often unclear whether the total amount of lobsters can be increased or is only concentrated if shelters are provided. Only a few technical options for a sustainable rehabilitation of coral reefs are available at present: re-colonisation of degraded areas via transplantation of autochthonous coral species into devastated parts of coral reefs by the aid of adequate, ecologically safe artificial substrates combined with intense activities of coral farming. An example from the Philippines illustrated that especially the combination of transplantation and coral farming represents a set of possibilities to enforce local and regional socio-economic infrastructures:

- coral species are farmed by locals themselves
- corals nubbins for transplantation are taken from coral farm, thus vital coral reef areas are not impacted
- transplantation is done by locals
- the farm generates income for the locals, since coral farms are potential sources for the international trade market for corals

It was underscored that the stage of development of present coral reef rehabilitation technologies using transplants (coral nubbins) does not allow for an application to hundreds of square kilometres of coral reefs. Small scale applications are thought to be an adequate tool for technical rehabilitation activities. To apply coral reef rehabilitation on a small scale rather than to entire stretches of coastline also coincides with the social structure along human coral reef communities: tribes and small communities are the owners of “their” coral reef area. Technical coral reef rehabilitation therefore is considered as a technique which revitalises small reef areas as nuclei, from which the re-colonisation of the wider coral reef areas starts.

However, technical coral reef rehabilitation needs input from the national policy makers and a political, socio-economic frame. Financial aid is necessary to establish the coral farm infrastructure and for the transplantation materials and devices. Political help is needed on the local and regional level to foster the involvement of locals.

The sustainability of the financial and policy investments needed to start and trigger coral reef rehabilitation during the first, very difficult years, will finally decide on the effectiveness of reef rehabilitation and improvement of socio-economic infrastructures, which is badly needed in most of the human coral reef communities.

Panel III: Stakeholder Participation and Partnership

Contents

Collaborative natural resource management approaches which rely on stakeholder participation and partnership between state agencies, local communities and commercial users have emerged as major policy thrust in recent years. Panel 3 discusses the potentials and constraints of stakeholder participation and partnership from a theoretical, empirical and policy perspective. The contributions help to identify under which conditions participatory approaches meet their stated objective to contribute to an efficient, equitable and environmentally sustainable use of coral reefs and associated ecosystems.

The introduction to the first section will familiarise the participants with the analytical concepts of entitlements/property rights and collective action, which are essential for the analysis of community-based and collaborative management approaches. The second contribution focuses on coastal communities and analyses how they can articulate their political interests and thus increase their participation in coastal management in southern Kenya. As environmental education and awareness can be considered as a major precondition for successful user participation and involvement of stakeholders, the following two contributions discuss this issue using examples of educational efforts undertaken in Mangrove restoration in Kenya and in Zanzibar. The final contribution uses another example from Tanzania in order to highlight the often under-estimated role of the private sector as a stakeholder. The case shows that private sector initiatives can play a role not only in promoting protection but also in stimulating the policy formation processes that lead to more favourable framework conditions for conservation.

The second section presents three examples from the Philippines, a country which is renowned for its experience with collaborative management approaches. The first contribution analyses the role of the policy framework for stakeholder involvement. The second presentation illustrates the role of NGOs for mobilising stakeholder participation. The third presentation deals with stakeholder participation in one major conservation strategy - marine protected areas (MPAs) - and elaborates key factors enhancing community-based establishment and management of MPAs, drawing on the Philippine experience. The final paper discusses different approaches to the analysis of stakeholder participation to illustrate the contribution social sciences can make in this policy relevant area.

The Concept of Property Rights and Common-Pool Resources: An Economic Perspective for Analysing Sustainable Use[a]

By: Abdul B. Kamara[b]

Abstract

The growing concern currently attached to environmental policy issues is largely engendered by the practical problems encountered in natural resource management, and lessons learned from the diverse parts of the world. Previous experiences have led to the adoption of an integrated and interdisciplinary approach to resource management, involving experts from various fields, notably biologists, economists and social scientists. As the long focus on traditional methods of resource improvements such as stimulating growth through biotechnological methods and assessing technical options employed in resource exploitation do not seem to be effectively delivering the goods, the relevance of social organisation and management institutions are gradually being acknowledged for a complementary role in the search for solutions for efficient and sustainable resource management. Specifically, the reorientation focuses on the role of property rights – the system of duties and obligations, rules and regulations, and mechanisms of sanctioning that determine the access to natural resources – as being crucial for sustainable management. While various scholars repeatedly highlight the issue, a comprehensive synthesis of these concepts for easing interdisciplinary work, especially on coastal resources, is still very limited.

As a theoretical framework, the paper attempts to disentangle the inter-linkages between the basic concepts (particularly property rights) that form the precepts of the theories that underscore the principles and social dynamics of natural resource management. This is then related to marine resources especially coral reefs, taking their specific attributes into consideration which make certain forms of property rights generally appropriate, and the typical problems that are associated with their implementation. Key issues arising from property rights theory that are relevant for analysing the sustainable use of coral reefs and associated coastal resources are then highlighted and recommendations made.

Introduction

In the recent past, environmental policy issues have moved up the development agenda as more concerns are raised about current resource exploitation rates vis-à-vis regeneration potential and the sustainability of resource use. This growing concern is engendered by the practical problems encountered in natural resource management and lessons derived from the diverse parts of the world. Previous experiences have led to the integration of natural resource management and sustainability issues into an interdisciplinary approach involving experts from various fields especially biological and social scientists. In spite of this awareness, the focus of most of these disciplines have been concentrated on resource improvements or stimulating growth through biotechnological methods, and using technical options employed

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[a] Paper presented at the EU-Workshop: Policy Options for the sustainable Use of Coral Reefs and Associated coastal Ecosystems; Mombasa, Kenya June 19th – 22nd, 2000.

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in the exploitation of particular resources as a yardstick for judging sustainability of resource use (Ascher & Healy, 1990). Current discussions from many of these disciplines seem to be underscored by a common denominator that alludes to the relevance of social organisational and management patterns under which resources are held as a key to optimal resource exploitation (Bromley & Cernea, 1989). This growing realisation has revitalised the position of economists and other social scientists in examining institutions for their potential role in the sustainable use of natural resources (North, 1995). As the role of market institutions is relatively well established in economic theory, the reorientation focuses specifically on property institutions – entitlements, property rights or property regimes – whose appropriateness is now widely acknowledged as a fundamental prerequisite for the sustainable management of natural resources of varying characteristics (Oakerson, 1992). Specifically, the physical and technical attributes of some resources call certain forms of property regimes into question, while deeming others appropriate for their sustainable management and exploitation.

Clearly, land and water resources vary tremendously in their physical attributes such as jointness and scale of divisibility, which primarily determine the possibility of partition and subsequent exclusion of non-owners, or the assurance of owners to benefits streaming from the resource base. Focussing on coral reefs and associated coastal resources, one is confronted with the challenge that the nature of these resources is even likely to cut across many of these attributes, so that addressing their sustainable use calls for the incorporation of property rights into existing frameworks that seek to address their sustainable use. The issue is highlighted by various scholars, but remains largely unexplored (Jeffreys, 1993; Ostrom et al.; 1995; Bavinck, 1996). The multidisciplinary nature of current approaches to the globally acknowledged problem of degradation of marine resources (Roberts, 1998), particularly coral reefs and associated coastal resources, makes it imperative to examine some of these seemingly elusive but vital concepts that play a role in the sustainable management and use of marine resources.

Issues and Objectives

As a theoretical framework, the paper attempts to disentangle the inter-linkages between property rights theory and the management and sustainable use of common pool resources, stimulating discussion on specific issues related to coastal resources and the often associated problem of open access. The success of interdisciplinary efforts towards sustainability requires an elucidation of some of the basic concepts emerging from the theories that underscore the principles of natural resource management. After a thorough analysis of natural resource use systems in many parts of the world, many researchers conclude that addressing sustainable resource use problems at the local level will not be successful until the very nature of the property and authority systems governing the resources are clearly understood (Bromley & Cernea, 1989; McKean, 1992). The view recommends a critical examination of specific property rights or entitlements for specific resources under particular circumstances, as against their physical and technical attributes, which will determine appropriate management systems. This view, which is now ubiquitously shared by many scholars, is used in this paper to examine coral reefs from the perspective of sustainable use.

The paper examines the question of sustainability from different perspectives and disciplines. This is then related to the concept of property rights, paying more attention to the peculiar attributes of common-pool resources – which best describe coral reefs and associated coastal resources – in relation to the practical applicability of recommended methods for their exploitation (or restoration) and sustainability. The concepts of substractibility, jointness, exclusion principle, and scale of divisibility that determine the creation of physical boundaries

and effective implementation of rules and regulation, are reviewed (Oakerson, 1992; North, 1995). Thus, the objective of the paper is to show how the concept of property rights and common-pool resources could form a basis for analysing the sustainable use of coral reefs and associated coastal resources. The paper is specifically intended to:

- explain basic concepts that form the basis of theories that underscore the principles of sustainable resource management from an economic perspective, specifically focussing on the concepts of property rights and common-pool resources;
- draw attention to the potential role of property rights in the development of a framework for the sustainable management of coral reef and associated coastal resources;
- theoretically show how some of the peculiar attributes of coral reef resources may create the need for the implementation of certain forms of property rights; and
- highlight key issues arising from property rights theory that are relevant for analysing the sustainable use of coral reefs and associated coastal resources; and
- assess the potential for incorporation of some of the above concepts to the development of a broader framework for analysing sustainable use.

Coral Reefs as Common-Pool Resources

Marine resources generally belong to the category of resource-systems described as common-pool resources. These are resource-systems (renewable and non-renewable, natural or man-made) from which units of benefit stream can be appropriated by individuals or groups of individuals. The stock of a common-pool resource is sufficiently large to the extent that it is costly to exclude outsiders from obtaining subtractable units of the resource (Ostrom, 1992). Common pool resources are thus characterised by a high cost of achieving physical exclusion, and the presence of subtractable resource-units. Coral reef resources belong to the pool of marine resources that exhibit the above attributes. Because of its physical attributes, the flow of our marine resource or resource stock (the sea), almost renders the creation of physical boundaries impossible, so that exclusion of outsiders from appropriating resources units (fish, reef organisms, oysters, etc.) can only be reduced to a certain scale of joint ownership – continental borders, national waters, fishing community, coastal village with riparian rights, and so on. In all these instances, it is expedient to distinguish between regulations of access of individual members of the commons, from exclusion as applied to the deprivation of a certain community or user group as a whole.

This analysis requires a review of the attributes of common-pool resources. The definitions distinguish between the resource system or *resource stock*, and the flow of *resource units*, which individuals can appropriate from the resource system – e.g. reef organisms or fish harvested from the ocean. This characteristic is associated with the attributes of *jointness*, *indivisibility* and *subtractability* (Ostrom, 1992; Kamara, 2001). Indivisibility refers to the relative scale on which a common pool resource can be divided without significantly impairing its management potential or production value. This attribute is crucial in determining the physical possibility of creating boundaries, so that partitioning such resources – even with the existence of economic incentives for doing so – may be constrained by nature or technology, or fuzziness of boundaries demarcating the domain of the commons (Goodhue & McCarthy, 1999). Such physical demarcations may be much divergent from jurisdictional units or boundaries imposed by law. The phenomenon is exemplified with common property resources such as a village pond or stream, maritime waters, underground aquifers, etc. Sometimes even if the resource may be technically divisible, economic, social or cultural reasons may deem it necessary for the treatment of such a divisible resource as a commons.

Because of these physical and technical attributes, limited scale of divisibility and problems of exclusion, the consumption of common-pool resources is often confronted with such rivalry that sometimes amounts to huge loses to the resource base. The FAO (1993), for instance, estimates a worldwide annual loss of about $15–30 billion worth of fish due to the fact that competing users in international waters do not allow fish-stock to recover. Similarly, a conservative estimate by Pezzy et al. (1998) suggests that the value of coral reef fisheries alone would increase by over a billion US dollars if no-take reserves were set up worldwide. A similar statistics is presented by the US on the loss of valuable stock in federal waters due to lack of stock regeneration. Incentives for exploitation, under such competition, are usually based on a comparison between the price of entry (which the exploiters have to bear) and the expected income they hope to acquire. These huge externalities and the reduction of value of the common-pool resource base can be minimised on if a functional system of property rights that regulates access to and appropriation of common-pool resources is in place.

Property, Entitlements and Property Rights

Property in its literal sense depicts a possession, ownership, entitlements or a claim. It may refer to the rights of individuals to resources or an authority given to individuals or groups to use resources within the limits of a set of permissible uses. Property is also related to an institution by which people orient themselves in accordance with prevailing institutional arrangements. In this context, many perceive property as a social contract that defines an individual and an object of value, vis-à-vis all other individuals. Property, however, is not a tangible object such as a building, or a piece of land, but is rather a right to a benefit stream that is only as secure as the duty of all others to respect the conditions that protect that stream (Bromley & Cernea, 1989). When one has a right, one has the expectation in both the law and in practice, that one's claims will be respected by those with duty to respect that right. This perception gives the concept of property rights a dual character, which is much understood as a social relation that defines the property holder, with respect to something of value, against all others (Bromley, 1992).

Thus, property can be viewed as a triadic social relation involving *benefit stream*, *right holders*, and *duty bearers* (Bromley, 1992; North, 1995). Property is thus defined as a benefit stream that can be accessed, acquired and enjoyed as a result of having a structure of rights to a resource. Property rights are the rights to have an access to or control over a resource from which some form of benefit stream is expected. Property can therefore be posited as a *claim* and property rights as a *claim to a benefit stream* which some higher body – usually the state – will agree to *protect* through the assignment of *duty* to others. The triadic conceptualisation of property and property rights are summarised in Figure 1 below.

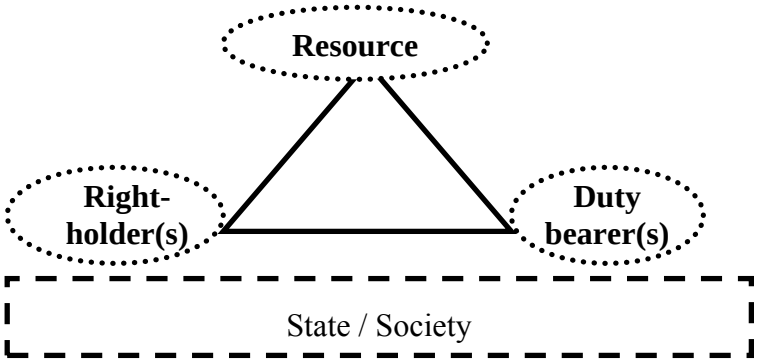

Figure 1: Triadic Conceptualisation of Property and Property Rights

As indicated in the framework, property relations between individuals or groups are defined by a structure of rights and duties. That is, one individual or group is guaranteed a right to a

property by an authority system (state or society), which at the same time obligates others to respect those rights. Some speak of property rights as consisting of a 'bundle of different rights' which together constitute a property (e.g. Birner, 1999). This notion of a bundle of rights includes the right to *use* the resource, the right to *manage* the resource, the right to the *income or benefits* streaming from the resource, the right to exclude other potential users, the right to *transfer* the resource temporarily or permanently to another user, and the right to *compensation* resulting from damages to the resource. These six rights, guided by *punishment* and *liability* rules, formulated and implemented by an authority system, all together form the concept of property. While the punishment rule assists the property owner to enforce the accorded rights, the liability rule secures the non-owners against external effects resulting from the owner's use of the resource. The resource is a private property if these rights are vested in an individual, a state property if the state becomes the custodian and enjoys the accorded rights, or a common property if the rights are accorded to a group. The resource degenerates into an open access if no one bears these rights and duties, and rules, regulations and sanctions are not implemented.

This set of institutional arrangements – that is property rights or the prescribed rules – that determine *who* can access *what* resources, *how* and *when* is a principal determinant of the manner of exploitation and subsequent conservation or degradation of resources. These institutional arrangements, referred to as property regimes or resource regimes, are crucial for the sustainable management of resources.

Conclusions and Implications for Coral Reef Management

While property rights remain crucial for sustainable resource management, the formalisation of property rights over common-pool resources needs to consider both formal and informal claims of local level users. From the attributes of common-pool resources, it is crystal clear that effective implementation of rules and sanctions to achieve exclusion can be both physically and technically limited. Implementation is largely dependent on the incentive and willingness of the resource users to comply with rules and regulations in the interest of cooperation to maximise the joint welfare of the community. People's incentives to comply will clearly depend on the modes of creation of property rights, which will determine the legitimacy of the newly assigned duties and obligation, at least in the eyes of those without the bargaining power to participate in rule formulation. Experience worldwide indicates that investment in resource improvement and compliance with resource management rules, e.g. in integrated coastal zone management, is higher when there is a thorough local consultation process, capacity building and information-sharing process that recognises the riparian and other traditional rights of local communities (Ngoile & Linden, 1998; Makoloweka & Shurcliff, 1998).

The above synthesis has an important implication for the sustainable management of coral reefs and associated coastal eco-systems. The formation of no-take zones and marine protected areas, among others, will benefit from greater security and reassurance that species will regenerate, if the process takes the local communities onboard so that it becomes legitimised and accepted to them, while addressing issues related to alternative sources of income of coastal dwellers. While a right-based management is recommended, it should be largely underscored by a co-management approach that involves the different tiers of the riparian dwellers, in a community-based management system that informs them about the direct and indirect benefits of co-management. In particular, a clear information on the short and long-term benefits accruing to alternative uses of resources (tourism, recreation, etc.) should be made available to the local communities, complemented by an elaboration of how these will improve the collectives welfare and livelihood of the society as a whole in the long run.

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Managing without formal institutions: the role of communication networks in marine resource management. A case study from southern coastal Kenya.[a]

By: Anthony King [b]

Introduction

Despite increasing involvement of local stakeholders, resource management policies often fail to meet expectations. The suggestion in this paper is that this is partly because too much emphasis is given to the role of formal and informal institutions in shaping policies. Institutions are understood to be the complexes of norms of behaviour structuring human interactions, with formal (rules, laws…) and informal (conventions, customs…) constraints. In relation to common pool resources, such as coral reefs and associated fisheries, institutions are generally considered to be the working rules used to organise repetitive activities, such as harvesting or gaining access. Their importance stems from the fact that they confer rights and responsibilities and provide livelihood opportunities by authorising and legitimising people's actions. Their appeal for policy formulation is, along with their roles, that they provide a structure on which to base management strategies. With increasing involvement of local stakeholders, this has meant that increasing numbers and levels of institution are identified, from national laws to local customs or traditions, and incorporated into management strategies.

However, institutions are not the only way people organise activities in their daily life. For example transient networks are often mobilised to provide information, financial support, and practical help. In many instances these kinds of less structured processes occur when people face the kinds of problems resource management policies also seek to tackle. Understanding these processes may benefit natural resource management policies, and would help to explain why local people may be reluctant to participate in collective projects, preferring instead to work in loose networks.

This paper is drawn from social network analysis of three resource access and control problems faced by a small fishing community on the south coast of Kenya. The role of institutions in solving these problems is examined.

Socio-economic setting

The community of Biga in Galu sublocation is typical of the south coast of Kenya, with most households dependent on a mix of fishing and subsistence agriculture and cash cropping. Over the last two decades fishing has become more important than subsistence agriculture because the availability of land has decreased due to the policy of land adjudication and consequently private development. People are now more dependent on income earning activities, such as fishing or growing fruit trees, in order to buy food. Despite the proximity of tourism development to the community, few households have found employment there due to

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nepotism in the industry based on tribal affiliations. (From a socio-economic point of view the terrestrial environment should also be considered an ecosystem associated with the coral reef/seagrass bed environment).

Within the community itself there are three ethnic groups: 90% are local Digo people, 7% are from inland tribes, and 3% are migrant fishers from Pemba island in Tanzania. The population is about 1,500 people. In the general area of the community there are also a number of European and Asian expatriate residences, some tourism development and small business. These groups tend to occupy beachfront land. This paper focuses on the Digo households, which could be further differentiated according to their production systems, summarised in table 1.

Table 1: The importance of fish for the different Digo household groups in Biga.

Group by production System	% income from fish
Households with boats (dugout canoes)	**78**
Households without boats	**96**
Fish trader households	**55**
Subsistence agriculture households	**8**

Solving resource access and control problems

The institutions that should theoretically determine resource access and control for the Digo fishers were identified and are summarised in figure 2. In order to determine the role of these kinds of institutions the communication networks that were formed when community members sought to resolve resource access and control problems were analysed. The analysis was retrospective because the outcomes were known to favour the Digo members of the fishing community. The problems that were analysed were: a) the attempted implementation of a Marine Protected Area that would have incorporated the community's fishing grounds; b) a conflict with the migrant fishers from Pemba over the use of fine meshed beach seines; and c) the threat to access to the sea due to land grabbing by local politicians.

It was possible to determine the role of different institutions through the importance of the various actors in the networks. Both formal and informal institutions were identified. From a network perspective, actors have constraints or opportunities according to the way they are embedded in a network. The extent to which an actor is connected to other actors can determine how favourably they are positioned in the network, and consequently whether they are in a position of power over other actors. In this study, the actors present in the networks were considered to represent institutions, for example Fisheries Department personnel were considered to represent national fisheries legislation (these assumptions were verified through semi-structured interviews, documentation etc.), and an actor's importance in a network reflects the importance of certain institutions.

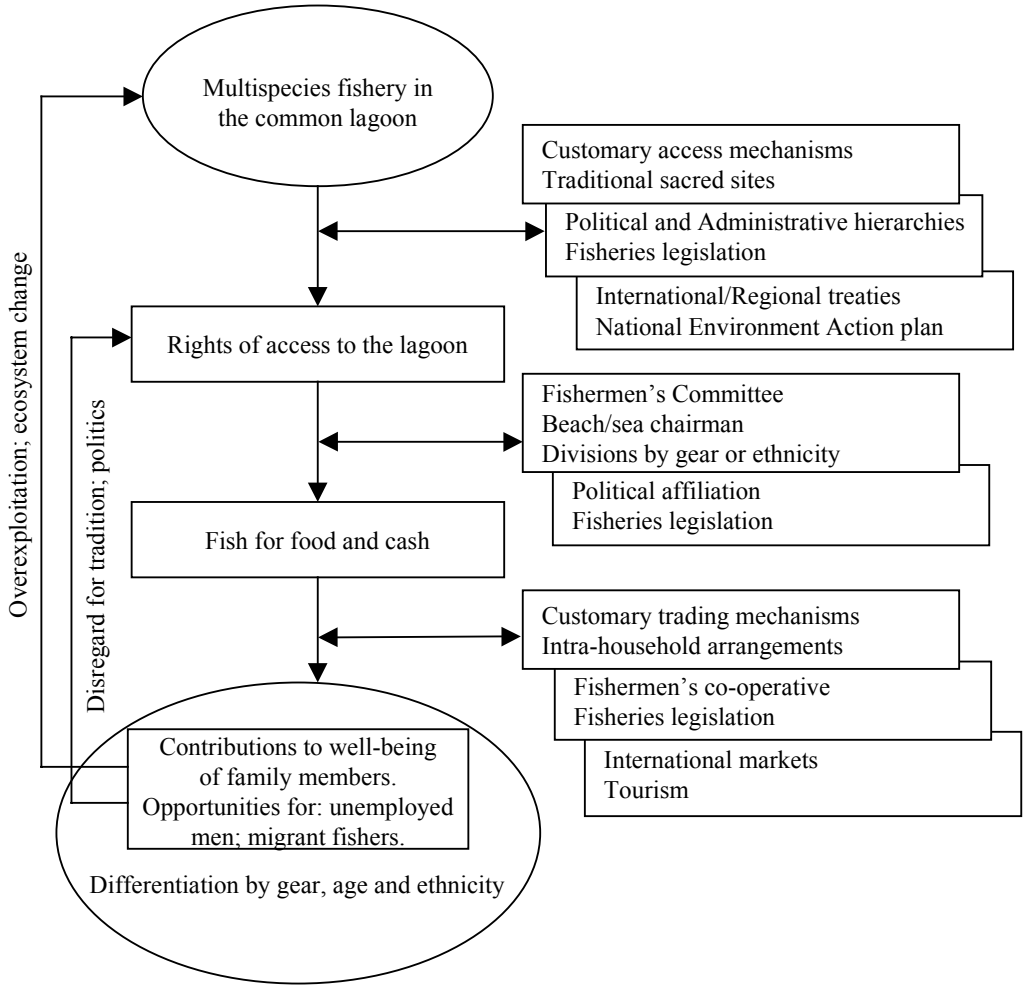
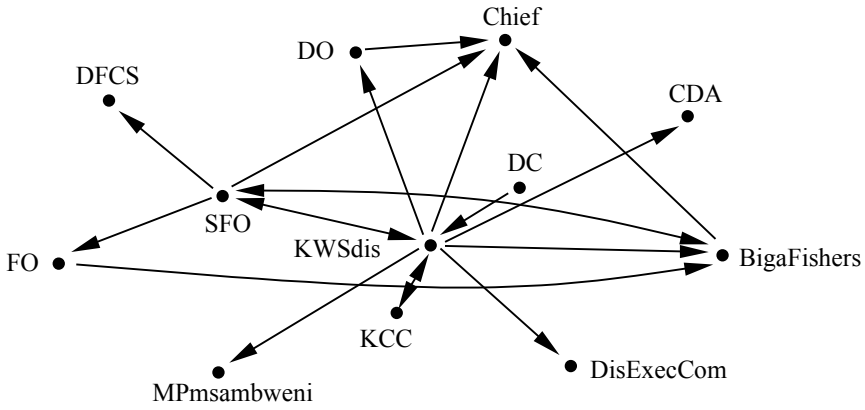


Figure 2 Formal and informal institutions that theoretically shape fishers' resource claims and practices in relation to fishing in the waters adjacent to Biga.

Results showed that each of the issues had distinctive phases (for example see figure 3), and that the number of actors and communication ties tended to increase in the later phases of the issues.

Phase 1.



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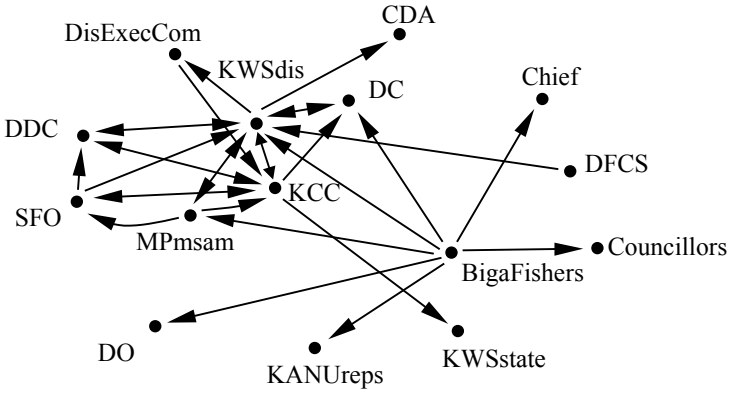
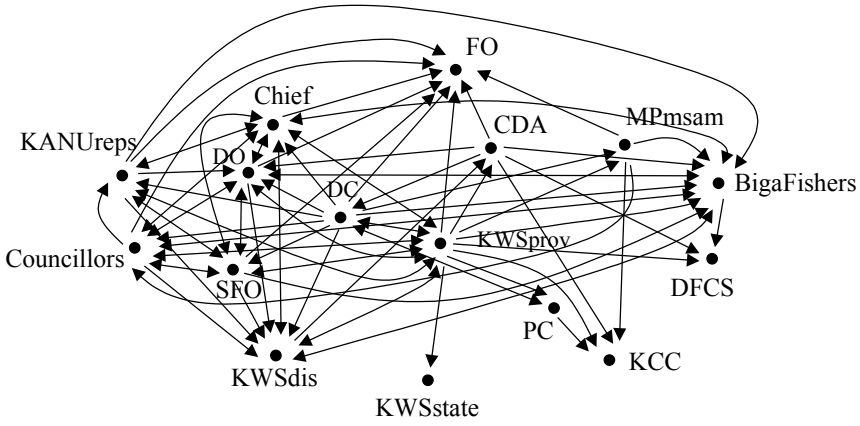


Phase 3.



Key: CDA – Coast Development Authority; DC – District Commissioner; DDC – District Development Committee; DEC – District Executive Council; DFCS – Diani Fishermen's Co-operative Society; DO – District Officer; FO – Fisheries Officer; KANUreps – Political party reps.; KCC – Kwale County Council; KWS – KWS district, state, province level; MPmsm – MP Msambweni; PC – Provincial Commissioner; SFO – Senior Fisheries Officer.

Figure 3 Directed graphs for the marine reserve issue (abbreviations below).

A generalised impression of the roles and importance of the different actors and the represented level of institution for each of the issues investigated is given in figure 4. The early phases of each issue revolved around the actors that instigated the problem. Despite attempts by the fishing community to resolve the problem through organisations responsible for natural resource management, nothing was resolved, and a *status quo* was maintained. The important actors in the networks reflected the nature of each issue and tended to include the Fisheries Department or Kenya Wildlife Service and the local administrative authorities such as the Chief. The importance of these actors in the networks showed that formal institutions were actually maintaining the *status quo*, and not helping to resolve the issues.

In the final phase of each issue, problems were resolved because there was a break in the *status quo* and a number of new actors became important in the networks. These actors tended to be senior members of organisations that did not represent institutions designed to tackle natural resource access or control problems. They tended to be members of the Administration, with the District Commissioner usually being the most important actor.

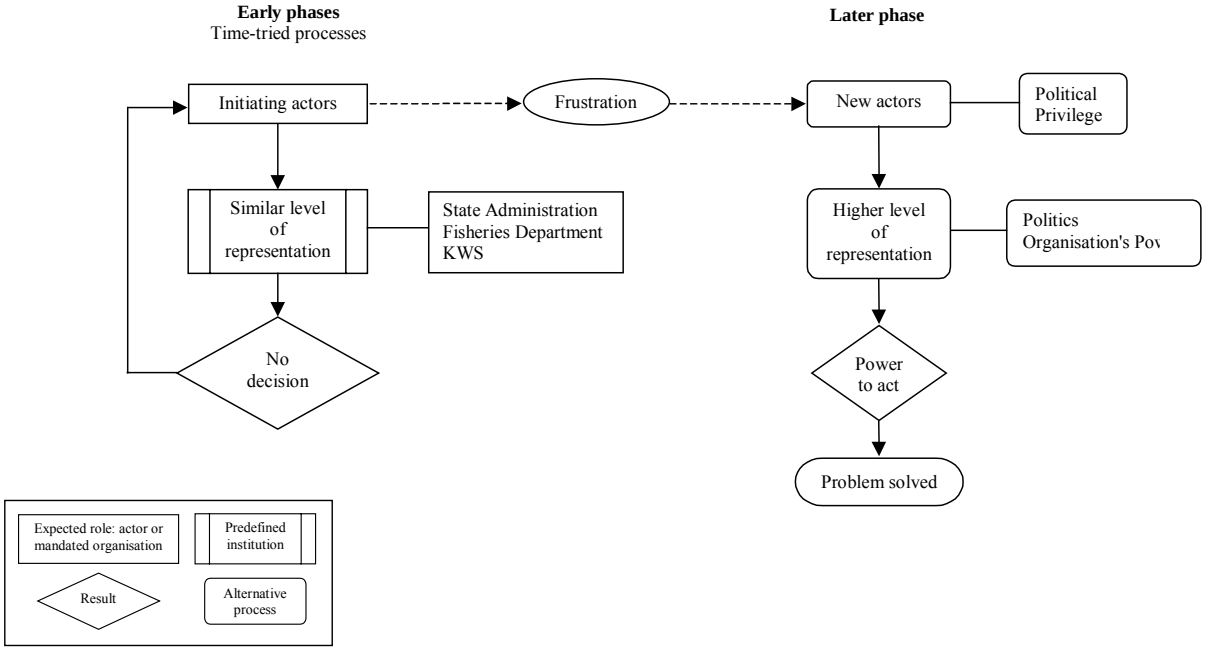


Figure 4 Simplified flow of communication as fishers attempt to resolve resource access and control problems.

The level of representation in the networks was also found to influence the situation in each issue. In each case, when the important actors in the networks were local level representatives of organisations the *status quo* was maintained. Resolutions to the problems only came about when more senior actors were involved. A key aspect in this shift from local level representation to higher levels was the need for political or privileged actors to become involved in order to provide access to senior individuals in the Administration. This reflected the course of action the fishing community were forced to take in response to the lack of action on the part of the mandated organisations.

This situation may not seem unusual when considering people's experiences in trying to tackle resource access and control problems in countries such as Kenya. But from a resource management perspective it raises questions about the role of natural resource related institutions because each of the issues should have been resolved by the legally mandated natural resource management organisations, such as the Fisheries Department or Kenya Wildlife Service. But the analysis showed that they contributed to the problems, and that the

Administration became important in the process because of the lack of action on the part of the resource management organisations.

In addition the role of traditional institutions was found not to be important in the networks. For example the community elders were in the networks, but they did not feature as important, and the traditional role of the beach/sea chairman had no influence in the issues. The fishermen were also relatively low powered despite being the main stakeholders and being involved in a high number of relations with other actors. They relied on other actors to raise the profile of their concerns. Significantly, the actors they relied upon were seldom acting in relation to resource management institutions and few of the processes that secured successful outcomes for the fishers involved formal rules relating to natural resources. In fact natural resource related organisations used formal institutions to maintain a *status quo* and constrain the process of problem resolution.

This situation could partly be explained by the nature and roles of natural resource related government organisations. These organisations suffered from bureaucratic problems, were poorly represented at the local level and their relative position of power meant that individuals within them tended to be prejudicial about the problems faced by local people. Consequently the formal institutions were unable to keep pace with changes occurring at the local level. This in turn meant that local people's ability to adapt to changing conditions was constrained, thereby reducing their livelihood complexity and diversity.

The communication networks showed that it was possible for the main stakeholders to express multiple interests where no useful institutional arrangements existed, and that problems could be resolved through the networks.

The findings stress that resource managers need to appreciate that different people and organisations are important at different phases of resource related problems. The benefits of involving local people in resource management may stem more from facilitating problem solving than from trying to patch policies to the 'bag' of institutions they bring with them. The aim should be to manage for complexity and diversity, and focus should only be given to those institutions that promote or permit complex, diverse and locally fitting behaviour.

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Mangrove Restoration in Kenya: Constraints and Prospects[a]

By: James G. Kairo[b]

Abstract

The restoration of mangrove systems has received a lot of attention worldwide. The reasons for increased interests are fourfold. First, the long ignored ecological and environmental values of mangrove forests have scientifically been documented for many mangrove areas in the world. Secondly, there is a high subsistence dependence on natural resources from mangrove forests. Thirdly, large losses of mangroves have occurred throughout the world, some of which in need of urgent attention. Fourthly. Governments throughout the world are showing commitment towards sustainable development of mangrove areas.

In Kenya, the destruction of mangrove areas is approximated at 600ha/year. Such destruction has been attributed to, unchecked heavy cutting of the trees for building and firewood, fishpond ventures, solar salt works and pollution effects. The loss of mangrove forests in turn is affecting the local economy, as indicated by shortage of building poles and firewood, damage to agricultural fields, and decreasing coral and fishery resources. The damage can be overcome by restoration of mangrove areas.

Recognizing the ecological and economic importance of mangroves the local community at Gazi bay, in cooperation with the Kenya Marine and Fisheries Research Institute (KMFRI) initiated a community participatory forestry for the rehabilitation of degraded mangrove areas of Gazi bay in 1991. The program got momentum in 1992/3 when aid was received from Biodiversity Support Program, A USAID – funded consortium of World Wildlife Fund, Nature Conservancy and the World Resources Institute. Some 300,000 mangrove trees were planted. The Kenya Wildlife Service (KWS) and KMFRI are planning similar undertaking to rehabilitate critically degraded mangroves of river Ramisi. Results obtained so far indicate that it is possible to implement mangrove reforestation programs in Kenya.

For these programs to succeed, they must be fully understood, accepted and supported first and foremost by the inhabitants of the area. Over-exploitation of mangroves in Kenya occurs due a lack of awareness of the problems of deforestation, more than to a lack of economic alternatives. Policy makers, developers and the general public generally do not understand the need or the urgency to protect these resources. The attitude that the benefits derived from protection are minimal when compared to the benefits of the activities that degrade these ecosystems must be changed. A policy statement on the multiple use management of mangrove resources should be formulated and politically supported at the highest level of government.

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Towards Sustainable Utilization of Mangrove Resources in Zanzibar: A Brief Review[a].

By: Jude Peter Shunula[b]

Key words: Mangrove; Zanzibar; Economic value; Management; Community.

Mangroves are vital tropical intertidal forest formations, which though often composed of only a handful of tree species play a crucial role as life support systems to local coastal fishing communities. These forests, in association with coral reefs, have been variously referred to in the literature as the backbone of most tropical fisheries.

The mangrove resources of Zanzibar cover an approximated area of 18,000 hectares, 67% of which is found on Pemba Island and the rest on Unguja Island. This area represents about 1/5 of the total land area of the islands.

Zanzibar, like many other islands states is limited in its land-based natural resources. There are few areas of terrestrial forests, (Ngezi; Jozani and Masingini and Pongwe) and about 50% of the land is not arable. Most of the eastern areas of especially Unguja Island and to a small extent Pemba Island, is fossil coral and unsuitable for most agriculture. The land based economic activities are therefore concentrated on the exploitation of the limited terrestrial forests, mangrove and associated resources, more especially by the rural poor. A number of activities that involve the use of mangrove wood and wood products can be recognized, these include:

- Building The local house construction industry draws out of mangrove wood up to about 50% of its material requirement, including wall frames and roof rafters, ceiling boards, door and window frames. Mangrove wood is durable, termite resistant, and is therefore preferred. Earlier records (Griffith, 1949) show that the total number of mangrove poles used in Zanzibar town was about 2 million per year. In 1992, it was found that the number of poles harvested from Chwaka Bay mangrove forest alone was far in excess of 10 million (Shunula 1996). There has been an obvious upward trend in the demand for mangrove wood products.
- Energy: Between 50-100% of domestic energy supply in rural areas may be obtained from mangrove forests. Mangrove wood produces better grade charcoal compared to other tree species, (Jiddawi et al 1999). Given that electricity is not available to most rural areas, and that kerosene is expensive, wood remains the cheapest and most available source of energy for the majority of the rural population.
- Furniture: Most of the household furniture needs, such as bedsteads, chairs, cartwheel hole handles, etc. are met using mangrove wood. This satisfies up to 30% of the needs.
- Fishing gear: boats outrigger canoes, dhow masts, and a variety of fish traps such as the fixed stake traps and dema traps, constituting 50-100% of the small scale fisherman's locally manufactured fishing gear are made of materials that originate from mangroves. The fixed stake traps for example are mostly made of *Rhizophora*

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stilt roots, while the framework of dema traps are made of mangrove wood (Jiddawi et al. 1999).

In addition to the use of the mangroves to satisfy domestic needs, there is also the cash generating aspects. Thus trading in mangrove wood products constitutes between 50-100% of the poor villager's source for cash, trading in firewood, building wood, charcoal, and fish-traps.

The importance of mangroves to the fishing industry is evidenced by the fact that the fishing effort of the local fishing fleet is over 90% concentrated in areas within the vicinity of mangrove forests (Ngoile and Shunula, 1992), and even the number of fish landing sites is far greater in mangrove vegetated zones (having an average of 22 as compared to 12 in non mangrove areas). This underlines the close relationship between the mangrove ecosystem and the fisheries of the area. Several finfish species breed in and use the mangrove habitat as a nursery ground. Studies have shown for example that at least 62 finfish species belonging to 29 families reside within the mangrove areas at Chwaka Bay, either to feed or to breed, (Muhando and Ngoile, 1994). The genus *Apogon* often dominates the catch followed by *Ambassis natalensis* and *Gerress oyena.* Also fish species of commercial importance such as Lethrinids, Serranids, Scarids and *Chanos chanos are* very common in mangrove creeks. Such species dominate the catches obtained from the vicinity of mangrove ecosystems (Shunula and Ngoile, 1992).

Among the most common fishing methods within mangrove creek is the fence trap fishery locally known as uzio or wanda. The trap collects various types of fish about 75% of the catch is composed of juveniles, indicating that the mangroves are important breeding areas for fish. Even the pelagic fish, *Rastraliger carnaguta,* (the Indian mackerel) locally known as Kibua is a common visitor of mangrove creeks and often forms a big fraction of the catch in the fence trap fishery at Kisakasaka village (pers. obser.).

Important prawn species such as *Penaeus indicus*, *P. monodon*, and *Metapenaeus monoceros* are also often quite abundant within the mangrove habitat (Shunula et al. 1999). Chwaka Bay and Unguja-Ukuu all on Unguja Island are among the locally important fishing ground for these species. Commercially important crab species such as *Scylla serrata* are present year around in the mangrove habitat. Similarly, well over 90% of shellfish mainly *Anadara antiquata* collecting occurs in the mudflats especially adjacent to the mangrove areas (pers. obser).

However, the inshore fishery has recently started to show signs of overexploitation. This has been very conspicuous especially in Zanzibar town where statistics document a declining trend in annual catch. The total annual catch was about 20,000 tons in 1988, but has now dropped to less than 13,000 tons per year (Jiddawi, 1999). This is a worrisome trend, especially considering that the critical habitats for inshore fisheries, coral reefs and mangroves, are being degraded rapidly. Given the intimate linkage between marine ecosystems, the loss of mangroves, necessarily removes vital nursery and breeding grounds for fish and crustaceans, and it may give way to erosion and consequent siltation, there by degrading coral reefs beyond, which are essential for inshore fish diversity and health. The presence of mangrove forests often acts as shield against coastal erosion, and there by also protects coral reefs and sea grass beds from being smothered, as they act as filters of suspended particles in the water column.

The indirect benefits, too often eclipsed include: the mangrove ecosystem acting as a source of organic matter that fuel food chain processes within and in adjacent ecosystems such as sea grass beds and coral reefs. The various mangrove species in Chwaka Bay (mangrove area 3000ha) for example have an average annual production of 39200 tons of leaf litter; Kisakasaka (2000 ha) produces about 16875 tons while the small stand at Maruhubi (76 ha)

produces a total of 726 tons (Shunula 1996). A significant portion of this litter production fuels food chains within the mangrove ecosystem while the rest is exported elsewhere where it also supplies energy.

In terms of management, the mangrove resources in Zanzibar have until very recently been considered among the common pool properties, traditionally regarded as belonging to no one, hence accessible to all at all times. Traditionally such resources have been assumed erroneously as inexhaustible. However in previous times there was relatively low demand, as such, natural recovery processes were able to take care of any destruction. With the current high demand on forestry resources and the introduction of quick gain projects such as salt production that involve clearing of mangrove vegetation during the construction of salt pans, the adverse impacts on the forest ecosystems have become more real today than they were thirty years ago.

Management of these resources has been problematic partly because there has previously been low local knowledge especially on the fragility of the resource given that traditionally they have been regarded as inexhaustible and naturally highly resilient to the extent of requiring no managerial intervention by man. More has locally been known on the use values but less on the interdependence of the different facets or components (wood, and animal) of the mangrove ecosystems. The inter-linkages of the various components have mostly been obscure. On the other hand research results have previously been hardly disclosed to the traditional managers (the local communities), rendering the implementation of management options impossible.

In 1988, the government of Zanzibar decided to establish a department of environment in response to the general local and international awareness for the need of environmental conservation. This constituted the need for conducting research in order to generate baseline information on the country's status of the natural resources, including mangroves, and the fishery resources. Subsequently it was revealed that the demand for mangrove wood products had been increasing, more so on Unguja Island, with the result that more destruction of mangrove forest had occurred on Unguja than on Pemba Island. One basic problem was that in all cases, the local communities did not regard mangrove forest as their own property, hence had little concern for its sustainable use. There were also no strict laws regulating the use of the forests, and offenders often went unpunished because of weak enforcement procedures. Villagers were not instilled with the sense of ownership of these forests and their associated resources, and hence did not feel responsible for their protection, much as they cherished the benefits from therein.

The dissemination of information is key to a management strategy that recognizes the participation of the local communities. Thus seminars and workshops involving the local communities, which focus on the mangrove resource and its significance for the livelihood of the coastal communities, the dependence and availability of other resources such as fin fishes as well as crustaceans on the mangrove ecosystem are important for soliciting public support for management of the resource through controlled exploitation. Video screenings on the mangrove ecosystems and its values, hand in hand with practical demonstrations on mangrove replanting as well as the production of simplified literature on the mangrove resources are vital tools for obtaining collective management.

Arising from these activities, a 'bottom-up' type of management can then be recommended, so as to empower the local communities, especially those residing near these forests, to take charge of regulating the use of the resources with the support of the central government.

During the last few years, encouraging results have been noted in Zanzibar. Some villagers now perceive the mangrove resource as an essential lifeline. The Kisakasaka villagers for example have managed to set up a village committee responsible of regulating and monitoring

all activities taking place in the mangrove forest belonging to them. They have established a closure system whereby an area is designated closed for exploitation, while another is opened, for up to five years. Similarly they have introduced massive replanting activities of deforested areas, and have thereby largely controlled degradation. These measures have brought about good forest growth, and consequently associated resources such as the crab and finfish resources are currently on the increase.

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The Political Challenge of Private Sector Management of Marine Protected Areas: The Chumbe Island Case, Tanzania[a]

By: Sibylle Riedmiller, Eleanor Carter[b]

Abstract

The Chumbe Island Coral Park (CHICOP) in Zanzibar, established in 1991 and probably the first fully functioning MPA in Tanzania, provides an interesting illustration of issues that arise with the instalment of a privately created and managed protected area. The history of CHICOP and the legal processes involved in the establishment of such a privately owned protected area are briefly discussed. Management experiences, problems and achievements are described and lessons learned are summarised.

One of the major achievements of the project is the successful on-the-job training of local fishers as park rangers. Lacking more robust means of enforcement, the rangers protect the closed areas by educating visiting fishers about the value of a healthy reef as a breeding ground for fish and other marine organisms that will help restock overexploited adjacent and downstream areas. This fisher-to-fisher-education approach led to a comparably high degree of compliance, as evidenced by monitoring data produced from 1992. Thus the Chumbe Reef Sanctuary is probably the only totally protected reef in Tanzania that also functions as such. A discussion on how private investors can cope with challenges from the legal and institutional environment for private investment in conservation is presented. These challenges arise from a wide range of issues including the lack of legal and institutional framework for conservation, issues related to bureaucratic red-tape and lack of enforcement of existing legislation. This is coupled with a risky environment e.g. a hostile climate for foreign investments, cumbersome regulatory frameworks, rent-seeking practices in the civil service, lack of trained manpower, the volatile tourism market, and the lack of long-term security of tenure.

Because of these risks, and the more noticeable conservation impact on the ground, a case is made for more donor support to direct users of marine protected areas resources. These include both informal traditional fishers and conservation-minded tourism operators. As direct stakeholders from the formal and the informal sectors of the economy, they potentially have a strong interest in a healthy marine environment, and thus more common grounds for agreements and their implementation than at times remote management bureaucracies dominated by vested interests that may have little to do with marine conservation.

1. Introduction

It is widely recognised that Marine Protected Areas (MPAs) play a crucial role both in biodiversity conservation and in coral and fish stock replenishment. One of the main obstacle's to successful management of tropical coastal ecosystems, including protected areas, is the lack of political will and/or financial resources. This has led to a large number of classified parks existing where little or no active management is present. A primary reason for

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this is that governments assign low priority and insufficient financial resources to pay for the infrastructure, training, education, and a host of recurrent costs, despite the true benefits generated by protected areas. This is especially true in developing countries.

Besides government funding, revenues for park management can be generated from activities in and around the protected area. User fees, accommodation charges, tour guide services, loyalties, charges on research and fees for game permits, restaurant charges and private donations are other potential sources of revenues (Dixon and Sherman 1990). These could help the park become a conservation success without being a financial burden to the government and the donor community.

One step beyond this option are so-called entrepreneurial marine protected areas (Colwell 1998), where the government has actually handed over the day-to-day management to a private entity, for example an ecotourism establishment or an NGO. This can be done for part of the total management, such as day-to-day enforcement but it can also be a complete hand-over of responsibilities, for instance through a performance contract. It is also possible that private entities, be they enterprises or NGOs, can actually buy up or lease certain areas of high biodiversity with the aim of protecting the biodiversity of these areas. For instance, The Nature Conservancy (TNC) buys large amounts of land in the United States with endangered resources and manages these privately. In the Netherlands, the Stiching Natuurmonumenten, the largest Dutch environmental NGO, similarly owns considerable areas of land, wetland as well as cultural heritage sites that the foundation keeps under protected management.

In this paper, a private entity, the Chumbe Island Coral Park Ltd., is discussed as an example of a protected area that has been privately created through agreements with the local government and where the private entity is working to balance conservation management and commercial feasibility. Though operations follow commercial principles, the project is non-commercial, as profits from the tourism operations are -re-invested in conservation area management and free island excursions for local schoolchildren. The overall aim is to create a model of sustainable conservation area management where ecotourism supports conservation and education.

The paper is structured as follows. Sections 2 and 3 look at private protected areas as a conservation management model and at the legal and institutional aspects of this model, with specific reference to the Chumbe Island case study. Section 4 gives a brief history of the Chumbe Island Coral Park. Section 5 discusses the financial viability of the Park. Section 6 discusses the lessons learned from the Chumbe case. Finally, sections 7 and 8 discuss the challenges in coral reef conservation and outline some major conclusions.

2. Private Protected Areas as a conservation management model

In spite of the considerable economic potential of nature reserves through tourism, the sustainable management of nature reserves by central government agencies has proven difficult in many African and Asian countries. This is because supportive institutions are often weak and revenues generated by tourism are normally not re-invested in the management of the reserve and in related services. In addition, nature reserves managed by governments often suffer from conflicting interests among different user groups, particularly between traditional users and tourism interests.

Attempts are being made to overcome these problems by devolving authority for wildlife conservation to local communities. These efforts are increasingly favoured by donor agencies and therefore attract considerable funding. However, government agencies find it difficult to actually transfer authority and funds to local levels, and local communities have limited management capabilities, particularly where there is no tradition of resource management

(Scheinman & Mabrook 1996). As a consequence, privately managed protected areas are now beginning to be acknowledged as a viable alternative. Indeed, all over the world, new environmental legislation is being put in place to specifically allow for protected area management powers to be delegated to private entities.

A review of private wildlife conservation initiatives in selected African countries showed that more than half of all protected areas in South Africa are under private ownership and management. Namibia, Botswana and Kenya also have a considerable number of private protected areas (Watkins et al. 1996). As the authors observed, "Countries which have had free-market economies for a long time and in which the purchase of freehold property is permitted, have attracted private individuals and corporate bodies to invest in conservation-oriented initiatives."

The study further concluded that "The private sector makes an invaluable contribution to biodiversity conservation", and that "Private protected areas provide a variety of important conservation and other services. These include providing safe havens, the breeding of endangered species in the wild for subsequent re-introduction, ecological tourism and sustainable use of wildlife." In some cases, the conservation role of private protected areas is crucial for the survival of particular endangered species. The overall conclusion of the study was that "There is much to learn from the private sector, particularly with respect to the economics of managing protected areas through sustainable use of wildlife resources, ecotourism and other enterprises."

The private sector is also beginning to be seen as a management option for marine protected areas (MPAs). Reviewing cases of successful private initiatives in coral reef conservation in the Philippines and Honduras, Colwell (1999) suggested that 'entrepreneurial MPAs' may perform several valuable functions. They protect discrete areas that serve as refuges for threatened marine life, build local capacity in MPA awareness, support and management, act as test cases for MPA management techniques and provide core areas around which larger MPAs could be developed. By establishing effective on-site management more easily than with more traditional government-formed MPAs, entrepreneurial MPAs provide the quick success stories that planners and managers need in order to convince a broader audience of the value of MPAs. Colwell concludes that "for the immediate future, private management of small-scale MPAs may well be the key to successful conservation in a number of coral reef areas that otherwise would have little or no hope of meaningful protection."

Though endowed with a wealth of natural resources, which have a high conservation value, Tanzania so far has not attracted private investment in conservation. Two decades of poor economic policy resulted in what some may describe as the near collapse of the economy and made the country highly dependent on donor funding. This was compounded by the fact that tourism was not encouraged until relatively recently and therefore the full revenue potential of conservation areas could not be realised. However, changes in donor policies have encouraged Tanzania since the mid-eighties to undergo policy reforms in the direction of economic liberalisation and environmental sustainability. Private investment is encouraged in general and tourism is expected to become one of the leading economic sectors in the country, with an official emphasis on the concept of ecotourism.

On the conservation side, Tanzania traditionally has a well-established system of world-renowned terrestrial protected areas, while the several marine parks designated along the coast have yet to receive the same level of management (Jameson et al. 1995), as rampant dynamite fishing etc and other destructive fishing methods have damaged many coral reefs most likely beyond recovery (UNEP-RSRS, 1989).

3. The legal and institutional environment

At the start of the CHICOP project in the early nineties, liberalisation of the economy had been initiated. However, the still predominantly state-controlled legal and institutional environment of Zanzibar/Tanzania did not yet encourage private investment nor non-governmental initiatives in conservation. Legislation needed for the registration of NGOs was not available before the Societies Act was passed in 1995 and there was no explicit policy and legal framework for environmental conservation or institutions for managing protected areas in Zanzibar.

While coastal communities dependent on fishing possess a wealth of traditional environmental knowledge (Tobisson et al. 1998), reef management is really only just beginning to be seen by communities as a necessity (Scheinman & Mabrook 1996). In some coastal communities corals are still referred to as 'mawe na miamba', stones and rocks. Formal education does also not yet provide environmental information on this important natural resource, as revealed by an analysis of the syllabi of primary and secondary education (Riedmiller 1991, Riedmiller 1995). As a result, decades of destructive fishing methods, such as blast fishing, coral smashing to chase fish into encircling fishing nets and beach-seining, have until recently met with little public and governmental concern (UNEP-RSRS 1989, Horrill 1992, Guard 1997).

At the same time, Chumbe Island, a small coral island of approximately 22 hectares off the coast of Zanzibar, presented a rare chance for coral reef conservation along a coast otherwise subjected to heavy over-fishing. Moreover, it was not included in any proposal for establishing marine protected areas in the country. The island was uninhabited and seemed to face little immediate threat. Fishing was traditionally prohibited along its western side bordering the strategically important shipping channel between Zanzibar and Dar es Salaam, as small boats would have obstructed large vessels. For many decades the area surrounding the island was also a military area where the army routinely conducted shooting range exercises from the adjacent coast. In addition, few boatmen could then afford an outboard engine to go to this most distant of the islets surrounding Zanzibar town.

4. History of Chumbe Island Coral Park

Chumbe Island Coral Park Ltd. (CHICOP) was established in 1991 as a privately funded and managed reef and forest conservation project covering the entire Island and the fringing reef on its western side. Though privately funded (with some donor inputs covering about a third of the investment costs), the project is non-profit-oriented. Revenue from ecotourism is to be re-invested in conservation area management. Permitted uses of the park include research, education and recreation (swimming, snorkeling, underwater photography). Extractive and destructive activities, such as fishing, anchorage, or the collection of specimens (even for research) are not allowed. For a more detailed history refer to the contribution by the authors in panel 1, (this volume).

The Chumbe Rangers are an essential team within the project, and capacity building of these former fishermen has been an integral component of the project from the beginning. Through the successful awareness raising of the fishers by the rangers, infringements in the Marine Protected Area are rare (Carter et al. 1997).

As a result of successful management, the coral reef is in extremely healthy condition, with 370 species of fish (Fiebig 1995) and over 200 species of reef-building corals, at least 90% of all those recorded in East Africa (Veron pers.com. 1997). The forest covering the island is one of the last pristine 'coral rag' forests in Zanzibar (Beentje 1990) and has now become a sanctuary for the highly endangered Aders' Duiker (Cephalophus adersi) which has been

translocated from the main island of Zanzibar (Unguja) where it is facing extinction from poaching and habitat destruction (Kingdon 1997). The island also has a large population of the Coconut crab (Birgus latro) and in 1994 a large breeding population of Roseate terns (Sterna dougalli) classified as 'rare' (Iles 1995) were identified on the island. CHICOP has gained several international awards.

5. Project costs

The original feasibility study of 1991 suggested an investment of little more than US $200,000 in order to establish the park and to construct a visitors' centre and guest bungalows. Revenue for running the park was to be generated with snorkeling, glass-bottomed boat trips, nature trails, overnight accommodation and restaurant services. Payback of the investment was expected to start after three years with an internal rate of return (IRR) of 27%.

However, before the Project could be fully initiated it took three more years before work could begin in negotiating the official gazettement of the island as a protected area, the several management contracts, land lease, licenses and building, research, work and residence permits. Thus, the feasibility study had to be updated in 1994 based on an adjusted project design and more realistic conservation costs, resulting in more than three times the original investment.

According to Soley (1997), by mid 1997 conservation costs accounted for 52% of the investment realised so far, while 9% had been spent on educational infrastructure (nature trails and information materials). The remaining 39% were used for building the tourism infrastructure (visitors' centre and seven eco-bungalows). In addition, by then altogether 171 person months of professional volunteer work (154 at senior level) had been contributed to the project, but were not included in the above calculation.

An economic analysis in 1998 (Neckening 1998) calculated the overall investment made by then to nearly 1.2 Million US$, out of which 220.000 US$ were grants from a variety of donors for several non-commercial project components. By this stage the start of commercial operations had been revised once more to commence in mid 1998, and the objective of this study was to propose a commercially viable price structure for the reserve considering the increased investment cost. The finding was that a net, all-inclusive overnight price (excluding agents' commission) of US$200 per person and an occupancy rate of at least 41% were needed to reach the break-even-point for running costs, without capital payback. The grant component of the project costs had not been included here.

Presently, as we approach the end of the second year of commercial operations, the Chumbe project still receives less than this amount on average per guest and has a lower overall occupancy rate than required. Thus, the project is maintained with very cost-conscious operations and has required the continued volunteer work of the owner and other expatriate management staff. A recent update of the feasibility study based on nominal costs (not including volunteer work and opportunity costs) produced an IRR of 9% and a capital payback period of 7 years. This is certainly less than what most investors in tourism facilities in Tanzania would consider attractive.

However, since the recent media publicity following the British Airways award, the occupancy rate has increased greatly. The rainy season withstanding Chumbe managed to achieve greater than the break-even point of 41% occupancy following the award and this looks set to continue during the peak seasons. However, this still does not guarantee the mean occupancy rate of the year will be as required.

6. Lessons learned

6.1. On the Positive Side:

Coral reef conservation can work on the Ground! The Chumbe experience suggests that private management of marine protected areas is technically feasible and efficient, even when government enforcement is not available or is ineffective. This is probably the case for coral reefs that are not yet over-exploited by communities depending on them for their survival, or by commercial fisheries.

A private protected area such as Chumbe can provide important community benefits, particularly in capacity building, biodiversity conservation and restocking of fisheries resources. The Chumbe Reef Sanctuary and Forest Reserve provide a safe haven for endangered species and breeding grounds for corals, reef fishes and other marine and forest organisms that are under threat elsewhere. Fishers report that their yields have been enhanced in areas downstream from Chumbe.

The hands-on approach to capacity building and monitoring through inexpensive on-the-job-training of local fishers by volunteers has produced very competent and committed park rangers. They are stationed on the island and manage the Reef Sanctuary with no means of enforcement other than persuasion of their fellow fishers. Lacking policing power, the rangers interact with fishers by stressing the role of the protected area as a breeding ground for fish. This has proven very successful. Village fishers now generally respect the park boundaries (see attached table) and report that catches outside the boundaries have increased. The rangers closely monitor any event or infringement and also record observations on any major change in the coral reef, such as storm or coral bleaching.

The project has also helped to raise conservation awareness and understanding of the legal and institutional requirements among government officials. Seven Government departments were involved in negotiating the project in the initial phase and were represented on the Advisory Committee. This has enhanced political support and prepared the ground for improvements in Zanzibar's legal framework to support conservation projects. In Zanzibar, The Environmental Protection and Management Act 1997 finally stipulated provision for private management of protected areas.

With an overall investment of US$1.4 million over nine years at 1999 prices, the cost of private management seems to be considerably lower than would have been the case with a donor-funded project through the usual government mechanisms.

Most importantly, it can also be argued that there are better prospects for sustainability, as the incentives to struggle for cost effectiveness and commercial survival are much stronger for private operations than for donor-funded and government-run projects.

6.2. On the Negative Side:

Coral Reef Conservation Is a High Commercial Risk Under Developing Country Conditions. As is widely perceived among investors, the regulatory environment is characterised by cumbersome bureaucratic requirements with wide discretionary powers for government officials (Rauth 1997). This encourages rent seeking and delays operations, thus increasing investment insecurity and costs, and creating obstacles to innovative and environmentally friendly project designs. (2)

Investment security is reduced by the fact that land tenure in Tanzania and Zanzibar is only available on leasehold, in contrast to other African countries, such as South Africa, Namibia,

Botswana, Kenya, which allow freehold and have attracted considerable private investment in protected areas (Watkins et al. 1996). The above situation could be offset to a certain degree by legal provisions creating special incentives for investment in environment and conservation, such as long-term land lease and management rights, reduction of, or exemption from land rents, licenses, fees and taxes. However, these are not readily granted (Sterner and Andersson 1998).

The logistical requirements of building on an island greatly increase development costs. In particular the innovative technology for water and energy provision, as well as the commitment to minimise degradation of the island environment can be cost-prohibitive. A compost toilet, for example, which operates without producing any sewerage, costs about five times the price of a flush toilet in real terms. However, following the principles of environmental economics and the associated valuations of natural resources in real terms finances, the overall cost of a compost toilet would be far less than a flush toilet. Unfortunately as the economics of real terms are yet to consider the cost of natural resources, the higher price of compost toilets would still be regarded by commercial enterprises as a greater cost than regular toilet systems.

Another risk is that capital recovery from investment in conservation is typically dependent on one single sector of the economy: tourism. The tourism industry is somewhat volatile and sensitive to political turmoil (often associated with election periods), adverse weather conditions (el Niño) and perceived security and health risks. In 1997 and early 1998, East Africa as a whole had more than its fair share of these problems, and suffered the associated decline in tourist arrivals over this period.

The increased investment costs and the continuing burden of government licenses, fees and taxes has forced CHICOP, as mentioned in the aforementioned financial analysis conducted in 1998, to revise the price structure for tourist operations and to target the higher end market. For this to be achieved, successful marketing in top end publications is essential and can be an additional cost burden. Thanks to the nature of the Chumbe project much of the marketing occurs through journalistic publications, thus reducing this burden. By approaching the higher end market clientele, additional demands are made on the park rangers and local staff to meet the sometimes demanding logistical and service expectations of that particular market.

In addition, and very importantly, realistic price levels that reflect conservation costs are difficult to realise as long as unmanaged and donor-managed wilderness areas can be accessed at relatively low cost by the tourism industry. It can be said that Chumbe Island may face unfair competition' from destinations subsidised with donor funds.

7. Challenges in coral reef conservation

The policy discourse on conservation issues in African countries is dominated by international conservation and donor organisations that also provide most of the funding. Though the role of the private sector is increasingly acknowledged in principle (Moffat et al. 1998), sufficient attention has yet to be paid to the particular constraints that (even non-profit and charitable) private initiatives face on the continent.

The Chumbe case demonstrates that private commitment to, and investment in conservation on the African continent as well as in many other developing countries can pose a high commercial risk. This is the result of an often poor investment climate, particularly due to the lack of long-term security of tenure and the costs of bureaucratic red-tape, as discussed.

In addition, conservation programmes in large parts of Sub-Saharan Africa depend on donor funding and do not require income from tourism and other sustainable uses. Though more attention is paid to 'sustainability', this concept is in its early stages of implementation. This

crowds out conservation-oriented investors who cannot compete in a climate where park management is funded by external grants that sometimes tolerate the high overheads of state-run institutions. This situation perpetuates a systematic cycle of non-sustainability in the economic management of the resources (Cairncross 1991).

The difficult investment climate for private initiatives in conservation is compounded by a general ideological climate among governments and large sections of the donor community that is sceptical of private sector initiatives. Colwell (1999) reflects this scepticism in his assessment of two examples of entrepreneurial MPAs. He states that such private initiatives are "only appropriate where the government or local community is unable or voluntarily chooses not to exercise its right to manage local marine resources." He adds that "there is a great potential for abuse of power by a resort or other commercial entity which has profit as its primary motive and does not answer to a public constituency", and suggests that "the resort's activities, including disposal of sewage and solid waste, coastal clearing and construction, and recreational use of the marine resources, must be subject to scrutiny by a government agency, NGO or other unbiased observer."

It is suggested that there are certain common assumptions among donor and conservation agencies that hinder private-sector investment in conservation. These assumptions include:

- local communities, by way of their close relationship with their surrounding environment, have an inherent proprietary right to use and manage these marine and other resources;
- government agencies, donor bureaucracies, NGO representatives and researchers are not stakeholders, but 'unbiased observers' that are answerable to public constituencies;
- there is a lack of compatibility between the private sector's profit motive and conservation or good environmental practices, and therefore this sector needs to be controlled and regulated to adhere to certain minimum standards.

However, these assumptions can be challenged with evidence from Tanzania. It is argued below that local communities respond to similar economic motives as the private sector and, indeed, form an integral part of this sector. It is also argued that governments, donor agencies and NGOs are neither unbiased nor always answerable to public constituencies, and that finally, given the right incentives, the private sector may have an interest in conservation.

7.1. The Fishery Sector Is Also Profit-Oriented

Traditional resource users often have a close relationship to the natural environments within which they operate. However, it should not necessarily be assumed that traditional fishers or resource users from the informal sector have any greater incentive to protect their resource base than any other resource user. (3)

In Tanzania, where the fisheries sector still appears dominated by traditional artisanal or 'subsistence' fishers, there is growing evidence that these form part of sometimes far-reaching trade networks that supply both expanding urban markets and distant rural areas. Some urban and rural leaders and business people finance and operate 'dynamite' boats to distant reefs, provide explosives to local fishers and buy their produce, harnessing the incentive that often accompanies conditions of poverty among the fishers (Guard 1997). Dried sardines (dagaa) from the coast are traded as staple food for the majority of the population and provide the cheapest source of protein to rural areas in the interior of the country, sea cucumbers are exploited for export to Asian markets (Semesi et al. 1998), and lobsters are over-harvested for the growing tourism industry (Bakari and Andersson 1998). Most of these trade networks belong to the informal economy and may not appear in trade statistics, but form a highly organised part of the private sector nevertheless.

7.2. Tourism Operators Are Often Also Interested in Marine Conservation

Contrary to common perceptions, private-sector resort managers and dive operators may have a strong interest in helping manage and preserve coral reefs, particularly when their customers are increasingly environmentally aware, and demand and acknowledge such commitment. Along the Tanzanian coast, dynamite fishing practised by rural fishing communities has for decades been and continues to be one of the greatest threats to coral reefs. Little was done to prevent it until 1997, when a private tourist hotel (Silversands in Dar es Salaam) initiated a press campaign that was fuelled by strongly worded letters to local newspapers from former guests. As the country's image as an emerging tourist destination was at stake, this for the first time generated enough political will to initiate drastic action. The navy was summoned and succeeded in reducing dynamite fishing at least along the reefs closer to shore. As a welcome side effect, this also increased political support donor-funded regional projects working with fishing communities in the Mtwara (Luhikula 1999) and Tanga regions (Horrill and Makoloweka 1998).

There is reason to believe that the marketing value of environmentally certified construction practices in resorts adjacent to coral reefs, and the proper management of recreational activities, give stronger incentives to owners and operators, than the inspection visits of often bureaucratically entangled government officials proposed by Colwell (1999). Prestigious awards such as the British Airways Tourism for Tomorrow Award, for example, provide valuable marketing publicity that small resorts would normally find hard to afford.

Moreover, marine and dive tourism can increase the real-world economic value of coral reefs and thus promote greater awareness and appreciation of a resource that previously was taken for granted and often traditionally believed to be inexhaustible (Scheinman and Mabrook 1996). The marine tourism market may attract local investors with little previous knowledge of and interest in marine resources and coral reefs, and thus increase political support for reef conservation. In Tanzania for example, where the recreational preferences of urban elites do not include marine sports and swimming is not considered a useful skill, attitudes are now beginning to change with the growing tourism industry.

7.3. Government and Donor Agencies are Stakeholders with Institutional Interests

It is commonly assumed that government is the appropriate body to mediate issues between stakeholders and their various interests. However, in highly donor-dependent countries such as Tanzania, both donor and NGO interests and various forces within the governmental bureaucracy itself, may well prevail over the interests of direct resource users. For example, while donor agencies are often under pressure to spend allocated aid money within a set time frame, international and local NGOs and national government institutions may compete for these funds to sustain their operations, or for direct appropriation. Such institutional interests may create their own dynamics, for example, by providing an incentive to increase the weight and complexity of the bureaucracy in order to justify continued funding. This can inhibit the effective conservation and sustainable resource management on the ground that involves local communities.

In practice, and contrary to good intentions stated in project documents, central and donor-funded management bodies may have few incentives and mechanisms to involve local communities, and even moreso, tourism operators. The main reason for this is that these management bodies are not accountable to local stakeholders, but rather to the same external funding agencies that are under spending pressure to compete for 'good projects'. In such a situation, an 'unholy alliance' may emerge between donors and recipients, which can tolerate even gross mismanagement of project funds. Thus, instead of promoting local and community

stakeholders' interests and participation in the sustainable use of their marine resources as intended, donor reliant projects may sometimes consume impressive funding with little to show in terms of effective management of the park on the ground.

7.4. NGOs Are Not Always Accountable

Where central governments are perceived as inefficient, undemocratic and unaccountable, external support for environmental and conservation projects is increasingly channelled to non-governmental organisations (NGOs). However, what is often overlooked is that NGOs are not accountable by definition or through the mere act of registration. Public control and political will, appropriate legislation and supervisory bodies are required to ensure that NGOs actually fulfil their mandated work and use their funds effectively. These conditions are not yet fully given in Tanzania. As elsewhere, the lack of public supervision of NGO activities can encourage the formation of briefcase organisations. After decades of donor assistance to government, civil servants or those with experience in this realm are the most conversant with application procedures, terminology and reporting formats of donor agencies. And where, as in Tanzania, the tax legislation provides few incentives for charitable contributions of individuals and business organisations, there is also a risk of NGOs being formed mainly for access to external funding, rather than for stewardship for environmental and community interests. This situation undermines transparency and accountability to both the members of a NGO (in case of membership organisations) and the intended beneficiaries.

8. Conclusions

There are limitations to privately managed MPAs such as Chumbe as their effective functioning and success may largely depend on the political environment. The creation of more complex bureaucratic structures and procedures for instance, is bound to increase overhead costs, making private ownership of MPAs unnecessarily costly, if not impossible altogether. The definition of boundaries and the implementation of certain legislation (e.g. the prohibition of dynamite fishing) go far beyond the capacity of private owners, and require a committed governmental and institutional framework. Therefore there are subject matters where private owners (or conservation projects) should pursue their interests by lobbying for more favourable government policies that will safeguard their effective operation. It is up to governments to devise appropriate institutional structures and appropriate legislation. This certainly implies effective implementation, because where implementation is lacking, policies are irrelevant. There must be commitment between governments and private investors if private management of MPAs is to succeed.

The predominant donor perception of the private sector as being located outside and antagonistic to an at times romanticised 'local community' is not helpful for understanding stakeholder interests in coral reef management. Though traditional fisheries and the harvesting of reef resources may belong to the informal sector of the economy in many countries, these are still economic activities that are sometimes highly commercialised. Ignoring this reality does not help in the identification of genuine stakeholders.

Viable partnerships for the management of a particular marine area are more likely when local communities, traditional fishers and tourism operators are acknowledged as belonging to the (formal and informal) private sector that responds to similar economic incentives. Small-scale fishers, tidal harvesters and seaweed farmers who depend on reef resources for their survival, may have more common interests with local tourism and dive operators than with central government agencies and foreign-funded NGOs.

In order to safeguard the sustainability of their economic activities, tourism operators, fishers and other resource users have a potential interest in coral reef management. Involving them in conservation projects and park management is likely to raise their awareness in this respect. Of course, outside support would still be required in certain cases, particularly where threats to coral reefs originate from distant areas, such as logging, siltation and large-scale infrastructure developments (World Bank 1999).

It is suggested that the international conservation and donor community would improve the impact of their investment in coral reef conservation if project designs focused more on direct resource users and stakeholders in a particular area, who have long-term economic incentives to co-operate. This may include support to private management, particularly where small highly protected MPAs are created. These have the potential of providing fish refuges, larval sources and suitable settlement areas, by which adjacent fishing areas are eventually replenished with marine species through reproduction or migration. Such well-managed small MPAs may become the core of large, multiple use MPAs and free access areas.

Support to private initiatives may help alleviate the commercial risks of long-term investment in conservation and integrate a wider range of stakeholders in coastal zone management, and thus improve local political support to MPAs. Last but not least, donor support for policy reforms that improve security of tenure and the investment climate in general may also encourage private investment in better environmental practices and conservation.

Notes:

(1) This paper is based on a presentation to the ICRI-International Tropical Marine Ecosystems Management Symposium (ITMEMS), November 23-26th, 1998, Townsville, Australia. A shorter version has been published in the InterCoast Newsletter, No.34, Spring 1999, Coastal Resources Center, University of Rhode Island, USA.

(2) Rauth (1997) elaborates that, as a heritage of socialist or state-dominated economic policies in the past, "most African countries still use control oriented approaches that have resulted in rule-driven bureaucracies with little service mentality. Institutional practices have been designed with the assumption that the private sector is the antagonist and procedures and regulations are formulated under the assumption that the private sector is guilty until proven innocent. This approach has resulted in particularly cumbersome regulations. In addition, the controls have given government officials wide discretionary powers that have encouraged corruption. Although taxes have been simplified and lowered, they remain numerous, ambiguous and complex. In Tanzania, officials at one prominent business organization estimate that 80% of all businesses must cheat to survive - and tax liabilities can represent as much as 60% of gross revenue." He concludes "the combination of the ambiguous environment and high taxes created a hothouse for corruption. Business people need to pay bribes to survive and remain competitive. Not surprisingly, civil servants perceive business people as corrupt, which leads them to erect more controls and more stringent regulatory processes, resulting in even longer delays. In reaction, businesses resort to bribes to accelerate the process. As a result, a vicious cycle of increasing delays (and) corruption is created for formal sector enterprises."

(3) Interestingly, a recent study in the Pacific islands came to similar conclusions that "many local communities do not appear to be effective in restricting their own harvesting effort." (World Bank 1999)

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Policy Framework and Research Initiatives for Sustaining Coral Reef Ecosystems through Coastal Resources Management in the Philippines[a]

By: Ester C. Zaragoza, Rudolf Hermes and Alejandro B. Olandez, Jr. [b]

Abstract

Coastal fisheries production in the Philippines has declined over a 10-year period from 1.06 million mt in 1987 to less than 900,000 mt in 1997. Catches are composed mainly of small pelagic fish, soft bottom demersal fish and reef-associated fish. The proportion of the latter shows an increasing trend, and coupled with still continuing habitat degradation and destructive fishing methods, reef fish production is not sustainable and in need of improved management.

The legal framework for coral reef conservation is embodied in policy enactments on coastal fisheries management, which include among others, the Local Government Code of 1991 and the Fisheries Code of 1998.

CRM is the typical policy option and approach for coral reef conservation at the municipality level. It consists of community organizing, public education, law enforcement, training, resource and habitat rehabilitation measures. Information on government programs supported by foreign and local institutions with the aim to promote sustainable use of reef resources is presented; differences in approaches and emphasis, ranging from habitat protection, surveillance and effort reduction, to training, awareness raising and institutional strengthening are discussed.

Issues affecting reef fisheries that are considered most critical are cyanide fishing, dynamite fishing, muro-ami fishing, siltation and pollution, and natural phenomena such as coral bleaching. Enhancing community participation and ownership of resources, data, and management schemes are considered crucial to promote sustainability of coral reef conservation measures.

Research initiatives on coral reef ecosystems focus mainly on developing improved assessment as well as impact monitoring and evaluation methods, and physiological studies with the aim to propagate corals and establish coral farming for habitat enhancement. The academe is also tasked to provide technical backstopping to municipalities in MPA establishment and management, mainly in assessment and training. Percentage coral cover is considered the most important indicator for assessing impact of conservation measures.

Studies are underway to document the learnings from more than 20 years experience with community-based MPAs. Geographical scope of currently undertaken research, monitoring and management activities on reef areas ranges from the South China Sea (Spratlys or Kalayaan Island Group) to the Sulu and Celebes Seas (applying the "large marine ecosystem" approach) and to the Eastern Pacific Seaboard (Philippine Sea).

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1. Introduction

The Philippines is an archipelagic country consisting of more than 7,100 islands with territorial water area, including the Exclusive Economic Zone (EEZ), of about 2.2 million km^2, a coastline of 17,460 km and a shelf area (with a depth of 200 m) of 18.4 million ha.

Its coastal and marine waters are endowed with a variety of aquatic and marine resources including ecologically important habitats such as mangroves, seagrass beds and coral reefs. The country's coral reefs, which cover approximately 27,000 square kilometres and nurture about 488 species of corals, account for 30% of the country's total fish production (ADB, 1993). The reefs serve as an important resource base for sustained food production: a healthy coral reef ecosystem is estimated to produce 20 tons or more of fish and other edible marine products per sq km per year while a destroyed reef will yield about 5 tons per sq km per year (Alcala and Gomez, 1985). Moreover, the coral reefs, beaches and clear waters support a growing tourism industry that provides livelihood to many coastal dwellers.

In 1995, the Philippines ranked 12th among the 20 most productive nations in the world in terms of fisheries (FAO, 1997). Figure 1 illustrates the total marine, commercial, and municipal fisheries production in the Philippines from 1987 – 1997.

The country's total fisheries production was 2.76 million mt (Fig. 2a) valued at P/ 80.71 B (Fig. 2b) in 1997. This accounts for about 4.3% of the country's Gross National Product (GNP) and provides employment to more than one million people (BFAR, 1994). This production was contributed to almost equal proportions by the three sub-sectors namely municipal fisheries (33%), commercial fisheries (32%) and aquaculture (35%).

Municipal fisheries production has declined over the last ten -year period from 1.06 million mt in 1987 to less than 900,000 mt in 1997. Catches are composed mainly of small pelagic fish, soft bottom demersal fish and reef-associated fish. Fish stocks have been over-harvested beyond their ability to replenish themselves to feed an exploding Filipino population.

With a population growth rate of 2.3% and more than 40% of its people in poverty, the Philippines is banking on the proper management of its coastal resources for sustainable development. This paper shall discuss some policy framework and research initiatives sustaining coral reef ecosystems in the Philippines.

2. Laws and Regulations Concerning Fisheries Conservation and Protection

Concern for fisheries conservation and protection has been increasing over the last 20 years. The legal framework for coral reef conservation is embodied in policy enactments on coastal fisheries management, which include among others the Local Government Code (LGC) of 1991 (Republic Act 7160) and the Fisheries Code of 1998 (Republic Act 8550) (Table 1).

The Local Government Code transfers the responsibility and right to manage the municipal waters, which extend out to 15 km from the shoreline from the national government to the local government units or coastal municipalities. Specifically, the municipal waters should be reserved for small scale fishing. The LGC mandates the local government units (LGUs) to establish Municipal Fisheries and Aquatic Resources Management Councils (MFARMCs). The FARMCs act as consultative bodies to LGU in a) determining priorities on fishing activities of municipal fisher folk; b) assisting LGU in formulating mechanisms in the use of municipal waters; c) determining license fees, closed seasons, fish sanctuaries; and d) enactment of appropriate ordinances. This mandate was recently reinforced with the passage of the Fisheries Code that allows commercial fishermen to fish in the municipal waters between 10.1 km and 15 km from the shoreline (Trinidad, 1998). In the area of habitat

management, the FC requires that at least 15% of municipal waters be set aside as marine protected areas.

The Fisheries Code strengthened the legal basis for coastal resources management and encouraged the local community and non-government organizations (NGOs) to participate in its implementation. However, this mandate is weakened by the law's provision that municipal waters exclude areas declared protected under the National Integrated Protected Area System (NIPAS Act). National legislation thus renders the jurisdiction and responsibility for coastal resources management complex.

It is unfortunate that most local government units in the Philippines do not know where their legal jurisdiction extends because maps delineating the outer boundaries of municipal waters are not available. Maps showing municipal water boundaries are critical in helping local governments manage coastal resources for sustainable use. In this light, the government has responded by assigning the National Mapping and Resources Information Authority (NAMRIA) of the Department of Environment and Natural Resources to delineate and map municipal water boundaries within the next two years.

Section 91 of the Fisheries Code bans the exploitation and exportation of corals. Particularly, it proscribes and penalizes gathering, possessing, selling or exporting of ordinary, precious and semi-precious corals, whether raw or in processed form, except for scientific or research purposes. It also consolidated previous laws dealing with electro fishing, blast and cyanide fishing, use of fine mesh nets, gathering of corals, and the use of super lights.

3. Threats and Issues on Coral Reefs

Like most developing coastal states, the Philippines has its share of problems concerning the management of coral reefs. Several issues affecting reef fisheries are considered most critical and will be discussed below:. These are blast fishing, which results in immediate reef destruction, cyanide fishing for aquarium and live reef fish trade that causes the destruction of coral polyps and other destructive methods of fishing such as muro-ami. Other important threats include siltation, pollution, and natural phenomena such as the coral bleaching event following the recent 1997-1998 El Niño.

Blast Fishing

The use of dynamite for fishing damages coral reefs. Each explosion may make a hole up to 5 meters**.** Recovery of adult communities from blast fishing is placed at 38 years (Alcala and Gomez, 1978) and at a slow rate of 1-3% coral cover per year. These information including the recovery of adult fish communities after intense fishing (Russ and Alcala, 1989), are the only ones that have been estimated for Philippine reefs. Long term monitoring is necessary to fill in the information gap. Apart from serious political will in enforcement, this issue needs to be addressed also through massive information and education campaigns as well as income diversification.

Cyanide Fishing

The use of cyanide to stun and capture aquarium fish destined for the pet shops and aquariums of Europe and North America began in the 1960s in the Philippines. More recently a growing demand for larger reef food fish has vastly increased the incidence and spread of cyanide fishing in Indonesia, Papua New Guinea, Malaysia, Marshall Islands, Tanzania and Vietnam (Barber and Pratt, 1998). Systematic scientific testing of the impact of cyanide on reefs is scanty, but tests show that cyanide kills corals.

The Philippines is the only country so far to take concrete actions against cyanide fishing. The country's Cyanide Fishing Reform Program, a unique partnership between the government and the International Marinelife Alliance (IMA), and a local non-governmental organization, has trained thousands of fishermen to use alternatives to cyanide such as fine mesh barrier nets draped over a reef section to catch aquarium-sized fish and hook and line techniques to catch larger fish for the restaurant trade. The government has stepped up enforcement of anti-cyanide fishing laws by establishing a network of cyanide detection laboratories that randomly sample fish exports at shipment points throughout the country and monitor all aspects of trade.

A public awareness campaign in the media and public schools is helping to educate Filipinos about the value of coral reefs and the threats posed by cyanide and other destructive fishing practices. Cyanide fishing has not ceased in the Philippines, but it has certainly been reduced as a result of these efforts.

Muro-ami

Another fishing method that destroys coral reefs is muro-ami or drive-in net. It is a method of driving coral reef fishes into a movable drive-in net with stone weighted scareline in water 7 to 30 meters deep (Gomez et al. 1987). About 150 to 200 young boys raise and drop 1-3 kg weights to drive the fish out of the crevices by creating noise and breaking the coral heads. Thousands of square meters of corals are damaged by muro-ami fishing every year.

Coral Bleaching

Massive bleaching was observed in 1998 in various reefs throughout the Philippines, alarming local reef managers, recreational divers and marine scientists alike. To determine the extent of the bleaching event in the country, data recording forms such as the "Coral Mortality Alert and Appeal for Information" were sent to individuals or groups working on coral reefs. The response was very promising, and reports started coming in beginning early June up to late November 1998.

The reports revealed that the onset of bleaching in different areas did not occur at the same time and that a downward movement of incidence was observed from north-to-south. Hotspot (or positive thermal anomalies) activities tracked during the same period (from NOAA/NESDIS website) also showed a north to south movement. Underwater survey done in 1998 also provided pre and post bleaching benthic conditions. Coral community studies detected significant decrease in live coral cover (up to 46%) and increase in dead coral cover (up to 49% (Arceo et al., 2000).

Both results provided more evidence that a major cause of bleaching events in 1998 was elevated sea surface temperatures. The extent and scale of the 1998 bleaching events in the Philippines could not be fully attributed to anthropogenic disturbances since severe bleaching was also observed in offshore reefs. Its coincidence with the El Nino - related temperature anomalies suggests that the main factors behind bleaching were more natural than anthropogenic.

Coastal Resources Management: Impact on Coral Reef Conservation

Coastal resources management is the typical policy option and approach for coral reef conservation at the municipality level. The concept of CRM in the Philippines is not new. Pioneering efforts began in the mid 70s when the Silliman University, a private institution in Central Visayas, Philippines, established the first marine protected area in Sumilon Island in 1974 (Russ and Alcala, 1994). The approaches of community-based management of coastal

resources have been advocated in the country since the late 1980s and have evolved to the multi-sectoral co-management approach in the 1990s.

CRM consists of community organizing, public education, law enforcement, training, resource and habitat rehabilitation measures mainly through marine protected areas (MPAs) as well as income diversification. Watershed management and pollution control measures are sometimes also included for a more comprehensive integrated coastal management (ICM). Stakeholders and participants in this process include peoples' organizations (POs), NGOs, and FARMCs, various national government agencies, the fisheries industry and the academe.

4. Past CRM Initiatives: Lessons Learned

In 1984-1994, a total of 43 community-based coastal resources management programs and projects were implemented in 105 sites in 12 regions of the Philippines. A recent report listed about 431 community-based marine sanctuary, fish sanctuary and marine reserve sites in the Philippines (Crawford et al., 2000). These programs were supported by foreign and local institutions with the goal to promote sustainable use of coral reef resources and other related ecosystems. Differences in approaches and emphasis were used, ranging from habitat restoration, surveillance and effort reduction, to training, awareness raising and institutional strengthening. The following are some of the major programs on CRM supported by international donor agencies:

I. Central Visayas Regional Project

The Central Visayas Regional Project (CVRP), supported by a World Bank loan, was a pilot project in community-based rural development operating from 1984-1992. One of its components was watershed management, including near-shore fisheries development in four provinces. Interventions included mangrove reforestation, coral reef protection and marine sanctuary establishment, artificial reef and mari-culture. A major finding from a 1995 assessment of CVRP was that baseline information was insufficient to evaluate the results (Silliman University Marine Laboratory (SUML), 1996; Calumpong, 1996). Thus, many of the potential lessons from such a large and comprehensive program were lost because they could not be measured.

II. Marine Conservation and Development Program

The Marine Conservation and Development Program (MCDP) of Silliman University, supported by the United States Agency for International Development (USAID), operated from 1984 through 1986 on three small islands in the Central Visayas. The MDCP had community participation and community development as a core strategy. This relatively small project generated important examples for community-based coral reef management that exemplified the potential sustainable use of coral reef fisheries and habitat (MCDP, 1986). The lessons from these three islands have increased over time as they continue to prosper and attest to the role of communities in sustaining management efforts in spite of changes in government personnel and policies.

III. Lingayen Gulf Coastal Area Management Program

The Lingayen Gulf Coastal Area Management Program (LGCAMP) implemented from 1986 through 1992 as one of six CRM planning areas in Southeast Asia supported by USAID and the Association of South East Asian Nation (ASEAN). This was the first attempt at Integrated Coastal Zone Management (ICZM) in the Philippines for one large gulf in Northern Luzon comprised of two provinces and 20 municipalities. The project first generated a comprehensive planning database, which included reliable fisheries data analysis to measure fishing effort reduction needs, since the most serious problem in the area was over-fishing

(Chua and Scura, 1992). The difficulty of implementing the recommendations on fishing effort forced the planning process to diverge toward education and political arrangement to coordinate planning and implementation. The Lingayen Gulf Coastal Area Management Commission (LGCAMC) was created in 1994 under the Office of the President of the Philippines. The set-up, although not completely effective, served as a model for the country (NEDA, 1992).

IV. Fisheries Sector Program

The Fisheries Sector Program (FSP) (1991-1997) was implemented by the Department of Agriculture (DA) with support from an Asian Development Bank and Overseas Economic Cooperation Fund. This very large program attempted to generate and implement CRM plans in 12 bays known for their rich fisheries, their management problems, and the growing poverty of their coastal residents. This government program tested the ability of the DA to incorporate community-based management as a mainstream approach to CRM. A primary strategy was to generate bay-wide CRM plans through the involvement of fishing communities by contracting NGOs to facilitate the planning and community organization process. The results have raised awareness about the need for management, and in a few cases actually improved fishery management in the bays. Unfortunately, as with the CVRP, the FSP did not do well on establishing and using a simple set of baseline information upon which evaluation and management decisions could be based.

5. Current Initiatives on Coastal Resources Management

In view of the continuing trends in resource depletion and habitat degradation, current CRM programs are designed to prevent further damage to the environment and to support the rehabilitation of critical habitats (e.g., coral reefs). These initiatives are grouped into four categories namely: area development program, multidisciplinary program, training, and database development.

A. Area Development Program

I. Integrated Conservation and Development of the Sulu and Celebes Seas

Under Proclamation No. 1028 dated June 1997, the then President Fidel V. Ramos declared the entire Sulu and Celebes Seas as an Integrated Conservation and Development Zone. With over 450 species of corals, compared to only 50 species in the Carribean, the Sulu-Celebes Seas is the world's center of marine biodiversity (Wood, 1983; Miller, 1994). The program will assist the countries bordering the Sulu-Celebes Seas in identifying the economic potential as well as the ecological carrying capacity of the area using the Large Marine Ecosystems (LME) approach. There are (2) other existing government programs in the Sulu Sea: The Tubbataha Reef National Park and the Marine Turtle Islands Heritage Protected Area. The Tubbataha program is supported by an intensive year round patrolling system to guard against destructive fishing and poaching of wildlife by fishers from far-off surrounding provinces. The Marine Turtle program, on the other hand, is bound by a collaborative agreement between the Philippines and Malaysia to conserve a common heritage.

II. Integrated Visayan Sea Coastal Resources and Fisheries Management Project

With funding support from the GTZ and the Philippine government, the Vis Sea program has MPA establishment, aside from other resource management interventions and supporting measures, as one of the expected outputs of the project. The purpose of the Vis Sea project is to assist 25 coastal municipalities and cities of the four provinces surrounding the Visayan Sea in implementing their ICM agenda.

Vis Sea carries the challenge from site specific or bay-wide ICM initiatives one step further, as it attempts to coordinate and implement ICM for a major part of the Philippine Inland Sea, which is also one of the most important fishing grounds of the nation.

III. Pacific Seaboard R & D Program

Another program with ICM initiatives is the Pacific Seaboard R and D program. The program has three components: 1) assessment of eastern reef resources; 2) oceanographic studies on the Mindanao Eddy and in archipelagic waters in Central Philippines; and 3) ICM of Lianga Bay. The special attention given to the Pacific Seaboard is basically due to its geographical extent which is estimated at about 700,000 km^2. The program is envisioned to generate a comprehensive characterization of reefs and associated ecosystems, oceanographic and meteorological condition of the Philippine EEZ along the Pacific Ocean (Philippine Sea) as baseline information for future sustainable utilization of resources.

IV. Influence of the South China Sea on Philippine Reef System

This program is under the Joint Marine Scientific Research (JOMSRE) in the South China Sea. The Philippines joined Vietnam in 1996 as initial step to ensure the significant contribution of the Philippines in the regional efforts on the SCS. This move was also intended to advance national interest to conserve the marine resources of the country.

This program has (3) components namely: 1) Biodiversity of Philippine shelf reef systems in South China Sea; 2) Recruitment dynamics of reef organisms; and 3) Marine Information System. The geographic scope of the research activities cover the shelf reef systems of the western Philippines and the coupling mechanisms with the shoal reef systems of the Kalayaan Island Group (KIG) and those of the Sulu Sea. This program complements the research activities being undertaken in the KIG which puts more emphasis on the reef systems.

B. Multidisciplinary Program

I. Coastal Environment Program (CEP)

The Coastal Environment Program (CEP) of DENR emphasizes community participation and a focus on national marine protected areas. Although the CEP is constrained by a lack of budget and trained personnel, it is the only national government program designed to manage the entire coastal environment, including water quality and shoreline land use, and is not solely focused on fisheries management issues. To date, the program has studied 62 sites; ten of these sites are already proclaimed as protected areas covering a total of 589,294 hectares.

II. Coastal Resource Management Project (CRMP)

CRMP is a five-year technical assistance project funded by the United States Agency for International Development (USAID) and implemented by the Department of Environment and Natural Resources (DENR). It focuses on leadership and empowerment, informed decision-making, and positive changes in human behaviour in the implementation of CRM.

III. National Fish Sanctuary Strategy (NaFiSaSt)

This is a high impact program under the Agriculture and Fisheries Modernization Act (AFMA). It is implemented by a consortium of several state universities and aimed at enhancing sustainable fisheries through improved Marine Fishery Reserves (MFRs). The program considers MFR as central to the framework of CBCRM and the National ICM

Agenda. One of the components of the program is the training of local fisheries managers (LGUs) and NGO staff with emphasis on monitoring and evaluation.

C. Training Program: National Course on Integrated Coastal Management (NCICM)

To develop human resources capability in managing the country's natural resources, six agencies involved in coastal management collaborated to develop and implement a Broad-Based Coastal Management Training Program in the Philippines in 1993 with support from the Rockefeller Brothers Funds.

The objectives of the program are to develop a local pool of coastal management practitioners in the Philippines from government organizations, academe, NGOs and POs at the national and local level and to bring together a core constituency of coastal managers in each region who will institute/facilitate and work together in the formulation and implementation of an integrated coastal management plan for each region in the Philippines. Through the program, the National Course on Integrated Coastal Management (NCICM) was developed.

To date the program has trained 198 middle level coastal managers in the nine training sessions from 1996-1998. The NCICM is also accredited under the UNDP-TRAINSEACOAST program on ICM. Building on the experiences gained for the NCICM and to ensure that the Local Government Units shall effectively implement the management and control, a training program on Integrated Management for Local Government Units is being developed.

D. Database Development Program

I. Coral Reef Information Network of the Philippines (Philreefs)

The Philreefs is a computerized database system of Philippine reefs in electronic form developed by the University of the Philippines Marine Science Institute (UPMSI) and Philreefs partners. This database is also presented in print form called the Philippine Coral Reef Atlas and is complemented by the Newsletter Unos. The Atlas contains descriptions of 50 reefs, updates of 11 reefs out of the 20 reefs covered in the UNEP-IUCN Coral Reefs of the World (1988).

In conjunction with the celebration of the 1997 International Year of the Reef, (IYOR) Philreefs launched IYOR Philippines with activities such as National Reef Day or Reef Week Celebration, photo exhibits, reef monitoring contest, reef clean-ups, coral reef feature stories, seminars and workshops, and the Adopt-a-Reef Program. This Program includes giving recognition to coral reefs that contribute significantly and positively to the socio-economics and ecology of the area. Technical write-ups on these reefs including actual site surveys by the judges were the major considerations for the Best Reef Awards. It is also noteworthy that from the Philreefs "Best Managed Reef Awards", the on-going "Best Coastal Management Program Award" for the best municipality in the country helps sustain the recognition of these laudable coastal management initiatives.

In joining the celebration of 1998 as the International Year of the Ocean (IYO), the then Pres. Fidel V. Ramos, declared May as the Month of the Ocean and signed the UN Ocean Charter under water. After the signing, concerned divers conducted giant clam seeding for conservation and rehabilitation purposes. The Philippines observance of May as Month of the Ocean is another step that the country has taken in support of global initiatives for the sustainable use and management of ocean and coastal resources.

II. Reefbase

Reefbase is a global database on coral reef and its resources developed by ICLARM . ReefBase 3.0 is housed in Manila, Philippines and is the official database of the Global Coral Reef Monitoring Network (GCRMN). The establishment of the network was facilitated by the Intergovernmental Oceanographic Committee (IOC) through the UNEP and UNESCO. It is a mechanism whereby the scientific community contributes in the ongoing understanding of the state of the reefs in the world and has information on over 8,000 reefs. It is available in CD-ROM.

6. Research Directions on Coral Reefs

The Philippine Council for Aquatic and Marine Research and Development in 1989 launched a national program promoting coral reef management and conservation. While the program primarily focused on coral reefs, the program broadly included seagrass beds and mangrove conservation. It also covered the assessment of the country's coral reefs, demonstration of the community –based habitat management and protection of the coral reefs to maintain biodiversity.

On going research initiatives on coral reef ecosystems involve a number of universities and focus mainly on developing improved assessment as well as impact monitoring and evaluation methods, and physiological studies with the aim to propagate corals and establish coral farming for habitat enhancement. Leading institutions in these fields are the University of the Philippines Marine Science Institute in Manila, the University of the Philippines in the Visayas, the University of San Carlos in Cebu, Silliman University in Dumaguete, Negros Oriental and the Bicol University in Tabaco, Albay. The academe is also tasked to provide technical backstopping to municipalities in marine protected area (MPA) establishment and management mainly in resource and ecological assessment and training. State colleges and universities involved in these activities include the Mindanao State University, the Zamboanga State College of Marine Science and Technology, and the State Polytechnic College of Palawan. Percentage coral cover is considered as the most important indicator for assessing impact of conservation measures, other indicators include reef fish census and catch per unit effort.

Other studies include coral transplant, coral farming, tridacna reseeding, DNA markers for reef connectivity/dispersal studies, seahorse breeding and conservation, sea urchin ranching, sea cucumber farming and seaweed farming.

7. Conclusions

With the over 20 years of experience in the Philippines on coastal resources management, lessons have been learned that can benefit present and future programs. The quality of the implementation of CRM programs is greatly affected by relevant government policies, participation of local communities and the role of the funding institution. The Philippines has issued several policies that affect the coastal environment, specifically the coral reef ecosystems and the communities that depend thereon. With the passage of the Philippine Fisheries Code, the law now gives prominence to resource and habitat conservation, people's participation and local decision-making and gives priority to small fishers in the utilization and management of coastal resources. In the area of habitat management, the Code requires that at least 15% of municipal waters be set aside as marine protected areas. Marine protected areas provide some of the great points of hope for coral reefs. Through networks of marine protected areas, we can protect reef ecosystems and allow sustainable harvests for present and future generations.

Past CRM initiatives have shown that there is a need to establish sufficient baseline information upon which evaluation and management decisions could be based. Other programs have generated important examples for community-based coral reef management that exemplified the potential sustainable use of coral reef fisheries and habitat. The importance of the role of communities in sustaining management efforts in spite of changes in government personnel and policies has also been demonstrated. Other programs have generated comprehensive planning database but could not implement the recommendations, (e.g. on fishing effort reduction) and were forced to diverge toward education and political arrangement to coordinate planning and implementation.

Research on coral reefs focuses mainly on developing improved assessment as well as impact monitoring and evaluation methods, and physiological studies with the aim to propagate corals and establish coral farming for habitat enhancement.

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WWF-Philippines Strategies in Promoting Sustainable Resource Use in Coastal and Island Communities[a]

By: Filemon G. Romero[b]

Abstract

The Philippines is at the world's centre of marine biodiversity but is considered most affected by the biodiversity crisis. Threats such as habitat destruction caused by siltation and other land based sources of pollution, destructive and unsustainable fishing practices including aquaculture, overexploitation and non-sustainable use of resources, environmental pollution and weak institutional and legal capacities are seriously affecting marine biodiversity in the country. As a result, most coastal communities suffer from the double-edged problem of continuing degradation of their coastal habitats and increasing poverty. In order to assist government check or limit the losses to biodiversity, the WWF Philippines made tools for conservation available to communities in order to promote shared conservation objectives thereby strengthening their capacity in managing their resources. This has been done through its major programs for the protection and rehabilitation of marine areas and small islands ecosystems of high biodiversity and threatened species of flora and fauna, improving capacity of government agencies, non-government organizations and other key actors of conservation programs, initiating and supporting sustainable community based resource management and financially viable alternative enterprises and enhancing public awareness though aggressive environmental education programs.

This paper shares the WWF Philippines framework for sustainable resource use, strategies, experiences and lessons learned from the different approaches to make target communities not only responsible marine resource users but also better stewards of their resources. Some of the strategies adopted are marine protected area management and Integrated Conservation and Development Projects (ICDP); species-focused conservation for marine mammals and elasmobranchs; promotion of eco-tourism; and integrated coastal management program. Recently, the use of market forces and incentives in order to promote sustainable fishing in coastal communities through the community based fisheries certification is being tested. The ERBC (Eco-region Based Conservation) program attempts to integrate all these site-specific initiatives into an eco-regional conservation and management unit. Finally it advocates policy recommendations that have emanated out of these initiatives in the local and national levels of government.

Introduction

The Philippines it at the global centre of marine biodiversity with about 1,900 species of fish, 400 species of corals, 7 of world's nine species of giant clams, 18 species of marine mammals, 20 species of reptiles, 15 species of snakes, and 6 of the world's 8 marine turtles species. Its

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marine flora is likewise very diverse with 16 species of sea grasses; 1,062 species of seaweeds, 531 of which are commercially important, and 29 species of mangroves (DENR 1997). However, today the Philippines is identified as one of the biodiversity hotspots because of high rate of biodiversity losses.

Habitat destruction, due to very heavy siltation brought about by massive deforestation from logging, shifting cultivation or kaingin, forest fire, and conversion of forest land to farmlands, is identified as one cause of this biodiversity loss in the coastal areas. An estimate of 700,000 has. of forest cover is lost every year. By 1991, the Forest Management Bureau estimated only 60,100 km^2 of remaining forest cover. As a result, siltation is identified as the primary cause of coral reef destruction in the Philippines (Gomez et al., 1994). Heavy siltation can also smother sea grass beds and impair its ecosystems function.

Unsustainable fishing like destructive fishing methods such as the use of explosives, use of sodium cyanide, kayakas, and muro-ami, trawl fishing, and purse seine (Cruz 1986, Rubec 1986) reduce biodiversity, change fish community structure, damage coastal habitats, and disrupt ecological processes (Bohnsack 1994; del Norte et al. 1989; Russ and Alcala 1989). Aquaculture also poses a significant threat to marine biodiversity because of the associated clearing of mangroves and pollution from intensive culture ponds. For example, in the Philippines half of the mangrove (279,000 ha from the original 500,000 ha) was cleared between 1951 and 1988 as a result of the development of culture ponds (Primavera 1995). These conversions not only eliminated large areas of critical habitat, but also contaminated aquifers and surrounding farmland with pond wastes, and adversely affected sea grass and coral reef areas (Primavera 1995).

Uncontrolled tourism development, environmental pollution and coastal development and socio-economic stresses like rapid growth of coastal populations, development policies that promote overuse of marine resources; weak enforcement of and compliance with environmental and fishery laws and lack of institutional capacity and political will to conserve resources are some of the contributory factors that aggravate the threats to biodiversity.

Since it is the primary responsibility of the state to protect biodiversity and the environment, government agencies like the Department of Environment and Natural Resources (DENR) and the Bureau of Fisheries and Aquatic Resources (BFAR) of the Department of Agriculture (DA) are mandated to provide strong and effective institutional responses to answer these threats.

From the civil society sector, the Kabang Kalikasan ng Pilipinas (KKP) or World Wide Fund for Nature Fund Philippines was established in July 1996 as a non-government and non-profit organization, with the mission to stop and eventually reverse the accelerating degradation of the natural environment in the Philippines. To attain this mission, the WWF has adopted the following values and principles: WWF believes in the application of modern science to the problems of conservation and sustainable development. It is non-political in the sense that it respects legitimate political authority in the country. It focuses on constructive cooperation and compromise rather than confrontation in resolving issues in conservation and believes that it cannot save the Philippines by itself. It should work in partnership with any NGO, government agency or private corporation with similar conservation objectives. Finally, it supports and encourages the active participation of local NGOs and POs in the implementation of its projects with equality as the fundamental basis of any working relationship (KKP 1996).

The KKP/WWF Philippines has earned the distinction for its sharp focus on marine biodiversity conservation issues and problems through implementing projects in marine, coastal and small islands in the Philippines. In addition, it continues to help enhance the capacity of government agencies, NGOs, and other key actors in conservation programs to

deliver services; initiate and support sustainable community based resource management and establishment of financially viable and environmentally sound enterprises; and promote public awareness and environmental education

Conservation Strategies

The Marine and Small Islands Ecosystem Conservation Program, the major program of WWF, has the objectives of supporting the protection and rehabilitation of marine areas and small islands of high biodiversity and threatened species of flora and fauna and to enhance the capacity of project partners in biodiversity conservation in different strategic areas of the country. In order to attain these objectives, the KKP has adopted the following strategies:

1. Marine Protected Area Management

Cognizant of the role of marine protected areas as wildlife sanctuaries, national marine parks or fish sanctuaries comprises objectives such as increasing fish yields, protection of an endangered species, source of recruits, habitat protection and eco-tourism, the WWF-Philippines developed and implemented programs like the conservation and management of the Turtle Islands Heritage Protected Area and the Tubbataha Reef National Park. This recognizes the role of MPAs as a management tool for fisheries management and marine conservation. (Sobel 1993, Kelleher & Bleakley 1995, Russ & Alcala 1986a; Roberts & Pollunin 1993, Gray 1997). The Turtle Islands Heritage Protected Area (TIHPA), established by virtue of a bilateral agreement between the governments of the Republic of the Philippines and the Federal Government of Malaysia, is the world's first trans-border protected area for the conservation of marine turtles. This is a response to the need for a joint management scheme to ensure the survival of the remaining 80% of ASEAN's remaining green and hawksbill turtle populations in the area. Studies have shown that this group of islands supports a single population of the endangered green and hawksbill turtles. The goal is to enhance the conservation of the marine turtles and protection of small islands ecosystem by implementing and supporting projects integrating biodiversity conservation and development approaches.

The Tubbataha Reefs National Marine Park (TRNMP), the first Philippine National Marine Park established in 1988 and declared a UNESCO-World Heritage Site in 1993 and Ramsar Site in 2000, is located in the geographic centre of the Sulu Sea. It has an area 33,200 hectares and is considered to be a centre of genetic richness and spawning ground that populates Sulu Sea with fish, invertebrates, sea grass and corals. The overall goal of this protected area is to conserve the unique and relatively pristine condition of the globally significant biological diversity and ecological processes of the Tubbataha Reefs National Marine Park (TRNMP) and to manage it and the surrounding area on a sustainable and ecologically sound basis. To attain this, conservation management; conservation awareness; enforcement; policy and advocacy; ecosystem research and monitoring; and sustainable resource management and livelihood activities have been implemented with the local government, national government agencies and the Protected Area Management Board.

2. Species Conservation

a. Marine Mammal Conservation Program

Initially, the program focused in assisting government in conserving the dugongs (*Dugong dugon*), the sea cow, and their habitats throughout the Philippines. This started with a research on the feeding habits of this endangered mammal in Dimakya Island in Palawan and

the determination of their distribution through boat and aerial surveys. Later, activities focused more on information and education campaigns through networking with local partners and conducting of workshops in areas, which are known as remaining habitats of dugong. This program was expanded to cover the conservation of whales and dolphins. Cetacean surveys are being conducted and at least 22 species of marine mammals have been confirmed to be present in the country. A marine mammal rescue program has also been pursued in cooperation with local groups to respond to many cases of stranding in various parts of the country.

b. Elasmobranch Biodiversity and Conservation Project

Since research on and conservation efforts for sharks have been wanting (Wetherbee et al 1994), the goal of this project is to assist the government conservation and management program for marine wildlife species like whale sharks, manta rays and sharks. This project aims to determine elasmobranch biodiversity in the Sulu Sea; determine the status of the fishery and trade of elasmobranch species in the study sites; and to initiate elasmobranch conservation and management in the Philippines. It is developing an education and information campaign to promote elasmobranch biodiversity awareness and facilitate communication processes in its conservation and management. It is working in partnership with the Silliman University and the Bureau of Fisheries and Aquatic Resources (BFAR) to develop a database from field data collection and from secondary data on elasmobranch biodiversity. It is also developing monitoring protocols and guidelines to enhance awareness for their conservation.

3. Eco-enterprises and Eco-tourism

This strategy is based on the proposition that conservation can be effective if in using the same resource we can convert the resource users from the traditional extractive to non-extractive forms of livelihood like whale watching and whale shark interaction. Eco-tourism has been found to be effective alternative for conservation (Wojan1995, Knight et al 1997, Gossling 1999) in coastal and island communities.

a. Pamilacan Island Dolphin & Whale Watching Village Integrated Development Project

The aim is to assist in the national conservation program for marine mammals especially whales by developing the capacity of local community to engage in eco-tourism focused on whale watching. The objectives are to develop a sustainable financing strategy to ensure the sustained implementation of program; build local capacity for the community to conduct whale-watching tours; develop an integrated master plan for the conservation of Pamilacan's natural resources; and conduct research on marine mammals like whales in the Bohol Sea.

As a result of this initiative, the Pamilacan Island Dolphin and Whale Watching Organization (PIDWWO), composed primarily of former whale hunters and their wives, has been organized and is now in full control of the operationalization of dolphin and whale watching tours. The organization has now been trained in fund management both from grants and the income derived from tours. This test case has proven that eco-tourism like whale watching is economically feasible and can be a conservation tool.

b. Whaleshark (Butanding) Eco-tourism Development Project

Donsol, Sorsogon has been identified as a major congregation area of whalesharks. The goal of this project therefore was to assist in the development of the capacity of the local community in the proper management of whale shark interaction eco-tourism program. This was initiated with the gathering of baseline information on whalesharks and coming up with

recommendations and guidelines for implementing a community-based ecotourism program based on whaleshark interactions. The Butanding (local name of whale shark) Interaction Organizations and Boat Associations were then organized after a conduct of stakeholders' assessment and workshop. In terms of capacity building, trainings on skin diving, medic first aid, rescue courses and whale-shark interaction procedure, basic whale shark biology and conservation and environmental awareness were conducted for boat operators, guides and butanding interaction officers. Planning workshops with stakeholders were conducted and this led to the development of policy guidelines for tour operators. A visitor centre has likewise been equipped with facilities like video player and TV. This community is now known as the whale shark tourism destination in the country and hopes to develop this as a global destination for whale-shark interaction.

4. Integrated Coastal Management

Integrated Coastal Management Program for Balayan Bay, Batangas

The Integrated Coastal Management goal is to sustain an acceptable level of environmental quality and conserve the scarce, fragile, precious, vital and non-renewable coastal resources of Balayan Bay. The three-year program thrusts include: enforcement crusade; training and capacity building; policy research and development; information and education campaigns through Project L.I.F.E. (Learning Interdependently for the Environment); provision for boats and equipment; and alternative livelihood for displaced fishers. The other components are waste management and the development of sustainable financing mechanisms. Under its institutional development program, it is giving assistance for the formulation of the coastal resources management plan and the inter-municipal strategic plan. It has organised the Mabini-Tingloy Coastal Development Council (MATINGCADC) and is now forging an NGO unity for more effective collaboration and stronger partnership.

5. Enforcement Crusade

It is a Sea Protection Crusade that integrates law enforcement and regular patrols, sustained community information and education seminars, scientific research and monitoring, and assistance for environment friendly alternative livelihood activities. The objectives are to reduce if not eliminate the number of violators; cultivate awareness and appreciation of the value of marine resources and the need for sustainable fishing practices, encourage community participation and serious commitment to enforce environmental laws, promote cohesion and eliminate jurisdictional disputes, conduct research and monitoring activities on marine communities and local fisheries within the project areas to measure the conservation and developmental impact, and develop a model of effective and sustainable enforcement system and a strategy for effective management of fish sanctuaries and/or marine protected areas.

This crusade works within the existing institutional framework, PAMB for Tubbataha and the Turtle Islands and Local Government Unit for Balayan Bay and Negros Occidental. This started with the forging institutional linkages and entering into MOA with key government agencies involved in enforcement. This involves donation of patrol boats and deputisation of fish wardens and fish examiners and conduct of paralegal training in Balayan Bay. In the Tubbataha Reefs, equipment for enforcement activities like boats and radio and communications equipment were beefed up for more effective surveillance and monitoring activities in collaboration with Navy Forces. Deputisation trainings for staff and other

partners were also given and this was followed by the implementation of the US Department of Interior Interagency Coral Reef Conservation and Marine Law Enforcement Training.

6. Fisheries Certification

Community Based Blue Crab (*Portunus pelagicus*) Fisheries Certification

Certification as a conservation strategy is adopted using market forces to promote the sustainable use of resources. This is done through strengthening of community-based organizations/institutions in preparation for community ownership of resource management strategies including the certification process, protecting and conserving crab fish populations and the marine environment on which they depend, promoting responsible management of the crab fishery, ensuring the sustainability of fishery stocks and the general health of the marine ecosystem, and providing economic incentives for better business practices toward managing the precious resource, (i.e. blue crabs).

The Project is working very closely with the Department of Agriculture-Bureau of Fisheries and Aquatic Resources (DA-BFAR), the provincial and municipal governments, other NGOs, and the fishing communities toward achieving its goal. It is actively promoting coastal resource management through the establishment of Fisheries and Aquatic Resource Management Councils (FARMCs) in coordination with the Office of the Provincial Agriculturist (OPA). These councils are intended to empower the fisher folk as the rightful stewards of the country's marine resources and are mandated to draft and implement fishery resource management plans. The development of the management system will be guided by the results of the biological and fishery assessment of the blue crab resources conducted by project consultant. The challenge for the project is the establishment of a fishery resource management system that will subject itself to assessment using the Marine Stewardship Council criteria, which are rather stringent for artisanal fisheries.

7. Geographic Information System

The South East Asian Marine Resource Information System (SEAMARIS) is an interactive computer-based information system that is used for policy analysis and as an information base to support the planning and management of the world's oceans and coasts. It is aimed at improving the current system for collection and delivery of information on marine resources and analysing this information to assist in evaluating the constraints and opportunities in the management of coastal and marine areas. Components of the SEAMARIS Database are the Marine and Coastal Information System, the Statistical Database Library, and the Documents Database.

8. Sulu-Sulawesi Marine Ecoregion Conservation Program

The Sulu-Sulawesi Marine Ecoregion Conservation Program (SSMECPD) is a program under development within the context of WWF's ecoregion-based conservation approach (compare Llewellyn et al. panel 4) to vast areas that are significant in terms of biological diversity and ecological processes. The Sulu-Sulawesi Marine Eco-region (SSME) was selected as a priority Global 2000 eco-region due to its extremely rich marine biodiversity and its ecological as well as economic importance. This involves trilateral participation of Indonesia, Malaysia and the Philippines in planning and implementing a Conservation Management Plan and a biodiversity vision for the ecoregion.

Problems Encountered and Lessons Learned

In the implementation of these conservation strategies, some problems have been encountered. In the area of marine protected areas and integrated coastal management, there is generally a lack of baseline information in marine ecological systems and protected areas, insufficient capacity of the Protected Area Management Board (PAMB) and the Fisheries and Aquatic Resources Management Councils (FARMC) to perform their management functions. It has also been noted that government programs are biased towards terrestrial protected areas. We have also been adversely affected by the unclear delineation of functions among government agencies involved in marine/coastal resources management sometimes resulting in conflicts between field personnel of the Department of Environment and Natural Resources and the Bureau of Fisheries and Aquatic Resources. Despite provisions of the local government code mandating local government units to implement coastal resource management programs, sustained political will and capacity of LGUs to support coastal and environmental management programs impinged heavily on our initiatives. As a result of this, enforcement of fishery and environmental laws are met with cold responses so violations are not addressed. In the area of fisheries certification, social and economic incentives from sustainable coastal management are not understood and appreciated. Generally, we are faced with the problem of a misconception on NGO roles in the community as provider of funds or project implementer rather than as a facilitator. So there is a tendency for communities to be over dependent on NGOs in project implementation.

After several years of project implementation we have learned that drawing from the official mandate of government agencies through MOA facilitates the government-NGO partnership and enhances attainment of conservation objectives. We have also shown that sharing of resources (manpower, funds, technical expertise, facilities and equipment) makes conservation/enforcement activities more effective. Moreover, involving stakeholders even at the planning stage makes them appreciate their critical role in the short term and long term goals of marine conservation and gives them a sense of ownership of the initiative. It has also been noted that enhancing the continuous flow of information on the status of project implementation to stakeholders and community local leaders, through a regular feed backing process, strengthens and increases effectiveness of partnerships. We have also learned that any intervention done needs in-depth social and stakeholder analysis and that training/livelihood programs should be based on needs of the community and their absorptive capacity.

Policy Options Adopted

National and International Level

The WWF has been responsible for advocating the passage of some major environmental policies that have advanced conservation programs in the country. Before the establishment of the WWF-Philippines, the WWF Philippines Program has been responsible for the implementation of the debt-for-nature swap and the Integrated Protected Areas System (IPAS). The debt swap program also resulted in an endowment of more than $23 million for the Foundation for the Philippine Environment which is now in the forefront in promoting sustainable resource management measures in different parts of the country. WWF also provided the leadership in the earlier stages of the IPAS Program that identified ten priority sites for declaration as protected areas. This initiative likewise resulted in the passage of Republic Act No. 7586, otherwise known as the Integrated Protected Areas Systems Act of 1992. This law mandates the classification and administration of designated protected areas to

maintain essential ecological processes and life-support systems, to preserve biological diversity, to ensure sustainable use of resources found therein and maintain their natural conditions to the greatest extent possible.

After more than four years of implementation, the WWF Philippines has been responsible for the declaration of the Sulu-Celebes (Sulawesi) Seas as an Integrated Conservation and Development Zone under Presidential Proclamation No. 1028 in June of 1997 and also established the Presidential Commission for this purpose. This commission is tasked with assessing the current status of resources in the Sulu-Sulawesi Sea and developing an institutional strategy for the prioritisation of conservation and development work within the marine eco-region. The WWF-Philippines, through the Sulu-Sulawesi Marine Eco-region Conservation Program (SSMECPD) program within the context of WWF's eco-region based conservation (ERBC) approach, is helping government in prioritising areas within the eco-region that are significant in terms of biological diversity and ecological processes.

The WWF-Philippines was also instrumental in assisting government to justify the proclamation of the Tubbataha Reef National Marine Park as a priority Ramsar Site. It also pushed for the establishment of the Turtle Islands Heritage Protected Area, a result of a bilateral agreement between the governments of Malaysia and the Philippines for the joint management of the Turtles Islands for the conservation of the largest remaining nesting area of green turtles in the ASEAN region. This is world's first transborder protected area for the conservation of sea.

Local Level

At the local level, WWF has worked closely with local government agencies to push some policy reforms and initiatives. WWF has successfully lobbied for the declaration of the Turtle Islands as a Wildlife Sanctuary under the National Integrated Protected Areas System (NIPAS) through Presidential Proclamation No. 171. Prior to this, it supported the promulgation of DENR Administrative Order 99-31 implementing the Turtle Islands Eco-tourism Development Guidelines in July 1999. Subsequently it has pursued the establishment and strengthening of the Protected Area Management Boards in the Turtle Islands and the Tubbataha Reef National Marine Park. More impetus is given now that the Turtle Islands Wildlife Sanctuary has been established and the protected area plan is being developed. The participation of the local government and the indigenous people are now formalized and institutionalised through the creation of the Protected Area Management Board (PAMB) as mandated by the NIPAS Act. The park management policies rest in this board and the WWF Philippines, as the NGO representative in the PAMB, works closely in capacitating this board to push its conservation agenda. In the Tubbataha Reefs, the WWF assisted the PAMB to develop the management plan through a series of stakeholder workshops and to adopt a policy of providing sustainable financing mechanisms through a user fee system, which is used by the PAMB to finance the implementation of the management plan.

At the local government level, WWF has pursued the institutionalisation of the Fisheries and Aquatic Resources Management Councils (FARMC's) as fisheries resource management arm of the local government and in many municipalities, several resolutions and ordinances like defining fishing areas, limitation of gears, establishment and delineation of fish sanctuaries have been adopted. Enforcement campaigns through active participation of Bantay Dagats (Sea Patrols) with support from the FARMC's and local government has been institutionalised through Memorandum of Agreements with KKP and making this part of local legislations. Adoption of the coastal management programs has also been enhanced at the local level. Use of GIS and incorporating this into the database of SEAMARIS has been

adopted as an approach for the identification of priority biodiversity conservation areas through the SSME program.

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Key Sustaining Factors to Effective Implementation of Marine Protected Areas in the Philippines[a]

By: Rudolf Hermes [b]

Abstract

Marine Protected Areas (MPAs) are the major intervention aimed at resource regeneration within the framework of coastal resources management in the Philippines. More than 400 areas are under some form of protective management, ranging from cross-border international parks to small village-based sanctuaries. However, there is little doubt that only a fraction of the total can be considered functional and providing the expected impact or benefits. In order to help assure the likelihood of expected positive impacts and sustainable management of MPAs, regardless of size and lead implementing agency, several key contributing factors are identified.

These are, apart from the obvious funding support and political will, the following: (1) structured planning procedure (e.g. logframe or goal-oriented project planning) with clear, realistic objectives and properly defined, suitable indicators for monitoring and evaluation of process and impact; (2) the drafting and continuous implementation of an MPA management plan as a reference and guideline for the different project partners, informing clearly on roles, functions and responsibilities; (3) truly participatory (community-based) approach from incipient stage to monitoring and evaluation, even if the initiation of the process was academe- or NGO-driven; (4) continuity in partnership between community-based organization, local government unit, non-government organization, and academe; (5) provision of supplemental livelihood opportunities or income diversification in return for reduced access to traditional fishing grounds; (6) well designed information and education campaign carried out as on-going activity over an extended period of time; targeting general public, school children and decision-makers or local chief executives with appropriate media and contents; and (7) acceptability and manageability as criteria for MPA selection are of paramount importance, particularly on local government level; these can be influenced by constituency building, community organizing, or institutional strengthening and capacity building (training).

None of the listed seven areas of concern describe entirely new practices. Therefore, more than 25 years after MPA establishment was initiated in the Philippines, increased attention should be paid not only to the type of activities which need to be implemented in order to secure the MPAs' effectiveness, but more emphasis needs to be placed on the quality of the processes initiated and carried out.

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Introduction

In the face of widespread resource depletion and habitat destruction, the establishment and maintenance of Marine Protected Areas (MPA) is the major form of intervention for resource and habitat regeneration within the range of activities collectively known as coastal resources management. Other objectives of MPAs include e.g. the protection or enhancement of biodiversity, the promotion of tourism or a combination of different goals.

The expected positive effect from the MPA is the exclusion of destructive actions to both habitat and resource, as well as the replenishment of fish and other resources either in form of a so-called recruitment- or spill-over-effect. While monitoring and quantitative assessment of impact is notoriously difficult, there are already numerous studies documenting successes (Birkeland 1997; Bohnsack 1996; and literature cited therein).

There can be no doubt that the approach, under which MPA establishment is carried out, has to follow the process of community-based coastal resources management or fisheries co-management (Pomeroy 1998). This implies shared responsibilities in managing the coastal zone (including the MPA) between the community, local or national government agencies, and non-government organizations.

The co-management approach recognizes that government units at different levels have important roles to play, while at the same time people empowerment and active participation in self-help processes are other key ingredients. In this context, resource management can be considered the technical intervention and has to be complemented (and preceded) by community organizing, institutional strengthening and other supporting measures.

In late 1997 a workshop was held in the Philippines in order to take stock of the past MPA related initiatives in the country, and to define future directions to be followed. Sustainability and effectivity were among the concerns raised and discussed, and what improvements would be required to achieve these (Uychiaoco et al. 1999).

Sustaining factors

Over the recent 25-year period numerous MPAs (variably called fish or marine sanctuaries, marine reserves, refuges, etc.) have been initiated and established within municipal waters all over the Philippines. With some notable and relatively well documented exceptions (e.g. Apo & Sumilon Islands; Alcala 1998), a large number of these areas have not been maintained, or have not resulted in the expected or desired positive impact, or no impact has ever been monitored and ascertained (Pajaro et al. 1999).

It appears likely that in the case of the unsuccessful and unsustainable MPAs any single or several of a number of important supporting factors or sustaining mechanisms have been neglected or omitted. This may both apply to the early pre-establishment or start-up phase or the later following maintenance phase of the MPA. The availability of sufficient funding and the expression and actual application of political will are the obvious prerequisites for any activity of this kind and will not be discussed further. It is sufficient to state that lobbying and advocacy for both factors can be expected to be indispensable during the MPA implementation process. At the same time, the need for sufficient attention to the likewise important technical-ecological or biophysical considerations such as the suitability of the location as well as concerns such as area, size and zoning is fully acknowledged and affirmed.

Apart from the above, a number of components of the MPA establishment process, including those which can be considered important aspects of the approach chosen, have been identified based on the study of failures, successes and intermediate outcomes in recent years. The issue

of sustainability of MPAs is the consideration of highest importance in the establishment process (Alcala 1999).

Planning Procedure

Perhaps less than the scientific-technical issues it can be postulated that the procedural and socio-cultural issues have a much greater impact in determining the fate and sustainability of the planned or established MPA. Like in any other project expected to last for a considerable number of years, proper planning procedures should be followed in order to justify a budget to be allocated and expended for its implementation. There is a choice of established procedures (e.g. logframe approach, goal-oriented project planning, etc.), which provide for a sequence of structured, logical steps including participants analysis, situation analysis and objectives analysis.

These steps should be followed to generate a planning document of sufficient quality to facilitate or guide implementation. It should clarify project purpose (or the goals and objectives, for which the MPA is established), the required or expected results (or outputs) to be provided and the related activities per output to be implemented. It should of course be flexible enough to accommodate plan modifications based on monitoring and evaluation (M&E). Goals should be realistic and achievable, and suitable indicators need to be defined at this early stage to allow the application of appropriate M&E in order to document any progress made towards achieving the objectives.

The quality of the planning process is an important concern, especially in MPAs that are academe- or NGO- initiated. Planning and management subjects are usually not found in the curricula of the natural and social scientist.

Management Plan

The MPA project planning document should be further refined into the MPA management plan. Apart from the key components of the earlier plan for MPA establishment (e.g. in addition to the aforementioned hierarchy of goals, the roles and functions of cooperating implementers) the management plan contains a number of descriptive elements. These are the resource description, including the biophysical and geographical profile of the location as well as the socio-economic and demographic profile of local communities. A narrative of the important management issues as well as strategies and policies on how to deal with these form the main component of the plan. Administrative information and attachments (taxonomic inventory or resource assessment results, maps, copy of the municipal ordinance or establishing legislation, etc.) complete the plan.

The MPA management plan documents the agreement of the different project partners and serves as a binding reference and guideline during the lifetime of the MPA which should only be considered „established“, if management measures are being implemented continuously or regularly according to this plan. Among these, monitoring and evaluation as well as education as on-going activities are considered the most important, probably ahead of surveillance or enforcement.

The management plan, aside from the above-mentioned narrative parts, could also consist of the more familiar matrix format. The volume of this document is obviously related to the diversity of resources and complexity of issues, and probably also to the size of the area. It should be a goal to keep it concise and clear, but also as short as feasible, particularly for small village-based MPAs.

Participation

A central element of the community-based approach is the participation by those affected in the management functions regarding the MPA implementation. Participation helps to build up loyalty and conveys a sense of ownership. The need for participation in decision-making by those affected or responsible for maintenance and monitoring should be self-evident. Participation, however, does not mean that people can co-decide on something that they will not contribute to or be responsible for, and adherence to democratic processes implies also majority decisions. On the other hand, fake or „token" participation is worse than no participation at all; this could mean the early end to motivation and cooperation or result in increased opposition to the project.

It is probably true that the majority of municipal MPAs in the Philippines were started through the initiative of outsiders to the community (e.g. environmentalists either from non-government organizations or the academe, national government agency personnel). A compromise needs to be achieved between the right mix of outside intervention in terms of technical backstopping and the initiation of a community-based self-help process that should lead to the MPA establishment. True participation from the incipient stage to the later routine monitoring and evaluation will increase the sustainability of MPA implementation. Participatory monitoring and research methods need to be developed further, and it should become also a standard procedure to recognize the community as the owners of the resource and monitoring information and install feedback mechanisms to „repatriate" data, which were processed and analyzed by supporting institutions.

Continued partnership

In an ideal world with traditional artisanal resource use patterns, community resource property rights and access regulations, there may be less or no need for partnerships with external parties. In reality, during the pre-establishment phase, but also later on particularly in the field of monitoring, there is a need for continuity of external support in the form of a partnership between the community-based organization, the local government unit and an environmental non-government organization (NGO) and/or academic institution. It must be clear for all potential future partners from the beginning that they are about to enter into a long-lasting engagement, most probably putting considerable demands on their financial, institutional and personnel capacities. In the Philippines, this long-lasting commitment is more easily achieved if it involves locally based NGOs or academic institutions with a local presence, e.g. in form of a marine laboratory making them into of the local stakeholders. The process is also helped by transforming scientists from the providers of resource information into advocates for coastal management.

The intensity of any technical backstopping depends very much on the actual situation. The most important role of an NGO is certainly in the field of community organizing, advocacy and some aspects of institution building or strengthening. However, in order to improve the response to technical needs such as the complexity of fisheries related issues, it is also necessary that community organizers have an adequate technical background in the field of natural or agricultural sciences, preferably as a result of a formal degree course. Continuity is also important in the face of impending political changes, e.g. the succession of local leaders as a result of elections. Clear policies and a supportive legal framework are essential to reduce the risk that important initiatives are discontinued by a newly elected local chief executive.

Supplemental livelihood

Any prospective MPA is likely to be the traditional fishing ground of somebody whose livelihood depends on it entirely or to some degree. In the case of MPAs for the purpose of resource regeneration, expected economic benefits will only be realized over a number of years, given the relatively slow growth of reef fish as compared to pelagic fish. Compensation for initially reduced harvests or higher fuel costs to reach more distant fishing grounds is therefore considered appropriate, justified or even mandatory. With all business options initiated from outside the community, the question must be raised: if these were economically feasible, why have they not yet been tried and utilized? Great care must be taken to attend particularly to the economic feasibility (taking technical feasibility as already validated) including access to market, transport cost, business management capability, etc.

Livelihood assistance could take the form of special credit funds administered by a rural bank or the community-based organization, provision of training or equipment grants and seed money. In some cases, especially if the MPAs objectives include promotion of tourism, economic benefits through user fees may be more immediate and direct employment opportunities are an option. Typical income diversification options are not discussed here. Fisheries-related (mariculture, post-harvest) activities should be considered for traditional fisher families, while recent migrants to the coast from inland or upland areas should be encouraged to move out of the fisheries sector as much as possible.

Information and education campaign

Education in some form or another is most certainly a component of all efforts towards MPA establishment. Education may well be the key to create or strengthen a sense of ownership of the MPA within the involved community. During the pre-implementation phase of the MPA, education will be required to generate awareness and support for the project. The Information and Education Campaign (IEC), however, should not be considered as a one-time activity at any suitable phase during this early stage, as it was undoubtedly often a practice in the past. IEC needs to be an on-going concern over the lifetime of the project, similar to monitoring and evaluation, carried out over an extended period of time. It is a particular challenge for those tasked with IEC to demonstrate potential or expected long-term advantages and benefits to be derived from an MPA in the face of the essentially short-term outlook dictated by perceived or real economic necessities.

All appropriate and available media or communication tools should be utilized, incorporating both formal and non-formal elements, addressing all ages from school children to adults. Following the principle of training-of-trainers, education and information should reach all segments of the coastal population, but putting highest emphasis on the youngest age groups, i.e. elementary school children. In addition, campaigns patterned after the advertising strategies for the promotion of commercial products should be designed and implemented. Such an IEC effort is likely to be costly, but it can be expected that extra money spent in education is money saved in both monitoring and enforcement. Among the most costly, but also considered most promising and effective IEC approaches is the so-called cross-visit or exposure trip to existing well-managed demonstration sites.

Selection criteria

Application of a range of selection criteria has become standard practice during the pre-implementation phase of the MPA. Typical criteria include biophysical (e.g. ecological), economic and socio-cultural aspects. Weighting of scores given to each of the criteria should be based on the objectives of MPA establishment. Proper use of the criteria, not only with

regard to biological information, requires a considerable level of knowledge on the state of the resources. In those cases where delays caused by the need to generate more information could result in further resource or habitat loss, it may well be justified to proceed with the establishment process and fill in data gaps at a later stage.

Applying criteria such as naturalness, species richness, and importance to fisheries is faced with the problem how to distinguish between the need to preserve areas given high scores on any of these accounts, or to prevent and, ultimately, reverse losses in degraded areas with good recovery potential.

Acceptability and manageability as criteria for MPA selection are considered of paramount importance, particularly on local government level; and both can be influenced by constituency building, community organizing, or institutional strengthening and capacity building (training).

Conclusion

These seven areas of concern are considered essential to increase the likelihood that the MPA will be properly established and can be maintained and managed in a sustainable way, preferably within the context of a larger integrated coastal management initiative. None of the factors discussed are entirely novel practices or new components of the MPA agenda. Emphasis should therefore be placed not so much on the mere fact that they are being considered or addressed, but rather on how they are operationalised or implemented; i.e. on the quality of the process. Continuous monitoring and evaluation, which were mentioned repeatedly, are also considered of utmost importance, not as a sustaining mechanism, but rather as the tool or set of tools (including surveillance and enforcement) by which it can be ascertained that progress is made towards the objective of sustained management and achievement of desired impact.

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Making Stakeholder Participation Work: The Role of Social Science Research[a]

By: Heidi Wittmer[b] & Regina Birner[c]

Abstract

During the last decades, the management of coral reefs and associated ecosystems has been characterized by a shift from state-based natural resource management systems to collaborative management systems that involve the participation of local communities and other stake holders such as NGOs and private sector organizations. This paper develops a conceptual framework for the analysis of stakeholder participation in coral reef management and presents different concepts of the social sciences that can be applied for the analysis of collaborative management systems. A distinction is made between the analysis of resource use problems and collaborative management arrangements on the one hand, and the analysis of political processes and frame conditions on the other hand. The application of social science research results is discussed.

Introduction

Managing coral reefs and associated eco-systems in a way that meets ecological, economic and social objectives is a challenging task, which requires research contributions from the natural and the social sciences. The present paper gives an overview of possible contributions from the social sciences and outlines options for interdisciplinary collaboration with the natural sciences. The term social sciences is used here to in a broad sense to refer to economics, sociology, cultural anthropology and political sciences. For reasons of scope, we focus on analytical tools developed in socio-economics that have been applied or can be applied for the analysis of participatory coral reef management systems. The paper addresses researchers and practitioners in coral reef management who are less familiar with social science research, thus aiming to facilitate interdisciplinary communication and collaboration. We have included references to homepages, where further information can be found conveniently.

The paper proceeds as follows: In Section 2, we outline the concept of participatory coral reef management and identify different fields of social science research in this context. Section 3 gives an overview of the analytical concepts that can be used by social scientists for research on issues of participatory coral reef management. By way of conclusion, Section 4 shows how social science research can contribute to the success of stakeholder participation in coral reef management

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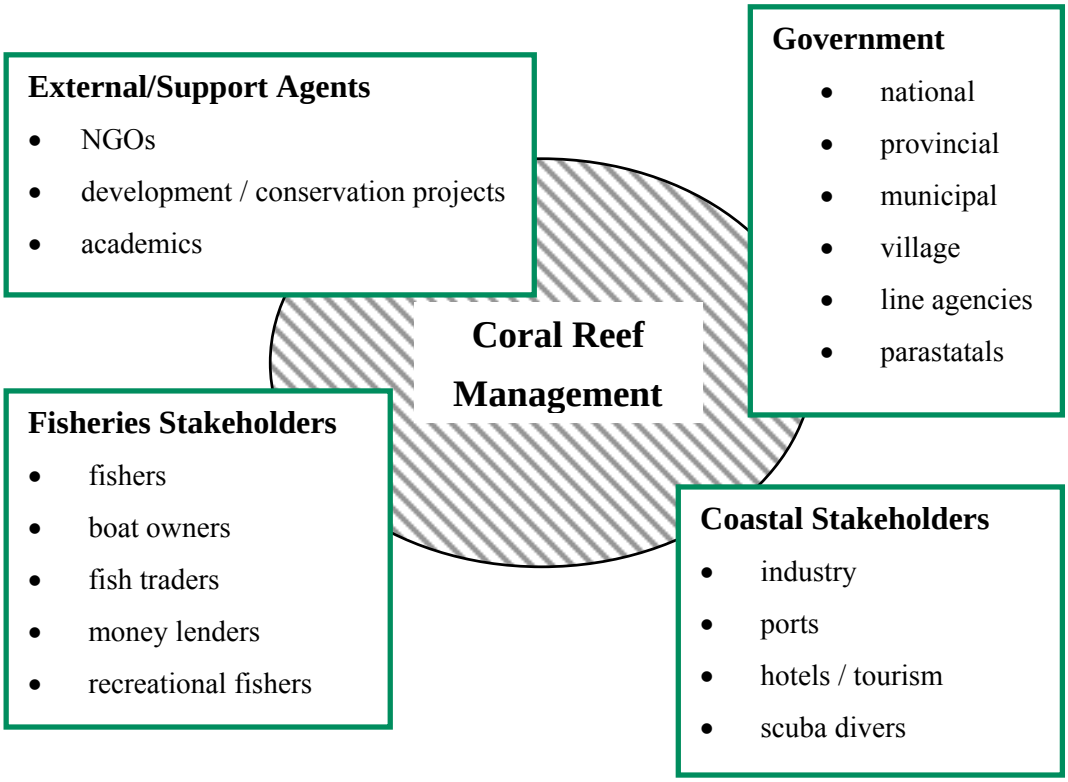
Stakeholder Participation in Coral Reef Management

The last decades have seen a shift from centralised state-based natural resource management systems to collaborative management systems that involve a sharing of rights and responsibilities between state agencies and different stake holders, especially the local communities, NGOs and private sector organizations. Coral reef management is no exception to the general trend from state-centred to collaborative natural resource management systems. Similar to other resource sectors, the capacity of the state institutions to manage coral reefs and fisheries in a sustainable way proved to be rather limited. At the same time, the capacity of the local communities, and the value of their local knowledge were increasingly recognized as an important factor in promoting sustainable reef management. The catalyst role of NGOs and the possibility to identify "win-win" approaches that involve private sector organizations has gained importance, as well. Participatory approaches have also been promoted by the Earth Summit in Rio in1992, which acknowledged that the conservation of natural resources is only possible if it is accompanied by economic development and if takes into account issues of social equity. The need for stakeholder participation as a requirement to reach these goals of sustainable development has been highlighted in the documents signed in Rio, such as the Rio Declaration, the Convention on Biological Diversity and the Agenda 21.

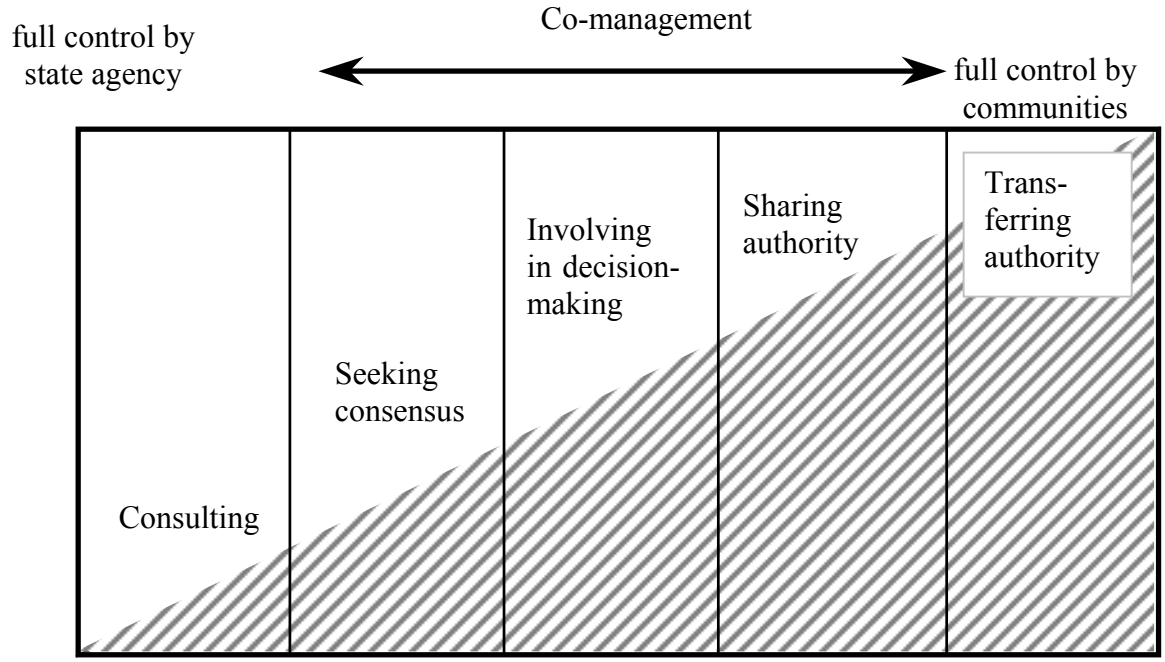


Source: adapted from Pomeroy 2001: 117

Fig. 1: Stake Holders in Coral Reef Management

In Coral Reef Management, the range of different stakeholders that can be involved in collaborative management systems is large. Figure 1 represents possible stakeholders from different sectors, including the government and fisheries but also other coastal stakeholders and external or support agents. Within and between these groups, there are typically different and often conflicting interests and equity concerns. This constitutes a major challenge for establishing collaborative reef management systems.

Social science researchers classify participatory approaches in natural resource management according to the level of participation in a continuum between pure state management, on the one hand and pure stakeholder-based management on the other hand. Figure 2 illustrates this approach.



Source: adapted from Pomeroy 2001: 118

Figure 2: The Continuum of User Participation

The way in which such arrangements influence the outcome of a collaborative management system is illustrated in Figure 3. The management arrangements have to be seen in connection with the physical and technical attributes of the resource system, and with the characteristics of the various stakeholders involved. The outcome of the management depends on the way in which the different stakeholders react to the management arrangements, for example, on their compliance with the established rules. Following the concept of sustainable development, one has to consider ecological outcome parameters, such as the degree of coral destruction, economic parameters such as the income level of the local population, and social outcome parameters, such as changes in income disparities.

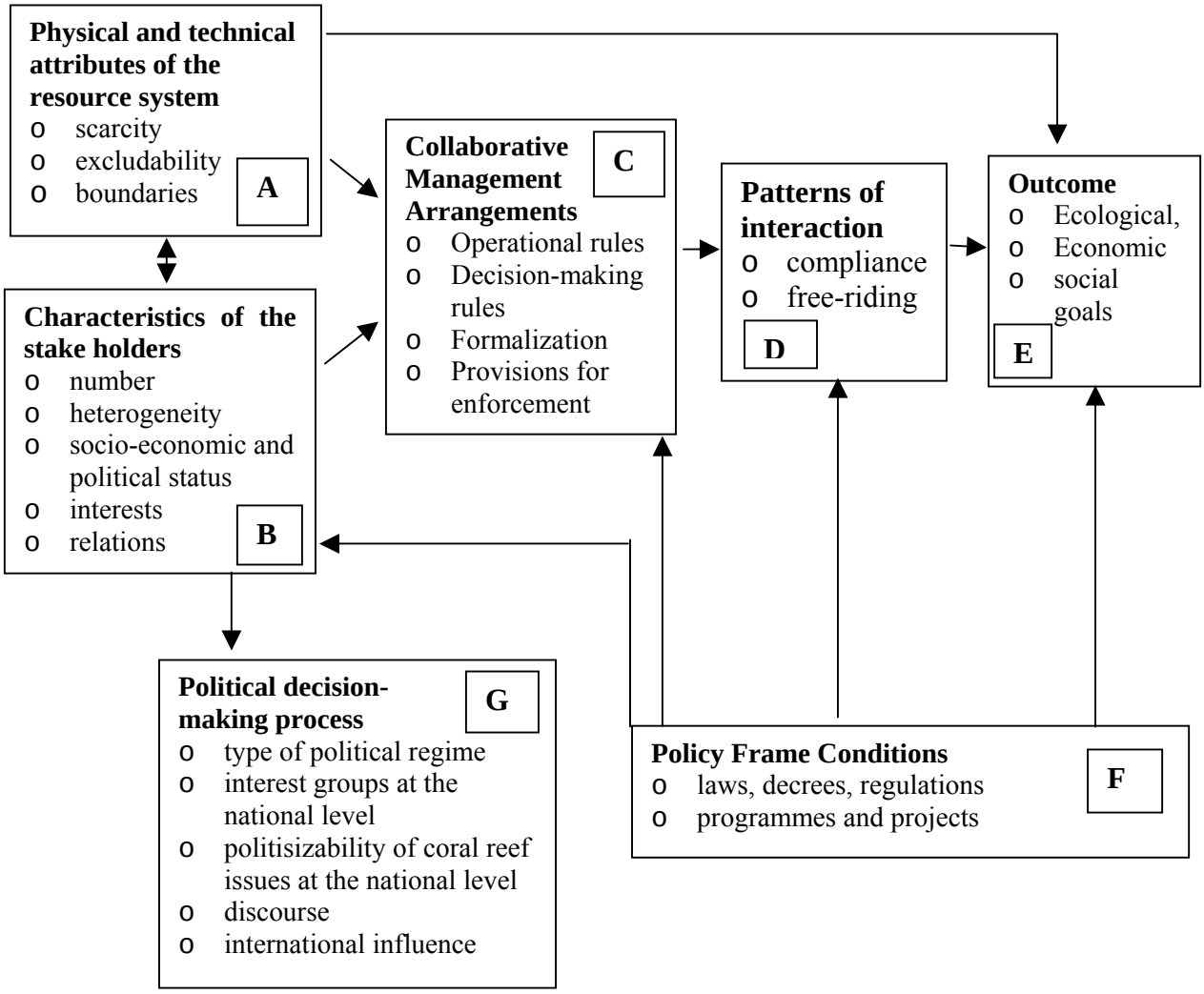
On the basis of this concept, one can distinguish two major fields of research. The first field is the analysis of collaborative management arrangements at the local or regional level, while the second field concerns the influence of the policy frame conditions. As Figure 3 shows, the analysis of collaborative arrangements includes several elements, starting from the analysis of the physical and technical attributes of the resource system (Box A), over the analysis of the various stake holders involved (Box B), to the analysis of the arrangements themselves (Box C) and the patterns of interaction created by these arrangements (Box D). These steps of analysis help to explain the final outcome in terms of economic, ecological and social indicators (Box E).

A close collaboration with natural scientists is required for this approach, especially in the following three fields:

(1) the analysis of the physical and technical resource attributes, e.g., the boundaries of the resource system, the relative scarcity and degradation of the resource stock, etc., (Box A)

(2) the assessment of the collaborative arrangements, especially with regard to the rules for resource conservation, harvesting rates, etc., (Box C), and

(3) the evaluation of the ecological outcome of a collaborative management regime, for example with regard to the identification and measurement of the ecological parameters that can be used to judge the outcome (Box E).



Source: adapted from Oakerson, 1992: 56.

Figure 3: Fields of research regarding collaborative management of coral reefs

From the local and regional perspective, the laws, decrees, programmes, etc. that govern coral reef management (Box F in Figure 3) have to be considered as frame conditions that are taken as given, at least in the short run. However, these policy frame conditions can themselves be considered as objects of analysis. This analysis can further be divided into two fields of research: The first field concerns the analysis of these laws and decrees, programs, action plans and other policy documents e.g., with regard to their coherence and appropriateness. The second field consists in the analysis of the political process, which has led to these

policies (Box G). The following section presents the major analytical tools to be used in these different fields of analysis.

Analytical Tools

Table 1 below gives an overview of the analytical tools presented in this section. Following the considerations of the last section, we distinguish concepts to be used for the analysis of resource use problems and collaborative management arrangements (upper part of Figure 1), and concepts used for the analysis of political processes (lower part of Figure 1).

1. Concepts for the Analysis of resource use problems and collaborative management arrangements

a. The Concept of External Effects

External effects are a basic concept in environmental and resource economics. An external effect exists if "an action of an economic agent affects the utility or production possibilities of another in a way that is not reflected in the market place." (Hueth & Schmitz 1982: 269, quoted in Ellis 1996: 255). One can distinguish negative and positive external effects. Examples of negative external effects in coral reef management are damages to coral reefs caused by anchors, damages to marine resources caused by dynamite fishing. By definition, external effects are not considered in the decision-making of resource users, because they do not have to bear the costs of the damage caused. In the above examples, the damage affects the society at large and/or future generations. Policy interventions such as regulations or taxes are typically required to "internalise" external effects. An example of a positive external effect in coral reef management is the protection of coral reefs by a private enterprise for tourism development. Such type of conservation creates benefits not only for the tourists, but also for the society at large, e.g., the maintenance of biological diversity. These are positive external effects.

b. The Concept of Common-Pool Resources

The concept of common-pool resources is essential for the analysis of the physical and technical attributes of the resource system (Box A in Figure 3). Common-pool resources are characterized by two attributes: Non-excludability and rivalry in consumption. Coral reefs and associated eco-systems can typically be considered as common-pool resources. It requires special efforts to exclude people from using the resources (non-excludability), and the resource units consumed by one person, e.g., the fish caught, cannot be appropriated by consumed by any other person (rivalry in consumption). Common-pool resources can be held under different property regimes, and their management of common-pool resources has to deal with the problem of collective action.

c. Property Rights Analysis

Economists used to distinguish a bundle or cluster of property rights or entitlements that constitute ownership. They include the right to use, the right to manage, the right to the income, the right of exclusion, the right of transfer and the right to compensation. Depending on the entity holding these rights, one can distinguish four basic types of property systems: (1) private property, if the rights are held by a private person or entity, (2) state property, if these rights are held by the state, (3) common property or communal property, if the rights are held by a community, and (4) open access, if these rights are not assigned. For the purpose of analysis, it is important to keep in mind that property rights may be customary (informal) or formal (backed by state legislation). Customary and formal property systems often overlap,

which can be an important basis for conflicts over resources. As the paper by Abdul Kamara (this panel) shows, property rights analysis can help to understand which stakeholders have claims to marine and coastal resources and on which basis these claims are made. Based on such an analysis, the interests of the different parties involved can be understood more easily. For organizations supporting participatory management approaches, property rights analysis is, therefore, an important tool to understand the baseline situation and the nature of the conflicts that may arise among resource users as well as between resource users and state agencies. Property rights analysis is also essential to assess to which extent coral reefs are managed as common-property by local communities, and to which extent they are de facto open access resources (compare Kamara, this panel).

d. Theory of Collective Action

The theory of collective action can be used to explain under which conditions individuals can overcome problems of co-ordination and free-riding and act collectively in order to achieve common goals. This question is essential for the management of common-pool resources under common property management regimes (see above). Free-rider problems exist, if some individuals do not comply with rules for common resource management in order to increase their private benefit, while the damage caused by such behaviour has to be borne by the entire community. A typical free-rider problem in coral reef management exists if individual fishers do not respect no-take zones. The theory of collective action allows identifying under which conditions free-rider problems can be overcome. Conditions that have been identified in empirical studies include, for example, a clear definition of the boundaries of the resource systems, the availability of different levels of sanctions, institutionalised monitoring, and participation of the resource users in decision-making (Ostrom 1990). The application of collective action theory is also particularly important in cases in which the stakeholders involved are not yet organised. Game theory is a more formalised approach that can be used for the analysis of collective action problem. It allows determining typical outcomes and hold-up situations, which may appear in negotiation processes leading to collaborative arrangements.

e. Social Capital and Network Analysis

Social capital can be defined as the shared knowledge, understandings, norms, rules, and expectations that allow members of a society to act collectively. (See Wall et al. 1998 for a review of the concept). In natural resource management, the concept of social capital has been applied to analyse the rules that allow local communities to manage common property systems in a sustainable way (Ostrom 1994). Social capital can, thus, be a very important asset for controlling resource use by community members, however it will fail to solve problems involving outsiders, if communities are not given the legal and physical means to exercise control over the resources they are to protect. The analytical tool of network analysis has been suggested to measure social capital (Coleman 1990). Network analysis, which applies mathematical methods to analyse the structure of social relations, can also be used to analyse patterns of social interaction, such as participation and negotiation processes. Anthony King (this panel) has presented an illustrative example that shows how network analysis can contribute to the understanding of negotiation processes involving coastal resource use.

f. Transaction Cost Economics

Transaction costs arise for the enforcement of property rights and for making contracts. According to Eggertson (1990: 15), transaction costs can be categorized according to the following activities:

- searching for information about potential contracting parties (stake holders) and the value and quality of the resources to which they have claims or property rights,
- bargaining that is needed to find the position of contracting parties and reach an agreement on the terms of the contract,
- making of a formal or informal contract defining the obligations of the contracting parties,
- monitoring of contractual partners to see whether they abide the terms of the contract, and
- enforcement of the contract and the collection of damages when partners fail to observe their contractual obligations.

The first three cost categories are also considered as ex-ante transaction costs and the last two categories as ex-post transaction costs, because they arise before and after the contract enters into force. As co-management arrangements can be considered as formal or informal contracts, transaction cost economics is a useful tool to assess the efficiency of such arrangement from an economic point of view.

Hanna (1995) studied the implications of user participation on transaction costs and hypothesized that participatory or co-management arrangements involve higher ex-ante transaction costs than pure state-managed regimes because of the need to co-ordinate the various stakeholders concerned. The ex-post transaction costs, however, are often considerably lower in co-managed systems, because user participation provides legitimacy, which can considerably reduce the costs of monitoring and enforcement (Hanna 1995). Kuperan et al. (1998) empirically measured and compared the transaction costs of co-managed and state-managed fisheries in the Philippines and found that the transaction costs of co-managed systems were indeed lower. With the exception of Kuperan et al. (1998), however, empirical studies on transaction costs involved in the management of marine resources have remained scarce. To be able to make a complete assessment of the efficiency of different management systems, one has, moreover, to simultaneously consider transaction costs and production costs and perform a cost-benefit analysis (see below).

Following Williamson (1991), transaction cost economics can also be used to assess the efficiency of different management arrangements more generally. In order to derive hypotheses on the efficiency of different management arrangements, one has to study the attributes of the transactions involved in a management regime, such as planning activities, monitoring and enforcement activities, etc., and the prevailing frame conditions, such as the capacity of state agencies and the social capital of the local communities (Birner & Wittmer 2000).

g. Economic Valuation of Natural Resources and Cost-Benefit Analysis

The economic valuation of natural resources has been a central theme of resource economics. Special techniques such as contingent valuation are necessary to assign monetary values to environmental goods and services, for which there are no markets. Economic valuation of natural resources is a precondition for analysing the costs and benefits, which allows analysts to assess the efficiency, of coral reef management systems. Hassan (panel 1 this volume) deals with these topics in more detail.

2. Tools for the Analysis of Political Processes and Frame Conditions

A variety of concepts developed in political science, political economy and political sociology can be used to analyse the frame conditions of coral reef management and the political processes that are typically required to create and change these frame conditions. The lower part of Table 2 lists some important concepts. (See Keely & Scoones 1999 for a review).

a. Policy Cycle Analysis

Policy cycle analysis is a useful tool to structure policy processes into different phases such as policy formation, policy implementation and policy evaluation, which can then be analysed in more detail. For example, to understand policy formation in coral reef management, it is essential to analyse which interest groups are able to bring coral reef issues on the policy agenda and why. The politicizability of coral reef issues may differ considerably between countries, depending on the role of marine resources in the economy as a whole. The role of the press is essential, too, in the phase of policy formation. In the phase of policy implementation, the analysis concentrates on the role of the state agencies and other actors in charge of implementing laws and programs. The concept of the policy cycle also draws attention to the fact that the current frame conditions are influenced by the experience of previous policy cycles.

b. State-centred and Society-centred Approaches to Analyse Policy Processes

In political science, it is conventional to distinguish state-centred and society-centred approaches to analyse policy processes and political outcomes. State-centred approaches focus (1) on the role of politicians, (2) on the role of the bureaucracy, and (3) on the state as an actor itself. Policy outcomes are explained by assuming, e.g., that politicians act in such a way as to maximize their votes and chances for re-election. Likewise, the behaviour of state agencies is explained by hypothesising that they try to maximize their benefits and influence. The reluctance of state agencies in charge of coral reef management to devolve power and responsibilities to local user groups can, for example, be explained by this approach. The so-called "predatory theory of the state" holds that the state itself can be considered as a rational actor, which maximizes its revenues or tries to increase its power.

Society-centred approaches explain policies as the outcome of a competition between different interest groups. This approach is useful to analyse lobbying activities, for example of environmental groups for coral reef conservation policies. The society-centred approach is typically based on the assumption of a Western model of democracy, in which different interest groups can freely organize themselves and participate in the political process. Therefore, adjustments have to be made to analyse policy processes in countries, which are not organized according to a model of pluralist democracy.

c. Political Resource Theory / Political Capital Theory

Political resource theory focuses on the different resources that political actors can mobilize in order to pursue their interests in the political process. For example, one can analyse which resources local communities can mobilize in order to pursue their interests, when laws, decrees or programs concerning coral reefs are being developed. Such resources can consist, for example, in their capacity to involve in lobbying or organize public demonstrations. The concept of political capital is applied in the same way, but it allows analysts to consider the aspect that actors may invest resources to build up a stock of political capital. Local communities and environmental groups may also use different forms of social capital (see above) for the creation of political capital (Birner & Wittmer, forthcoming).

d. Discourse Analysis

Discourse analysis focuses on the argumentation which different political actors use in the public debate to defend their position (compare Hajer 1995). Interest groups typically share different sets of factual beliefs (beliefs about facts such as the state of degradation of coral reefs) and evaluative beliefs (views on how to evaluate certain facts, such as given level of degradation). In natural resource management, one can typically distinguish (1) a conservationist discourse, which focuses on nature conservation as a goal in its own right, (2) an eco-populist discourse, which considers local communities as the true stewards of natural

resources and commercial enterprises and state agencies as the major threat, and (3) a developmentalist discourse, which considers poverty as the major reason for resource degradation and focuses on rural development activities as primary instrument to achieve conservation goals. The analysis of different discourses, which are more or less dominant in the public debate, helps to better understand policy outcomes. Different academic disciplines also tend to adhere to different discourse traditions, for example, biologists are more likely to follow a conservationist discourse, socio-economists a developmentalist discourse, and cultural anthropologists an eco-populist discourse. As Leach & Fairhead (2000) have shown, the unreflected adherence of scientists to a particular discourse tradition can lead to serious flaws in their research.

Empirical methods in social science research

To apply the analytical tools presented in this section, social scientists use a variety of different empirical research methods. One can distinguish quantitative and qualitative methods. Quantitative methods typically involve statistical sampling methods, such as stratified random sampling, to identify the respondents. Structured questionnaires are then used to interview the respondents. Quantitative methods make it possible to design the research in such a way that the results are representative, for example, for the local communities in a given area. Important qualitative methods in the social sciences include semi-structured and open interviews with key informants, group discussions and focus group interviews, collection of life histories and participant or non-participant observation of the activities of the stakeholders concerned. Qualitative methods are typically used in a case study approach.

During the last two decades, participatory research methods have received increasing importance in social science research. These methods allow researchers to involve the local population in an active way. Examples are Participatory Rural Appraisal (PRA) or Participatory Action Research (PAR). Participatory approaches use tools such as ranking (e.g., wealth ranking, matrix ranking, and pair ranking), construction of maps, seasonal calendars, transects, decision trees, and methods eliciting indigenous knowledge such as folk taxonomies and classifications. Participatory methods are used not only for research, but also for the implementation of development projects. Participatory Technology Development (PTD) and Participatory Learning Methods (PALM) are examples. Leeuwis (2000) has recently pointed to the shortcomings of some of these methods and recommended to reconceptualize participatory approaches in order to integrate negotiation techniques.

Table 2: Overview of Analytical Tools Used in Social Sciences

1) Tools for the Analysis of Resource Use Problems and Collaborative Management Arrangements a. External effects b. Common-pool resources c. Property rights and property regimes d. Theory of collective action and game theory e. Social capital and network analysis f. Transaction costs economics g. Economic valuation of natural resources and cost-benefit analysis
2) Analysing Political Processes and Frame Conditions a. Policy cycle analysis b. State-centred and society-centred approaches to analyse policy processes

c. Political resource theory / political capital theory
d. Discourse analysis

Source: compiled by the authors

Application of Social Science Research Results

An important application of the results of social science research can be seen in the identification of design principles, which have proved to increase the success of collaborative management arrangements. The insights summarized in Table 1, for example, allow scholars to derive design principles for the management of common-pool resources. Another example of a design principle is subsidiarity, which implies that a decision should be taken at the lowest feasible level. Equally important for the success of collaborative management arrangements is the legitimacy with which it is perceived. Participation in decision-making generally augments the perceived legitimacy of the decisions made. There are, however, situations where participation is impossible to achieve due to pronounced differences in the power and influence among the stakeholders involved (Cooke & Kothari 2001). Property rights analysis and institutional analysis can be a prerequisite for the identification of incentives for the protection of resources. Other fields of application of social science research consist in the monitoring and evaluation of co-management arrangements. Comparative analysis allows analysts to identify best practises and success factors.

The analysis of the political processes can be another contribution of social scientists to the success of stakeholder involvement. The analysis of micro- and macro-level processes makes it possible to understand the factors that promote or hinder the involvement of stakeholders in the management of coastal resources. Thus, the design of second-best, but politically feasible solutions will become an alternative option.

An important field for applying the results of social science research is the field of policy advice. Concerning the choice of policy options, policy advice could refer to the design of the arrangements, and the appropriate level of participation, depending on the capacities of the different stakeholders to be involved. As mentioned above, transaction costs economics can be useful to assess the efficiency of governance structures that differ with regard to the level of decentralization and the role of state versus civil society. Advice could also refer to questions concerning the actors who should legally receive the right to manage and the benefits of certain coastal resources, or the actors who are to enforce compliance with the convened arrangements. Another important area is the management of the ongoing political process, which can be improved, e.g., by organizing workshops for stakeholder consultation. Policy advice can also refer to capacity building required to improve the contribution of different stakeholders in a co-management regime. Finally incentive creation is a crucial option to increase the sustainability of resource use. Of course one must not forget that there can be stakeholder constellations that make it impossible to reach at sustainable solutions without changing the current power structure.

Concluding remarks

The paper aimed to demonstrate that social science can contribute in various ways to an improved management of coral reefs by applying analytical concepts that have been developed in its different disciplines. The paper also shows that the co-operation between natural scientists and social scientists is essential to make the sustainable management of coral reefs and associated eco-systems possible. Based on the insights of this paper, the roles of natural and social scientists in such a co-operation can be sketched in the following way: Natural scientists aim to identify the necessary conditions for a sustainable use of natural

resources from an ecological and bio-physical perspective. Social scientists aim to identify the rules and arrangements for sustainable use that will be feasible in the given social, economic and political setting. Applying their expertise concerning participatory methods, social science researchers can also contribute to actively involve the stakeholders and users of the research results into the entire research process.

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Summary of Discussion of Panel III

Heidi Wittmer

Trust between communities and the state was considered crucial for the success of stakeholder participation. The paper by King illustrated how the actual interaction between communities and state can take place and showed clearly that existing institutional structures were not functional to resolve conflicts in fisheries. To identify hindrances to building up this trust was therefore considered an important contribution of social research. Participants also stressed the importance of distinguishing between the interests of different groups of fishers' and/or fisheries since these interests are often conflicting. One problem especially common in many developing countries is the co-existence of different systems of property rights, i.e. state-based and community-based rights, which do not coincide. Over time, especially with increasing pressure on the resource base in question, these different systems increasingly conflict. In this context it was also stressed that poverty alone is not necessarily responsible for reef degradation.

Some of these issues were illustrated using the mangrove examples. The question was raised who manages mangroves, whether communities participate in the management or whether their participation is limited to the reforestation process. Closely related is the question how reforested mangroves can be "secured". How to distribute the tasks between community and state in the restoration and in the monitoring and protection of the restored areas? Again questions raised in panel 1 concerning the role of -in this case mangrove resources- for rural livelihoods are essential. Understanding this role is an important precondition for creating incentives for protection by local communities. Educating communities concerning the damage of mangrove destruction albeit important is therefore not sufficient to achieve conservation and sustainable use. A closely related question is whether the costs for reforestation and conservation measures should be considered as an investment, which needs to be paid back or as a donation. Donations are much less likely to provide incentives for conservation on the other hand it is hardly realistic for local communities to assume the costs of reforestation unless the benefits increase income opportunities accordingly. The question was raised what role the discussion and establishment of "sustainable aquaculture practices" play in mangrove management. Issues included over-harvesting of mangroves and prawn (shrimp) pond culture with significant detrimental impact to fisheries and local livelihoods (Asian experience). Possible solutions include systems of aquaculture that use channels in the mangroves and are an integral part of the mangrove ecosystem, often in the form of poly-culture or mangrove-based raising and fattening of mud crabs, which is possible without negative impacts on the resource system.

Again the need for conservation instead of rehabilitation was discussed. The emphasis of the discussion this time was on the need for an adequate legal framework. Here again coping with the co-existence of different law systems (traditional and state law) was considered crucial in order to achieve implementation of policies.

The role of devolution, meaning passing responsibilities and rights from state institutions to civil society, was also debated. The discussion focussed on two questions: how good devolution is for conservation and how to make devolution happen. An important characteristic of many conservation efforts is the fact that conservation costs arise at the local level and immediately, whereas benefits from conservation are usually less localised and often lie in the future. This basic pattern implies that at the local level there are less incentives for conservation than at more aggregated levels of decision making. At the same time the information available to decide where and how conservation measures can best be

implemented is much better at the local level. Finding out how to make devolution happen remains an important challenge for social science research. It clearly implies a shift of power and it is crucial that those in power have some incentive to concede it. Another related topic was the collaboration among different organisations (state and non-state) within a given country.

Apart from state and community two other important stakeholders for conservation where identified: Non-governmental organisations and private stakeholders. The discussion focused on the role of private stakeholders. First of all it can be difficult to identify who should be considered a private stakeholder and in how far community interests might also be dominated by the interests of influential individuals within the community with private stakes. The role of private stakeholders and tourism for conservation was discussed. The discussion centred on how policy can ensure tourism benefits to coastal people. Direct taxes to tourism for environmental protection constitute an important policy option especially if they are used to improve much-needed infrastructure for coastal communities. A large debate evolved around the potential of private actors like the Chumbe Island Coral Park for achieving conservation through tourism. A number of participants had doubts that the private sector might be suited for this task. This issue has been further elaborated in the conclusions.

The discussion focused on the equity dimension of sustainability. The question was raised whether global equity can be sustainable in the sense that African children might have the same access to resources (in a broad sense, i.e. including opportunities for education etc.) as children in Europe while conserving the global resource base.

Finally there was a discussion on determining the effectiveness of conservation efforts. In this context the need to distinguish between the donor and the recipient point of view was stressed. In a more general sense it was considered important to scrutinise donor-driven development and conservation projects which have less chances of aiming at sustainability in all three dimensions (this can also apply to NGO- and academe-driven projects). It was therefore considered important to formulate the objectives of projects and interventions in terms of sustainability instead of in terms of conservation alone.

Panel IV: MPA Systems – Striving for Sustainability

Content

As isolated small-scale projects are not sufficient to ensure the survival of species or entire ecosystems, more comprehensive strategies such as national action plans or networks of MPAs have been developed and partially implemented to protect coral reefs and associated ecosystems. Panel four analyses such initiatives at different levels: The first two contributions present national frameworks and action plans from Mozambique and Kenya. The following three papers are devoted to regional initiatives involving several countries, including a network of MPAs in the Red Sea and various African regional initiatives. Finally a global approach suggested by WWF will be presented.

The contributions will help to identify and discuss the challenges that are specific for international initiatives such as creating institutions for intergovernmental co-ordination and developing mechanisms for monitoring and conflict resolution.

A Framework for the Management of Coral Reefs and Associated Coastal Ecosystems in Mozambique[a]

By: Helena Motta [b]

Key-words: Mozambique, Integrated Coastal Zone Management, Coral Reefs, Ornamental (Aquarium) Fish, International Trade, Mozambique Coral Reef Management Programme (MCRMP), Legal and Institutional Framework

Introduction

Mozambique is situated on the eastern coast of Southern Africa, between 10°27´ S and 26°52´ S latitude and 30°12´ E and 40°51´ E longitude. The Mozambican coastline, about 2,770 Km long, is the third longest in Africa and is characterised by wide diversity of habitats including sandy beaches, sand dunes, coral reefs, estuarine systems, bays, mangroves and sea grass beds. Mozambique has a network of conservation areas established in the country early in the sixties. These conservation areas were mainly established to protect a diverse group of land mammals and in some cases forest areas. They were established with no consideration to the ecological range and or boundaries of the species (mainly in the case of animals). Although the conservation areas comprise a reasonable amount of the country surface area, 11.4% (i.e., 89,602 square km); the marine and coastal environment represent less than 1% of the protected area.

The coast of Mozambique is a compound shoreline produced by a succession of emergence and submergence. In relation to the distribution of coral reefs it can be divided into three regions:

1. The Northern Coast

The northernmost section of the coast extends for 770 km from the Rovuma River (10°20'S) in the north to Pebane in the south (17°20'S). It is essentially a coral coast and is characterized by numerous small islands that form the Primeiras and Segundas and the Quirimbas archipelagos. An almost continuous fringing reef exists along the eastern shorelines of the islands and the more exposed sections of the mainland coast.

2. The Central Coast

The central section of the coast between Pebane (17°20'S) and Bazaruto Island (21°10'S), a distance of about 950 km, is classified as a swamp coast. Twenty-four rivers discharge into the Indian Ocean along this section, each with an estuary supporting well-established mangrove stands. The coastal waters are shallow and combine with the sediment loading from the rivers to cause typically high turbidity levels. Consequently, coral reef formation in this area is severely limited.

3. The South Coast

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[a] Paper presented at the EU-Workshop: Policy Options for the sustainable Use of Coral Reefs and Associated coastal Ecosystems; Mombasa, Kenya June 19th – 22nd, 2000

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This section stretches for 850 km from Bazaruto Island southwards to Ponta do Ouro (26°50'S). The coastline is characterized by high parabolic dunes, north-trending capes, and barrier lakes. These dune systems, attaining heights of 120 m, are considered to be the tallest vegetated dunes in the world. The distribution of reefs along the coast and near-coast islands is patchy and typically rocky reefs with scattered corals (Rodrigues *et al*., 1999a)

This paper presents the efforts in Mozambique to establish an institutional and legal framework for the management of coral reefs and associated ecosystems. It describes the efforts by the Government in order to establish specific programmes of action for areas of concern, especially those related to coral reefs within the broader framework of integrated coastal area management.

The Government Initiatives

In June 1994, the Government approved the National Environmental Management Programme (NEMP), which is the master plan for the environment in Mozambique. It contains a national environment policy, environment umbrella legislation, and environmental strategy. The NEMP is also a programme of sector plans, containing projections for the medium and long terms aiming to lead the country to sustainable socio-economic development. One of the priority areas of the NEMP is a number of activities related to integrated coastal zone management. As for the arrangement for the coastal zone, it proposes the current inter-institutional committee to became a technical subcommittee of the National Council for Sustainable Development, created by the environmental law. While introducing national environmental legislation, the country has in the last years adopted and ratified important international environmental conventions, such as, among others, the Conventions on Biological Diversity, Climate Change and Protection and Management of the Marine and Coastal Environments in the Eastern African Region.

At the regional level, Mozambique has given support to the establishment in Maputo, in 1997, of SEACAM, the Secretariat for Eastern African Coastal Area Management, which followed a regional consensus since the Arusha Declaration and Seychelles meeting. The Secretariat has been collaborating with other regional agencies such as the Regional Co-ordination Unit of the Nairobi Convention. In 1998, the Mozambican concept of coastal zone management was presented to a broad forum of African countries in the Pan African Congress for Sustainable Integrated Coastal Management (PACSICOM), which was held in Maputo. The concept was widely accepted, as well as the foundations for regional programmes for the co-ordination of coastal management, which were laid.

The Mozambique Coral Reef Management Programme

The Ministry for the Co-ordination of Environmental Affairs (MICOA) initiated in 1997 a project for the development of a National Coastal Zone Management Program (NCZMP). This program encompasses the entire coastal zone and is multi-disciplinary in its approach. It is further envisaged that one of the components of this NCZMP addresses the critical ecosystems, which comprise the coastal environment, such as coral reefs, mangroves, seagrass beds, etc. Specifically, the coral reef management plan aims to address the component within the NCZMP entitled "National Programs for Specific Ecosystems".

In the light of the above and background discussions with a variety of individuals and groups that are in someway involved in coral reefs, four larger areas of activity stand out as being vital for the attainment of the main goal of sustainable management of coral reef resources. This four areas will form the Mozambique Coral Reef Management Programme (MCRMP) and are: (i) capacity building within the relevant fields required for effective sustainable

management; (ii) the collection and synthesis of relevant information and scientific data in support of sound management; (iii) the development of an appropriate and effective network for the coordination and sustenance of coral reef management related activities; and (iv) the process of identifying, characterizing and addressing current and eventual problems with coral reefs and their management (MICOA, 1997).

Coral Reef related activities in Mozambique and some Results

Several activities took place since the launch of the coral reef management programme; with the discussion of the draft programme being one of the most important activities. On the field, activities took place mainly in order to collect data and train national scientist. Some of those activities are summarized below:

1. The Coral bleaching preliminary assessment

A survey on coral bleaching was undertaken in 1999, at the end of summer. Evidence of bleaching was sought on a total of 17 reefs and a visual assessment was made of reef type, faunistic cover and the extent of reef damage attributable to bleaching and crown-of-thorns starfish (COTS). The results show that the effects of El Nino bleaching in Mozambique were most extensive on exposed reefs in the north and this diminished further south except at Inhaca Island where serious recent bleaching was encountered. Extensive COTS damage was also found at Bazaruto and Inhambane (Schleyer *et al.*, 1999).

2. Training Course

A training course was held in August, 1999, in the Centre for the Sustainable Development of Coastal Zones, Xai-Xai (MICOA). The course was attended by a number of participants from MICOA itself, the Institute of Fisheries Research and the University. The course will be replicated to other students and marine biologists from different departments. Some of the participants were later integrated in the team that started the monitoring programme.

3. Monitoring and monitoring stations installation

Sites were selected for a preliminary survey (Schleyer *et al*., 1999) according to a number of criteria, among which: (i) Representative of Mozambican coral reefs, i.e. typical of exposed Mozambican fringing reefs or of sheltered, specialized coral communities adapted to high nutrient levels, turbidity and thermal and saline stress in sheltered embayments. (ii) Evenly distributed along the extensive Mozambican coastline in areas in which corals occur. (iii) Reasonably accessible. The fieldwork was carried out between August and September 1999, during 22 days. For the first year of monitoring, nine "core" reefs were selected for annual survey. These reefs were widely distributed throughout the coast and represent different reef types. Before video transect was done, an observer would conduct a general survey and start a species list. This list was helpful on data analysis of video-transect (Rodrigues *et al.,* 1999b)

The Future Ahead

As part of the recommended actions at national level, Mozambique prepared a five-year programme of activities within the framework of the whole National Programme for Coastal Zone Management, with DANIDA being the main donor. The programme started in the middle of 2000 and is addressing the most urgent priorities for action at national level. The following are the immediate objectives of this programme: (i) establishment of an appropriate institutional and legal framework for coastal zone management; (ii) awareness raising and capacity building of all relevant stakeholders in the coastal area management; (iii) improvement of natural resources management through research, planning and legislation enforcement. Beneficiaries of this programme will be found at the local level, which will

benefit from capacity building and training programmes, increased and more secure access to natural resources.

Additionally, national sub-programmes for the management of specific ecosystems such as the sub-programme of coral reefs are well under way. Preparation of legislation, training of scientists, continuation of the coral monitoring programme and specific surveys on needed areas, are the main focus of the years ahead.

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Management and Utilisation Policies of inshore resource in the context of Science and Poverty[a]

By: Renison K. Ruwa[b]

Abstract

Management and utilisation of resources based on scientific information arguably offers the best directional method for sustainable use of the resources, which also ensures maintenance of optimal quality standards for balanced systems. Although universally accepted and well argued by Hatcher (1999) global disparities in economic wealth militate against these efforts leading to logical questions like that put by McClanahan (1999), "is there a future for coral reef parks in poor tropical countries?" Whereas the resource in question is the survival of coral reef parks, the same would be extended to other types of tropical habitats and their resources, e.g. sandy beaches and dunes, seagrass and mangroves.

These issues are examined in the Kenyan country domain by looking at the policies that govern management utilisation and protection of coastal and marine resources and economic activities and the level of research input as dictated by the relevant policies including the Environmental Management Act and regional and international policies to which Kenya is signatory. In the order of their relative importance, the major economic activities along the Kenya coast that have direct or indirect relationship and impact on inshore resources are: Tourism (45%) Maritime Transport (15%), Non-Agricultural Industry (15%), Agricultural Produce based Industry (8%), Fisheries (6%), Agriculture (5%), Forestry (4%) and Mining (2%). The multiple policies to regulate these resources have caused conflicts and attempts are being made to address them in the context of Integrated Coastal Area Management.

As regards the research policy, Kenya has a Science and Technology Act to deal with research matters and the establishment of the necessary institutional arrangement for research but her allocation for research has been about 0.5% of the Gross Domestic Product which is lower than in other developing countries in Southern and Eastern Asia which ranges 7-14% of the GDP. With an economic growth that has been declining over the period 1994–1999 from 3.3 % to 1.4% and a current population growth rate of 2.4%, which declined from about 3.8% in the 1990s, funding for research will still be meagre.

Hence, the scientific management of her resource and technological advances in research will be jeopardized by current poverty rates. However, the enthusiasm Kenya shows in scientific management as evidenced from ratifying and being a signatory to various regional and international policies concerned with management, protection and sustainable utilization of resources, collaboration in science at international levels with both developed and other developing countries, will help to narrow this gap.

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Development of a Network of Marine Protected Areas in The Red Sea and the Gulf of Aden Region[a]

By: Mohammed Younis[b]

Introduction

The Arab League Educational, Cultural and Scientific Organization (ALECSO) initiated the Programme for the Environment of the Red Sea and the Gulf of Aden (PERSGA) in October 1974. The formal launching of the Regional Organization for the Conservation of the Environment of the Red Sea and the Gulf of Aden took place following the Cairo Declaration in 1995. It includes Egypt, The Hashemite Kingdom of Jordan, the Kingdom of Saudi Arabia, the Republic of Sudan, the Republic Djibouti, the Republic of Yemen and North-East and North-West Somalia as member countries. PERSGA was retained as the official acronym for the newly born organization.

Recognizing the uniqueness of the Red Sea and the Gulf of Aden (RSGA) Region and threats that face it, the Strategic Action Programme (SAP) for the Red Sea and the Gulf of Aden was initiated in 1995. Development of the SAP process continued and the project started in 1999 under the execution of PERSGA. Funds are primarily provided by the Global Environmental Facility (GEF) implementing agencies (UNDP, UNEP, and the WB), the Islamic Development Bank and Member States. The aim of the SAP is to support and facilitate the objectives of PERSGA, which includes development of a regional framework for the protection of the environment and the sustainable development of coastal and marine resources. In pursuit of its goals and with regard to the needs of the region, SAP focuses on the following key issues:

- Capacity Building for Regional Cooperation
- Reducing Navigation Risks and Maritime Pollution
- Sustainable Use and Management of Living Marine Resources
- Conservation of Habitats and Biological Diversity
- Development of a Regional Network of Marine Protected Areas
- Support for Integrated Coastal Zone Management
- Enhancement of Public Awareness and Participation.

This paper deals with the SAP component concerning the Development of a Regional Network of Marine Protected Areas. Within the network examples of habitat types and species communities in all ecosystems are to be protected to ensure full representation of the sum of the bio geographic sub-units in the region. Twelve declared and proposed marine protected areas (MPAs) in the region were identified during the SAP development process (Table 1). Of these, seven have already been funded by different agencies. Funds will therefore be used for the remaining five sites, in addition to selected regional activities.

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Establishment of a Regional Network of Experts Specialized in MPA Planning and Management

A Working Group (WG) has been formed consisting of MPA specialists, one from each PERSGA member states and headed by the MPA Lead Specialist. The objective of the WG is to provide guidance and advice to the SAP and PERSGA on establishing the Network of Marine Protected Areas in the RSGA Region. The scope of its work falls under capacity building and development of master plans and regional and national networking. The WG will contribute substantively to the implementation of the MPA component by assisting in:

- Reviewing existing information on declared and proposed MPAs and identifying information gaps to be taken into account in establishing the Network.
- Identifying human resources development needs and advising on priorities for institutional and legislative capacity building.
- Supporting development and organization of regional workshops/training programmes.
- Integrating, consulting and undertaking joint activities with other Working Groups, especially with regard to workshops on ecosystem-based regional conservation plans.
- Supporting public awareness programmes and acting as advocate for MPA activities, among government officials.
- Advising on the selection of national subject matter experts whenever necessary.
- Advising from the national perspective, while retaining regional standards, on aspects to be incorporated into management plans and training programmes.

It will be necessary for the group to hold two annual meetings in order to plan activities, exchange information and consult. The WG will also exchange programmes and meet with the other project working groups at the regional and national level to incorporate ideas generated by them into the MPA plans.

Another aspect of regional networking is the establishment of a regional network of MPA specialists in MPA planning and management. An inventory of MPA specialists will be compiled to create a forum of experts covering most relevant fields. The forum will have regular meetings and an established roster of regional MPA consultants. Interactions and information exchange will be facilitated through an established web-site at PERSGA headquarters.

Enhancement of Human Capacities for MPA Management in the Region

Emphasis on capacity building and human resources development is of pre-eminent importance for the establishment of the network since it entails presence of trained managers, support personnel and rangers on MPA sites throughout the region. The first step is to conduct a region-wide training-needs assessment in relation to planning and management of MPAs based on a review and assessment of national and regional institutional needs in the field of MPA. Following the assessment a training and exchange programme, with full involvement of the WG, will be designed to upgrade capacities in various aspects of management of MPAs. Training will, generally, cover the following:

- Training courses, one basic and one advanced, in MPA management, marine and coastal survey and monitoring, and marine ranger's duties. These courses will be held at various sites in the Region, partly building on the experience of existing MPAs.

- Exchange programmes and study visits among MPAs for current and proposed M PA managers, scientists and rangers in different countries of the Region. The programme visits should be crisscrossed among the developed, developing, undeveloped and proposed MPAs.
- Formal overseas professional MPA training to selected candidates, as recommended by the programme, who are willing to work in MPA management.

Organization of regional workshops on various aspects concerning MPA will contribute to the enhancement of capacities. MPA specialists will, also, regularly join workshops on related subjects organized by other components of the project.

Development of a Regional Master Plan

To establish a Network of Representative Marine Protected Areas in the Red Sea and the Gulf of Aden (RSGA) Region, there is a need to develop a Regional Master Plan that agrees with international guidelines and incorporates regional environmental and socio-economic conditions. Experience and lessons learnt from existing MPAs in the Region will supplement its development. In addition, public consultation involving all stakeholders in the region (local communities, fishermen, tour operators, government authorities and mass media) will be arranged. The Regional Master Plan will act as a template and will provide a broad framework to be adapted into site-specific management plans for the MPAs earmarked for development in the region. Presentation of the plan to future MPA managers and scientists in a workshop will enhance their MPA management capabilities and draw much-needed feedback from them in the form of first hand regional information during the deliberations. Moreover a workshop will be held in Ras Mohammed Marine Park, the only fully operational MPA in the region, which facilitates maximum opportunities for incorporation of the experience there into the Master Plan.

Development of Site-Specific Master Plans

Some of the countries representing the RSGA Region do not have management plans for their MPAs or lack the experience in developing and implementing them. Regionally standardized Site-Specific Master Plans will be developed for Iles des Sept Frères (Djibouti), Aibat and Saad addin Islands (North-West Somalia), Mukkawar Island and Dungonab Bay (Sudan), Sanganeb (Sudan) and the Belhaf-Bir Ali Area (Yemen). Initially, a programme for detailed surveys and monitoring will be designed. During the process of designing the survey and monitoring programme a few future managers and scientists will be trained. The programme will include surveys and monitoring of key habitats, biodiversity and resource use.

Secondly, a trained regional team under the supervision of an expert and based on survey methodologies prepared by the SAP, will conduct detailed habitat, biodiversity and resource use surveys at four selected sites, which lack current information - Djibouti, northern coast of Somalia, Sudan and Yemen. Consultation of local stakeholders on their views on management should continue throughout the process. Surveys of Socotra in Yemen, Ras Mohammed in Egypt and Farasan in Saudi Arabia will be covered by other projects and Sanganeb in Sudan has already been studied. Some of the surveys will be carried out in association with other project's components, i.e. Habitat and Biodiversity Conservation and Sustainable Use and Management of Living Marine Resources. Moreover information (i.e. GIS and stock assessments) generated from these components will be incorporated into the MPA management plans. Workshops will be held at the national/local level to present the results of the surveys and to review the site-specific plans. Relevant recommendations will be incorporated in the final plans.

Site-Specific Master Plan for each site will be a long-term policy documents that include short and medium-term management plans which define the everyday activities in the MPA. The regionally standardized format for all procedures and activities developed in the Regional Master Plan will be used as a template for developing the site-specific management plans. Revision of these plans will take place as frequently as the monitoring programme results demand. Development of site-specific management plans is considered key not only to the implementation of the MPA component during the lifetime of the project but also to the future management and sustainability of them. Therefore, the activity will be carried out in conjunction with intensive training programmes in MPA issues adjusted as necessary to local needs, for all concerned parties within the participating countries.

Legislative Process and Governments Commitment

To complete the legislative process for declaring proposed MPAs in the RSGA Region meetings will be organized in Somalia, Djibouti, Yemen and Sudan to review and evaluate the current framework for MPA declaration and management. The legal processes for designation of new MPAs of regional priority (proposed areas only) will be initiated by conducting dialogue with designated national authorities and by providing necessary support to facilitate such a process of declaration. Stakeholders are involved in all stages of MPA declaration and consents from respective partners are sought in an equitable manner.

Finalization of the legal process will be achieved by getting the necessary approval/decree for the concerned MPAs and they are declared and reported in national gazettes. It is of the regional interest to adopt the World Conservation Union (IUCN) Protected Area Categories and governments are encouraged to incorporate them in their legal systems. This will facilitate global collaboration and ease updating in the future.

The MPA component is designed in such a way that experience gained during this regional exercise will permit each country to introduce conservation management to the full set of its national MPAs. Governments are expected to express commitment towards the success of the whole project and the sustainability of chosen territorial MPAs on the one hand and the regional network on the other. One of the key priorities is the strengthening of the legislative and administrative frameworks in order to have the legal instruments ready for the consequent decree of declaration of MPAs. The regional dimension should clearly manifest itself in government procedures and preferably be promulgated in national laws and regulations. Regional governments are also asked to release Working Group/National Specialists members whenever contribution is needed from them. Trainees for MPA training are selected by government agencies according to motivation and proficiency, they will be timely released and maintained in their jobs during the project's lifetime.

Implementation Arrangements

To carry out surveys basic equipment such as cars, boats, diving gear and other survey material will be provided in Somalia, Yemen, Djibouti and Sudan as part of the overall support intended to sustain management activities in MPAs of these countries. For the implementation of the site-specific master plan and management plans a review of required resources for enforcement of regulations at existing priority MPAs is to be carried out and necessary basic equipment, facilities and on-the-job-training will be provided.

Involving stakeholders in, for example, policy decisions, daily activities and budget allocation will introduce a participatory approach to MPA management. Tour operators may decide on the best diving sites and assist on applying sustainable recreational practices. On the other hand, local communities may help in enforcement of laws and regulation

In collaboration with the Public Awareness and Participation Component, programmes for awareness and participation are to be developed for the various target groups at each site. In consultation with the other groups and in the context of respective management plans aspects these programmes should also highlight the regional importance of the Network.

Self-financing strategies for MPAs throughout the region may be explored to determine suitable approaches for each MPA. Among these is the suggestion and test of an eco-tourism plan as a sustainable income generating activity to supplement allocated budgets covering costs of running the MPA.

A pivotal mechanism for the success of the regional network at the local level is the provision of alternative livelihood for the local communities that are affected by the conservation activities taking place in their homeland or the neighbourhood. Local fishing communities at Saba Wanak (northern coast of Somalia), Iles des Sept Frères (Djibouti) and Dungonab (Sudan) will be provided with alternative livelihoods, including alternative housing and fuel and revenue from eco-tourism.

For the integrity and sustainability of the network, long-term monitoring activities should be carried out to check progress and impacts of the Management Plans at each site and propose adjustments where needed. Further actions for the effective implementation of the Regional network involves establishment of a central database at PERSGA to link MPAs of the network and incorporate them as nodes within the Organization's GIS. Supplementary funds should be sought out to provide for communication equipment (computers and Internet/e-mail access), as these are essential prerequisites for networking and linking of the regional MPAs.

Conclusion

In maintaining the established Regional Network of Representative Marine Protected Areas a set of priorities have to be taken into consideration. First, under the leadership of PERSGA, a series of regular review meetings will be held to exchange data, information and management experience among MPAs managers. Second, to allow easy access to information and efficient information exchange, copies of management plans, maps and other relevant documents for all regional MPAs will be deposited at PERSGA. Third, bilateral and multilateral agreements between countries of the Region are encouraged by PERSGA in order to establish and promote exchange of information, expertise and equipment to meet common goals.

Table 1: Sites suggested forming a regionally representative network of MPAs

No.	Country	Protected area	Year of declaration	Management/ Projects	Priority
1	Djibouti	Iles des Sept Frères and Ras Siyan	Suggested	None	Regional
2	Egypt	Ras Mohammed National Park	1992	High, supported by EU project	Regional
3	Egypt	Giftun Islands and Straits of Gubal	Proposed	GEF-Egypt and EU projects	National/ Regional
4	Jordan	Aqaba coral reefs	Proposed	GEF-Jordan project	Regional/ Global
5	Saudi Arabia/ Egypt	Strait of Tiran	Proposed	None	Regional
6	Saudi Arabia	Wajj Bank, Sharm Habban and Sharm Munaybirah	Proposed	None	Global
7	Saudi Arabia	Farasan Islands	1996	Terrestrial: high Marine: low	Global
8	Somalia	Aibat and Saad ad-Din Islands, Saba Wanak	Suggested	None	Global
9	Sudan	Sanganeb Marine National Park	1990	Low	Global
10	Sudan	Mukkawar Island and Dungonab Bay	Proposed	None	Regional
11	Yemen	Socotra Islands	1996	GEF-Socotra biodiversity project	Global
12	Yemen	Belhaf and Bir Ali area	Proposed	None	Regional

Contribution of Africa's Coastal and Marine Sectors to Sustainable Development[a]

By: Eric Odada[b]

Abstract

More than half of the world's population lives within 60 km of the shoreline, and in Africa trends in population growth indicate that this figure could rise to three quarters by the next century. The lives and reasonable aspirations for economic advancement of these coastal residents are inextricably linked to the productivity of coastal and marine resources. The coastal areas bordering the African continent have traditionally supported highly productive ecosystems from which fish and other aquatic resources have been harvested. Furthermore these natural systems provide valuable services in terms of recreation, tourism, transportation in addition to their natural protective functions against coastal erosion and flooding. Unfortunately, in many parts of the region, most of the natural resources are over-exploited and the fragile coastal and marine systems severely degraded by unregulated human activities. As a result, the productivity and usefulness of these coastal and marine areas have dramatically diminished and the prospects for sustainable development are greatly jeopardised.

There are a number of reasons for this serious situation. In general there is lack of knowledge and understanding of the coastal and marine resources and their interaction with terrestrial and oceanic processes. This lack of information and awareness, together with ineffective coastal and marine planning and management further aggravated the situation. In this paper, the present status and trends of coastal and ocean development in the African region are examined. The existing capacities in the region to implement sustainable development strategies are also assessed.

1. Introduction

Coastal and marine areas are uniquely situated to support a variety of activities and to serve diverse human needs for food, transport and recreation. Ninety per cent of the world's fish catch comes from the continental shelf and upwelling regions. Again, about 20 per cent of the world's oil production comes from offshore areas and it is estimated that about 70 per cent of the world's ultimate recoverable hydrocarbon resources lie in coastal waters 200 metres in depth or less. Finally, the coastal area is a source of many other raw materials in the form of sand, gravel, and a variety of placer minerals such as diamonds. Coastal areas are, therefore, an integral part of the development process in a large number of countries.

The Eastern African coastal and marine areas for example, have some of the world's richest ecosystems containing extensive coral reefs, lagoons, estuaries and mangrove forests. The seashores of Somalia, Kenya, Tanzania and Mozambique are extremely rich in marine habitats and sheer numbers of marine plant and animal species. Economic benefits derived

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from the coastal and marine environments are essential for a large part of the population in the countries of the sub-region. These coastal and marine environments provide coastal population and communities inland with essential requirements in life such as food, building materials, firewood and many other vital resources.

The west and central African coastline, stretches for approximately 8,000 kilometres and is characterised by marked diversity. The climate ranges from desert in the north -the Sahara - through a humid tropical belt, which contains two of Africa's largest rivers, the Niger and Congo, to desert again in the south - the Kalahari. The coastal zone shows equal diversity, ranging from dunes through marshy delta lands and mangroves to Rias with steep Cliffs. The continental shelf also varies markedly in width from approximately 70 kilometres in the Gulf of Guinea to about 4 kilometres off Angola and Zaire. Equally, the countries that make up the sub region differ markedly, from small island states like Sao Tome and Principe to large mainland countries like Nigeria and Senegal. Their state of development also differs. Some have economies based essentially on handicraft and subsistence farming, whereas others have quite well developed industries.

The pressures from rapidly growing populations in coastal areas of the African region, expanding coastal tourism, intensified fisheries and a large number of other economic activities, however, pose an increasing threat that jeopardises the quality of these coastal environments. Large-scale destruction of some of Africa's most valuable resources, the coastal forests and mangroves, the lagoons and the coral reefs has caused serious degradation of the environment, thus affecting the life of the coastal inhabitants and the economic development of the countries in the region. The Seychelles Island in the western Indian Ocean for example, was famous for its luxuriant forests and an incredible abundance of wildlife. But many reefs have been mined for coral for the purpose of construction. Mangrove forests on the granitic islands have been raised to the ground or drained and reclaimed. Severe erosion is a result of this destruction.

There is general lack of knowledge and understanding of the coastal and marine resources and their interaction with terrestrial and oceanic processes. This lack of information and awareness, together with ineffective coastal and marine planning and management further aggravate the situation.

The objective of this paper is to provide background information on the present status and trends of coastal and ocean development in Africa and on the existing capabilities in the region to implement sustainable development strategies.

2. Coastal and Marine Issues in Africa

The African marine environment is influenced by unregulated human activities on land and the changes can be viewed as taking place in a series of concentric circles - in the centre, desertification; towards the coasts, deforestation; on the coasts, erosion and pollution of the beaches; on the high seas, over-exploitation of marine resources, dumping of toxic and hazardous wastes and oil spillage. As the population increases, the African coastal and marine environments are assuming greater importance - hence the growing realisation that they need to be protected from pollution, coastal erosion, and overexploitation of marine resources.

2.1 Rapid Population Growth

The coastal areas of a number of countries in the African region are coming under increasing pressure as a result of population increase and expansion of economic activities such as agriculture, industry, tourism and infrastructure development. Lagos with upwards of 8 million people and 85 per cent of Nigeria's industry, and Accra-Tema with 60 per cent of

Ghana's industry are good examples. In Eastern Africa for example, a total of about 83.9 million people live in the coastal zone. The mounting concentration of people on the coasts of Africa for example has led to substantial increases in the volume of sewage and effluent being discharged into the nearshore waters - most of it untreated or only very slightly treated. With sewage discharge taking place in this way there is obvious risk to human health through water contact and through the consumption of seafoods, which might be contaminated by sewage organisms. This potential problem seems to have received little attention in the region, although sporadic outbreaks of human diseases attributed to contact with faecal remains on beaches have been reported (UNEP, 1984). Thus rapid growth of population is an urgent problem to be addressed in affecting development in coastal and marine areas of the African region.

2.2 Sea Level Rise

The African coastal zones along the Atlantic and Indian Oceans have been more and more vulnerable to sea level rise and other impacts of climate change. The coastlines of the eastern African sub-region for example, have been retreating inward and seaward as a result of the rise and fall in sea level due to past climate change (Odada, 1991). According to the estimate of the WMO/UNEP Intergovernmental Panel on Climate Change (IPCC), an average rate of mean global sea level rise could be about 6 cm per decade over the next century. This means that the total sea level rise could attain as much as one metre in a century. In such a case, hundred of thousands square kilometres of coastal wetlands and lowlands in the African region could be inundated. African beaches could retreat as much as a few hundreds metres and prospective structures may be breached. Flooding would threaten lives, agriculture, livestock, buildings and infrastructure. Salt water would advance landward into aquifers and up estuaries, threatening water supplies, ecosystems and agriculture in coastal areas of the African region. Given the near certainty of an accelerated rise in sea level, the only hope left for the African governments to avoid future chaos is through anticipatory planning and actions.

2.3 Development of Coastal Areas

A number of development activities are leading to major changes in coastal areas of the African region. The most obvious of these are the construction of towns with associated industries and the creation or extension of ports and harbour areas. Although these are confined to a few locations they are frequently close to areas that could be exploited as tourist centres. For example, at Lagos in Nigeria, Victoria Beach has been eroded 2 kilometres inland since the construction of breakwaters. Similar problems were created at the Port of Abidjan when the Canal de Vridi was opened in 1950; since then the beach has eroded to the east of the canal and a road cuts through the area.

New or rapidly growing coastal zone activities often lead to the creation or rapid expansion of municipal centres on the coast. When such rapid expansion occurs, it is extremely difficult for national or local authorities to respond by planning for and providing infrastructure and social services. In Malindi, Kenya for example, the growth of a large tourist-related section has occurred at a traditional small municipal centre with extremely limited services and infrastructure. Population growth rates have reached 20 per cent per annum, and authorities are hard pressed to meet basic needs for sanitation, education, and commercial organisation. Similar situations do arise wherever new coastal zone activities stimulate extremely rapid growth in new or small existing municipal centres. The social and environmental effects of such development must be considered and dealt with in economic planning for sustainable development of coastal areas.

2.4 Environmental Degradation

Coastal environmental degradation is a major problem facing many countries in the African region. Sewage and domestic and commercial discharges in the vicinity of coastal towns and cities, agricultural waste disposal, sand mining on the coastal strip and coastal and shallow waters; erosion and siltation, overcutting of forest products such as mangroves on the coastal strip and timber forests inland are mainly the sources of pollution from land. Poor agricultural practise, lack of agricultural land especially on the islands, over utilisation, burning, and mismanagement as well as over-exploitation of forest resources have resulted in extensive deforestation and severe soil erosion. This has caused severe siltation with the resultant destruction of coral reefs followed by erosion of the beaches and the destruction of the coastal mangrove and other trees. Examples of this are clearly seen in Madagascar, the Comoros and many other parts of the African region.

Development of ports and harbours, coastal construction such as reclamation for airport construction and dredging of the seabed also cause coastal erosion and especially siltation. There has been considerable work of this kind carried out in the African region in the past two decades and not enough environmental considerations have been given. For example, extensive dredging has been carried out in the Seychelles within the last decade and siltation of the coral reefs within the marine park and along the east coast of Mahe has been severe (UNEP, 1984). In some coastal areas, dynamiting coral reefs as a means of catching fish is widely used. These include Tanzania, Mozambique, and formerly Mauritius, which resulted in serious environmental degradation of their coastal and marine areas.

2.5 Coastal Erosion and Flooding

This is a prevalent problem especially in west and central Africa. The degree of seriousness of the problem and the attempts to mitigate the nuisance and negative economic consequences vary. Retreat of the coastline with the concomitant flooding causes hazards by uprooting settlements, destroying agricultural and recreational lands, disrupting harbour and navigational structures and dislodging economic facilities located along coastal towns (Ibe and Quelennec, 1989). Natural factors for erosion include: storm wave regime with 'sea level set-up, orientation and nature of the coastline, low relief of the coastal plain, vulnerable sediment budget, narrowness of the continental shelf, presence of off- shore canyons and gullies, global estuatic rise in sea level, etc. In many cases, man's intervention in the natural environment has served to exacerbate the impact of natural forces. The Seychelles Island in the western Indian Ocean for example, was famous for its luxuriant forests and an incredible abundance of wildlife. But many reefs have been mined for coral for the purpose of construction. Mangrove forests on the granitic islands have been raised to the ground or drained and reclaimed. Severe erosion is a result of this destruction. There is, therefore, an urgent need to react timely and appropriately to coastal erosion and flooding problems in the African coastal areas. (compare also Akumu and Heidenreich, 1993).

2.6 0il Pollution

Marine Pollution, especially from oil spillage, is a major regional problem and is often aggravated by leakage due to accidents, grounding, harbour operations and discharges from refineries. With the increasing number and size of tankers travelling through the Indian Ocean for example, fear of oil spills has also increased in the Eastern African sub-region. In 1981, 3551 million tonnes of oil were transported through the main route from the Arabian sea to the Far East. Tankers discharge operations in the sub-region are accident-prone and many such accidents have been reported in Mombasa, Maputo and Dar-es-Salaam where

large areas of mangrove forests were completely destroyed. Oil refineries are found in most parts of Eastern Africa, which significantly contribute to oil pollution of the coasts and seas.

The West and Central African sub-regions export oil to Europe and America. The coastline lies to the east and is downwind of the main route of oil transport from the Middle East to Europe. Much of oil found on beaches arises as a result of spills or tank washings discharged from tankers visiting ports in the region although other sources are also important (Portmann et al. 1989). Investigation of pollution in the Ebrie Lagoon (Ivory Coast) by Marchand and Martin (1985 cit. in Portmann et al. 1989) produced a wide range of concentrations of total hydrocarbons in the lagoon sediments (1000-24000mg/kg). The highest concentrations were associated not with shipping but with industrial and domestic sewage discharges. However, a spill of 400 tonnes of oil at a refinery in 1981 was still clearly detectable at the time of their survey in 1983 (Portmann et al. 1989). There is, therefore, an urgent need not only for the development of national and regional contingency plans to combat oil pollution especially in cases of emergencies, but also for monitoring the levels and effects of pollutants in the Eastern and Western African coastal and marine areas.

2.7 Coastal Tourism

The people of Africa have for a long time been associated with visitors from the Arabic and Persian nations, Europeans, and other distant lands. They are friendly and attractive with captivating life styles, customs and traditions, food preparation styles, costumes, and artistic expressions. In addition, the coastline of the African region is an area of great physical beauty, rich in living resources. In the Eastern African sub-region for example, Palm fringed beaches of white coral sand lead down to tranquil lagoons enclosed by spectacular coral reefs with their wealth of colourful fish, shell and corals. For many countries in the sub-region, coastal tourism is one of the most important sectors of their economies producing foreign exchange.

Although available evidence suggests that before the 1980s, the growth of tourism in Africa occurred without significant deterioration in the fragile coastal ecosystem, this is, rapidly changing (Odada, 1993). The impacts of tourism on both social and cultural as well as on the natural environment are causing serious concerns in the sub-region. To ensure that the importance of the tourism industry is maintained in the economies of the African countries, there is need to develop and maintain environmental policies to govern the industry. Protection and conservation of tourist attractions must be observed through the formulation of sound laws and regulations governing tourism, especially in the Eastern African sub-region, and elsewhere in the African coastal areas.

2.8 Coastal Agriculture

Agriculture is the main stay of the economy of most African countries. Agriculture contributes between 30 to 60 percent of their GNP and the majority of the population depends on it for their livelihood. In most African countries, the land that is available for agriculture is shrinking because of the use of the same land for non-agricultural purposes such as residential accommodation, industry or roads, and also due to loss of good agricultural land through soil erosion, salinisation and modification. As a whole, the net land resources available for agriculture are diminishing while population and therefor food demand is rapidly increasing in the African region.

The expanding agriculture is having undesirable effects on coastal zone and marine habitats due to erosion related to deforestation and unwise agricultural practises prevalent in the countries of the region. In Kenya, silt from rivers is affecting catches of fish, smothering

coral reefs and is sulling beaches with serious consequences for fishing and tourism. The effect of pesticide pollution on marine life are now becoming apparent in many countries of Africa and are absorbed into living organisms. The health of humans is threatened by these toxins reaching them through the fish they eat (UNEP, 1989). It is imperative, therefore, that soil conservation measures must be instituted particularly where agriculture is being developed in the coastal areas.

2.9 Over-Exploitation of Marine Resources

In general productivity of African coastal waters is dependent on the extent of the continental shelf, coastal upwelling, mangroves, coral reefs, and run off from rivers. Fisheries in the countries of the region reflect the availability of these physical characteristics. The relatively extensive continental shelves of Madagascar and Mozambique for example, support lucrative shrimp fisheries, while the absence of such areas in island countries make them depend on offshore tuna resources. Shrimp and tuna are the main commodities supporting export ventures in the Eastern African coastal sub-region. For west and central Africa, the total annual catch of fish in coastal zone is estimated to be about 2.6 million tons per annum (FAO, 1987) and about 10 per cent of the coastal population engages in some form of fishing activity. Fish, shells, beche-de-mer, dugongs and turtles are, however, all subject to over-exploitation on a massive scale especially in many parts of Eastern and Western Africa, where agricultural land is in short supply and food is scarce. The over-exploitation is due in part to burgeoning human numbers coupled with a shortage of land-based jobs. Therefore, solutions need to be found to this depletion problem that escalates as populations grow in Africa.

2.10 Institutional and Administrative Limitations

The institutional and administrative capacities of the different countries for coastal and marine resources development vary widely in the African region. It ranges from countries with virtually no capabilities to those with a growing capacity and considerable resources. There are however, two broad categories of the African coastal states as regards their present level of institutional and administrative capabilities. The first category includes countries like South Africa, Nigeria and Egypt, which already have good infrastructure for the development of coastal and marine areas and where the governments are well aware of the importance and crucial role of coastal and marine resources in the development of their economies. These countries have appropriate research and training institutions as well as other facilities so that they count with qualified national personnel to undertake an integrated management of coastal and marine areas.

The second category includes countries like Benin, Gambia and Djibouti which for various reasons are at a low stage of oceanographic development, where there is not as yet any substantial infrastructure for the development of coastal and marine resources, in the way of research and training institutions and other facilities, and where there are great shortages of trained manpower. In general, the present level of institutional and administrative capacities of practically all African coastal states is low, and far from adequate in providing a sound and sustainable base for the rational exploitation of coastal and marine resources of these countries. Thus, institutional and administrative capacity building in ocean affairs should be a top priority in the African region.

3. Capacity for Addressing Coastal and Marine Issues

In general, in the African region, environmental values and natural resources factors have not always been integrated into national development plans. Development decisions and

social trends appear neither to have minimised environmental degradation nor to have optimised the value obtained from using natural resources. Industrial expansion has often been carried out at the expense of the environment. Economic and social development, both in cities and the countryside, has tended to deplete natural resources and damage the environment and amenities. Institutions to promote environmental and resource values and to assure that they are taken into account in the governmental decision-making are just being created in some countries the region.

3.1 Environmental Policies

The general situation with respect to the environment and relationships to national development and the expansion of human settlement is exacerbated in the case of coastal development. The states of the region have not by and large developed explicit policies relating to coastal and marine related development. Environmental concerns have not played a significant role in the development of the coastal and marine areas of the sub-region. Very little efforts has been expended in incorporating socio-environmental concerns in development planning and though widespread problems have generally been discerned in the coastal and marine areas, they have generally been shrugged off as being an inescapable part of the development process. In the African region as elsewhere, the dynamic and, interactive nature of coastal and marine resources has meant that absence of adequate planning and management in these areas has been magnified in its effect on marine resources. Disturbing and perhaps irreversible trends are beginning to appear, some in connection with activities practised outside the coastal zone. The marine and coastal aspects of these problems must therefore, be effectively incorporated into national policy and decision-making.

3.2 Legislation and Environmental Law

Many countries in Africa have formulated regulatory measures for their resources management in coastal and marine areas such as the issuance of permits for fishing, logging and mangrove harvesting. However, most of these measures have proven ineffective. Increasingly, the countries of the region are enacting more comprehensive environmental laws that can provide practical frameworks at the national level to implement environmental standards and to regulate activities of enterprises and people in the light of environmental objectives. At the international level, conventions like the Law of the Sea, protocols and agreements such as the UN-EP Regional Seas Programme have been providing a basis for co-operation between countries at bilateral, regional and global levels for the management of environmental risks, control of pollution and conservation of natural resources in coastal and marine areas. There is an urgent need for the African countries to expand the accession to and ratification of these conventions and institute mechanisms at the national level to ensure their application.

3.3 Coastal Zone Management

In the African region a few countries are in the process of developing management plans for their coastal and marine areas. The Seychelles for example, initiated in 1992 a plan for coastal zone management under the UNEP Eastern African Regional Seas Plans. The objectives of this project are to prepare on inventory of the coastal and marine species, the state of coral reefs, mangroves and lagoons, to assess the extent, nature and causes of coastal and marine pollution and also to identify policy and remedial actions. The project components include training, institutional capacity building, workshops, provision of

laboratory equipment, etc. It is managed from the Department of Environment that was created in June 1989 under the direct leadership of the President of the Seychelles to solve the environmental problems that stem from a general increase in the population and the rapid development of the island. (Compare also Young, 1993 and Chua & Scrua 1992).

Tanzania is, as yet, only in the preliminary stages of the development of an integrated coastal zone management programme. In 1991, however, the country began the process of creating a protected area, to be known as the Mafia Island Marine Park (MIMP). This marine park will protect the last pristine coral reef ecosystem found in Tanzania's coastal waters - an area that is important as an economic resource upon which a significant coastal and island population group is quite dependent. The Tanzania government perceives that this project will serve as a preliminary or pilot project providing basic interaction and approaches for the development of Tanzania's integrated coastal zone management.

Uni-sectoral over-use of some coastal and marine resources has caused grave problems. For example, indiscriminate harvesting of mangroves might have brought large economic benefits to those countries in the Eastern African sub-region, but have proven detrimental to fisheries, aquaculture and coastal region tourism. Similarly, unregulated fishing efforts and the use of destructive fishing methods such as dynamiting have destroyed fish habitats and reduced fish stocks. Some African countries have formulated regulatory measures for their resources management such as the issuance of permits for fishing, logging and mangrove harvesting, However, most of these measures have proven ineffective due partly to enforcement failure, but mainly to lack of support from the communities concerned. There is, therefore, an urgent need for an integrated interdisciplinary and multi-sectoral approach in developing management plans for the coastal and marine areas of the African region.

3.4 Institutional and Administrative Limitations, Research and Training

Practically all African coastal states are at present making only minimal use of their coastal and marine resources owing to limitation in the necessary scientific knowledge and technological know-how and to the lack of efficient organisational and administrative machinery. For example, the shipping and navigation services, which are so vital for the management, control and exploitation of marine resources and for the development of international trade, are still very much in their infancy in most African coastal states. Marine technology is also very much underdeveloped in the region. In very few of African countries are there marine technology training centres with comprehensive programmes of marine technology - marine engineering, fishing and fishing gear, boat building and repair, navigation, instrumentation repair and maintenance (including electronic equipment), fish processing and preservation, economics and marketing. Thus, the development of sound training and research programmes and their effective linkages with the production system, are basic and most important steps towards enhancing the capability of African States to make full use of their coastal and marine resources.

3.5 Basic Marine Science

With regard to manpower the situation is similar. Although the majority of African countries now have national universities and other institutions of higher learning of their own, most of these institutions are young, and many are still facing teething problems concerning adequate staffing, adequate equipment, sound curriculum development, etc. In many of these countries, therefore, the universities are still grappling with the fundamental issues of producing adequate manpower for the vital organs of the civil service requiring high-level personnel, such as public administration, school education, public health and agriculture. It is understandable, therefore for the universities in these countries to be pursuing for the

present, narrow crash training programmes with the objective of producing high- level manpower badly needed in key areas of- the civil service.

4. Measures for Integrating Coastal and Marine Areas into Sustainable Development Strategies

Under Agenda 21, coastal states should "commit themselves to integrated management and sustainable development of coastal areas and marine environment under their national jurisdictions." In order to achieve this four priority areas for African governments can be identified: capacity building, creation of public awareness, policy formulation, and the implementation of effective integrated coastal zone management.

4.1 Capacity Building

Many countries of the African region are confronted with serious manpower problems that are proving to be great impediment in the economic development of coastal and marine areas of these countries. In many cases, the most important cause underlying these problems is the lack of adequate training facilities for the type of manpower required. Since the requirements for high level manpower in certain areas of marine sciences e.g. physical, chemical, biological oceanography, aquaculture, etc. are not so great in terms of numbers needed by any one country at any one time, existing institutions (e.g. universities) in the region suited for teaching and research in these areas should specialise as regional or sub-regional training centres. They can enlarge their facilities to enable the enrolment of students from other member states, wanting to study the subjects of their specialisation.

Oceanographic research should also be carded out on a regional or sub- regional co-operative basis using collectively-operated research vessels which are well equipped and well staffed for all types of oceanographic research and for the on-board training of marine scientific and technical staff. To start with one or two such vessels should be adequate for each of the sub-regions i.e. Eastern and Western Africa. The co-ordination of research on a regional scale, the exchange and dissemination of research information and the storage of research data are important support activities in the protection and development of coastal and marine areas of the African region.

4.2 Public Awareness

The African governments need to increase public awareness through education. The public should be informed of long-term ramification of coastal development. At present the general public is generally unaware of problems associated with the development of coastal and marine areas. In Madagascar for example, the wide beaches which previously attracted many tourists to 'the island have already disappeared. In spite of this, many structures are still being constructed on the eroding beaches. Campaigns should be instituted on a national basis to create greater public awareness of national and regional issues in the protection and development of coastal and marine resources of the African region. Education oriented towards protection and development of marine resources should be provided as part of the ordinary educational curriculum at the primary school, secondary school and university levels. This can be achieved through training of special instructors or specialised training of general educators, as well as through seminars and courses offered to the general public.

In the western Indian Ocean for example, a marine science association has been formed with the secretariat at the Institute of Marine Science in Zanzibar. The aims of the Western Indian Ocean Marine Science Association (WIOMSA) are: (1) to promote and advance the

educational, scientific and technological development of all aspects of marine science in the region, (2) to provide a forum for discussion and dissemination of information and organise meetings, seminars and workshops for the presentation of information, findings and experiences on all subjects related to marine sciences, (3) to encourage the support of marine science research, and the development and educational activities by government agencies and private sector, and (4) to collect and disseminate scientific, technical and other information on marine sciences.

4.3 Environmental Legislation

African states urgently need to review and where necessary expand, update or strengthen national legislation and regulation pertaining to the protection and development of the coastal and marine areas. The enforcement of national regulations related to coastal and marine resources protection and development needs to be improved. Equally there is an urgent need to expand the accession to and ratification of international conventions, i.e. the Law of the Sea, and institute mechanisms at the national level to ensure their application.

For example, groundwork has been prepared over the last two decades under the aegis of UNEP to establish legal framework to manage regional seas. African governments should intensify their efforts to implement legislative measures and other policies at national levels so that the environmental problems of coastal and marine areas are effectively tackled. Governments of the African countries should also be encouraged to settle their marine environmental and other related disputes by peaceful means, making use of the existing and emerging agreements and conventions.

4.4 Management Planning

The value of treating coastal and marine areas as planning entities within the overall framework of national development planning is not always fully recognised in the African region and very often countries lack the administrative and legislative basis for implementing such an approach. To solve these problems, the countries of the African region need to develop an integrated interdisciplinary and multi-sectoral approach in their management plans for coastal and marine areas. Pilot coastal sites can be selected in one or two countries in each sub-region and intensive interdisciplinary planning programme conducted, involving several resources and scientific personnel from various institutions in those countries, including universities, government agencies and non- governmental organisations. In addition, training courses, workshops and conferences should be organised, and publications and educational materials disseminated as part of the integrated coastal and marine resources management planning.

5. Summary and Conclusion

The coastal and marine areas of the African region have some of the world's richest ecosystems that support a wide diversity of plants and animals. The economic benefits derived from these areas are essential for the survival of a rapidly growing population. As in many other coastal zones elsewhere, the balance of the ecosystem is threatened by unplanned industrial development, exploitation of marine resources, shore erosion, expanding coastal tourism, etc. As stated in Chapter 17 of Agenda 21 of the Earth Summit in Brazil, coastal and marine management must play an important role if resources are to be exploited in a way that ensures sustainable development to a growing population.

To implement sustainable development of coastal and marine resources of the African region, there is an urgent need to: (1) build human resources by undertaking short-term and

academic training to strengthen existing capabilities; (2) promote public awareness by producing educational materials on the ecological and socio- economic contributions of the marine resources and the consequences of unsustainable exploitation, (3) organise policy workshops, seminar and/or conferences involving relevant policy and law makers to increase their understanding of and commitment to the sustainable use of the resources in their coastal and marine areas, and (4) implement integrated coastal zone management programmes by establishing case studies in pilot sites in selected countries of the African region.

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IUCN Initiatives Concerning Marine Protected Areas[a]

By: Sue Wells[b]

Abstract

IUCN's World Commission on Protected Areas (WCPA) provides a framework for promoting the development of a global ecologically representative system of MPAs. A review in 1995 showed that the current global network is far from complete, identified many areas of reef for protection, and emphasised the poor management of many existing areas. Much progress has been made since then, but further efforts are required to increase representation of coral reefs, with particular attention being paid to reefs that are sources for larval dispersal and to damaged or bleached reefs that have potential for recovery.

IUCN is also contributing to the improved management of MPAs with revisions of its Guidelines for the Establishment of Marine Protected Areas, and of its 1984 MPA management handbook. An IUCN/WCPA Management Effectiveness Task Force has been established to develop mechanisms and global standards for improving management effectiveness of protected areas. This is largely a forest initiative at present but there are plans to include MPAs. This will require close collaboration between monitoring programmes, such as those of GCRMN and Reefcheck, and national and regional networks of MPAs.

The IUCN Eastern Africa Regional Office is one of a number of IUCN offices that work on MPAs and coral reefs at the regional level. At the national level, specific activities include support to:

- two initiatives in Tanzania (the Tanga Coastal Zone Conservation and Development Programme, and the establishment of Mnazi Bay Marine Park);
- two initiatives in Kenya (development of new approaches to the management and financing of MPAs, with pilot sites at Kisite Marine National Reserve and Diani-Chale Marine National Reserve);
- the establishment of the first marine protected area in the Comoros.

More general work is also underway in other countries in the region that contributes to both coral reef conservation and MPA establishment and management. Current regional activities include assisting countries in the region in the implementation of the Jakarta Mandate and Convention on Biological Diversity, with particular emphasis on the implementation of the Nairobi Convention. IUCN-EARO also collaborates closely with other marine programmes in the region including CORDIO, WIOMSA, SEACAM, and WWF.

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Moving to Large-Scale Marine Conservation: Ecosystem and Global Approaches[a]

By: Llewellyn, C., Atkinson, S. and Cripps, S.J.[b]

Abstract

Supported by strong ecological arguments and driven by a need to achieve greater efficiency in the field, conservation organisations such as the World Wide Fund for Nature (WWF), The Nature Conservancy, Conservation International, and the World Conservation Society are increasingly turning to large spatial landscapes and ecosystems in their strategic programme directions. The increasing awareness of threats such as global climate change and chronic coastal pollution are driving a move towards conservation planning frameworks that: are equivalent in scale; can accommodate relevant biological processes; and can mitigate or compensate for anticipated changes in ecosystems.

The main weakness that has emerged from the classic Marine Protected Areas (MPA) network model is that although policies are passed to establish parks, or networks of parks, there is a lack of infrastructure, support, capacity or, in many cases, lack of political will for effective management; resulting in so-called "paper parks". Often, only a relatively narrow group of stakeholders is involved in the planning process, with the primary dialogue being conducted between the scientists and national planners. This results in a lack of support from local communities and creates difficulties in establishing sustainable management interventions. Another issue is that focusing on Marine Protected Areas as sites of intervention does not necessarily produce a net conservation gain for the country, but may simply result in "threat displacement" to areas outside the park's jurisdiction, and also takes little account of tradition or voluntary conservation areas.

In recognition of the importance of all these elements, WWF has developed their version of Ecoregion Based Conservation (ERBC) as an approach to achieve greater conservation effectiveness over large areas and at longer time-scales. The core elements of ERBC are to develop partnerships and involve as broad a range of stakeholders and conservation actors as possible in the formulation of an Ecoregion Action Plan and Conservation Strategy. The foundation of ERBC in any area is an ambitious long-term Biodiversity Vision, designed by scientific and local experts, which underpins, guides and informs subsequent planning decisions. It is hoped that by bringing a wider range of stakeholders to the table to formulate policy relating to conservation, there will be a greater will to enforce and comply with the policy framework.

At the global level, there are relatively few institutional or policy instruments to improve the effectiveness of coral reef conservation. As global issues, such as climate change and coastal pollution, emerge as chronic threats to coral reefs there is a need for a greater lobby within global political forums to mitigate these impacts and provide leverage on governments to increase allocation of resources and improve effectiveness of coral reef conservation efforts.

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WWF has a broad network of on-going coral reef conservation projects around the globe and has considerable experience in addressing reef resource and protected area management issues. In order to provide a learning forum within the organisation, and a platform for WWF and partners to address issues of global concern WWF is launching the CoralWeb initiative which aims to examine policy issues relating to coral reef conservation at local, national, ecoregional, regional, and global levels, and to promote best practices and policy solutions built from experience of WWF and partners in the field.

1. Background

1.1 Historical development of large scale marine conservation frameworks

During the 1960s and 1970s there was increasing recognition and concern about the environmental problems of the marine living resources of the world. In 1972, UNEP established the regional Seas Programme to address problems on a regional basis and in 1975, IUCN conducted a conference in Tokyo on MPAs, which called for the establishment of a well-monitored system of MPAs representative of the world's marine ecosystems. In 1982, the IUCN Commission on National Parks and Protected Areas (CNPPA) organised a series of workshops on the creation and management of marine and coastal protected areas, as part of the 3rd World Congress on National Parks in Bali, Indonesia. One of the results was the IUCN "Orange Book" – Marine and Coastal Protected Areas: A Guide for Planners and Managers, (Salm and Clarke, 1984), which has since guided the development of marine and protected areas around the world.

The design principle of most current marine and terrestrial protected areas systems are rooted in the notion that biogeographic regions should first be identified and a representative reserve system (in terms of habitats and species) should be established in each. The science behind this is rooted in the dominant conservation themes of the 1960 & 70's and technical considerations are largely based on the equilibrium theory of island biogeography (Diamond 1975; Goeden 1979), as articulated in the 1980 World Conservation Strategy, which were adopted in the World Conservation Strategy (IUCN/UNEP/WWF 1980). Conservation planning and policy approaches call for a strictly controlled sanctuary zone, or core area above a calculated critical minimum size. This period of policy development coincided with the application of the theory of island biogeography to nature reserve design, the Single Large Or Several Small (SLOSS) debate, and associate discourse on Minimum Viable Populations.

MPA-planning generally follows the guidelines laid out by Salm and Clarke (1984) and more recently "Guidelines for Establishing Marine Protected Areas" (Kelleher & Kenchington, 1991). These concepts contain clear guidelines for choosing priority sites for protection.

1.2 Current issues

In the twenty years since the basic theoretical framework for protected area planning was laid down, there have been several developments in marine conservation science thinking, many of which remain unresolved. Critical among these are the following: 1) the role of larval ecology, connectivity and dispersal in governing recruitment patterns among habitat patches; 2) disturbance, patch dynamics and the degree to which marine communities are stochastic assemblages or predictable successional sequences; 3) keystone species and the existence of multiple-stable states; 4) climate change impacts; 5) extinction risk in marine systems; and 5) resilience and refugia in the marine realm. Our understanding of ecological processes in the ocean is still in its infancy and it is clear that significant targeted research is still required to address these issues. Increasing evidence points out the need for co-ordinated networks of protection over large areas and the move to more landscape oriented approaches in order to maximise effectiveness (Simberloff, 1998).

Conservation approaches have also changed significantly since the establishment of the first marine reserves. Rather than focusing on strict enforcement of small numbers of sanctuary areas, efforts have moved towards integrated management through zoning schemes and greater involvement of local communities in co-management and community based management scenarios. Unfortunately, there does not appear to be any single solution that guarantees project success and WWF is currently piloting a number of approaches and intervention. At a global scale, there is also the realisation that conservation organisations order to maximise effort and results from the limited resources available.

Over the last 30 years a variety of spatial frameworks have been used to guide conservation action at the global scale. The goal of these 'planning' frameworks is to provide a basis for selecting and designing protected area systems. In the last five years, several new theoretical schemes have been published, including the first exclusively marine global conservation spatial planning systems. The new schemes include the ecoregional approach, developed and advocated by WWF-US (Dinerstein *et al.* 1995, Olson & Dinerstein 1998), the Large Marine Ecosystems (LMEs) approach, and the IUCN Commission on National Parks and Protected Areas' (CNPPA) map-based description of 'World Marine Regions' (Kelleher *et al*. 1995). The three new spatial marine conservation planning schemes mentioned above represent three different philosophical approaches. The IUCN World Marine Regions follows the traditional approach of defining spatial biogeographic divisions and then selecting representative habitats. The Large Marine Ecosystems (LMEs) approach focuses on 'trophically linked' areas of ocean, and as such is a more 'system' based approach. WWF Ecoregions place greater emphasis on spatial arrays of habitats rather than on biogeography, but have a loose definition that includes communities linked by dynamics and environmental conditions. In the marine realm this can also be interpreted as moving towards more functionally linked groupings. It is important to note however that the focus of the LME is regions of 'ocean space' (and presumably control of fisheries through regulations), whereas the focus of the ecoregions is 'habitats' and their resources, and their protection via 'Protected Area Networks'.

Given the connectivity, lack of clear biogeographic boundaries and widespread geographic representation of many genetic communities, a system or seascape approach may be more appropriate for MPA planning. It has been anticipated that marine conservation will move towards focusing on preserving key ecological processes (Agardy 1994). Ecoregions and the notions of LMEs, are clear steps towards spatial planning units that emphasise linkages and shared ecological processes, and may herald a general move towards a systems based framework of grouping marine ecosystems and habitats.

1.3 Policy required to support national MPA frameworks

Following the IUCN model, the historical approach to establishing national or regional networks of MPAs is to select a network of representative sites based on scientific assessment, and then have the relevant government agency provide enabling policy instruments for enforcement and management. Regulations governing management of individual protected areas are typically based on approval of a zonation plan, drawn up to provide for multiple-use, and which typically includes a core sanctuary zone large enough for effective replenishment of communities based on island biogeograhic theory. Within such a planning framework, the most relevant policies are those that provide for enforcement of zonation plans and use restrictions within individual parks. Typically park management regulations and protected area status are legislated individually. Designation of additional sites or change of status of a site is typically done as the result of national reviews or lobbying efforts targeting the relevant national government agency.

Commonly reported problems with existing legislated marine protected areas management plans include the following:

- Lack of flexibility to respond to new threats
- Unclear mandate for implementation of enforcement measures
- Terminology too vague and too easily open to misunderstanding and reinterpretation
- Conflicts with existing regulation from other government agencies
- Zonation schemes too complex and lack of clearly identifiable boundary markers leads to confusion
- Lack of incorporation of local stakeholder issues

General issues that have emerged that indicated how individual national policies relating to MPAs could be improved, include the following:

- Policy shortfall in terms of creating incentives for enforcement.
- Policies that support and provide incentives for innovation and excellence in management.
- Greater decentralisation for individual parks.
- Greater transparency and accountability for management decisions by park staff.

1.4 Gaps and needs with emphasis on policy: how to avoid networks of paper parks

In many cases, the problems with respect to government policy relating to marine protected areas are not the policies *per se* but rather the lack of enforcement of those policies. Many countries have a comprehensive policy framework for the management and regulation of individual MPAs within a well-designed national network of protected areas, yet few if any of the parks enforce or implement these policies, resulting in a network of 'paper parks'. Commonly cited problems include a lack of funding, lack of sufficient staffing and management capacity, and lack of infrastructure and equipment such as patrol boats. Problems such as these can be alleviated in the short-term, by partnering with a conservation-NGO that can provide the necessary training and equipment. In order for management to be sustainable in the long-term more serious issues need to be addressed such as a lack of political will and support for conservation at all levels from senior government to local park staff, including stakeholders and park users. Sustainable financing instruments to support effective management also need to be created.

Under an idealistic scenario, local communities, park users and park management staff would recognise the multiple benefits and importance of sustainable resource use practices within an area designated as an MPA, and would together develop a management framework that maintained the ecological integrity and biodiversity features, whilst allowing sustainable resource use practices. Under the current planning framework, often only a relatively narrow group of stakeholders is involved in decision making with the primary dialogue being between the scientists and national planners. The net result may be lack of support from local communities, which creates difficulties in establishing sustainable management interventions. Management plans are often perceived as being handed down from the central government with insufficient consultations process. Lack of awareness and understanding of the role and potential benefits of the park are a common problem, especially where local support and community-based initiatives could help enhance management in areas where governmental funding for implementation is limited. The implication is that policy should be strengthened to include much greater stakeholder participation so that local interest groups gain a greater sense of ownership in the planning process. The chances of successful implementation will then be greater.

In countries where there is a successful network of MPAs, this does not necessarily guarantee overall threat alleviation, since threats may simply be displaced to areas outside the formal

protected area network. Achieving net conservation gains within a region requires a range of conservation instruments that address the root cause of threats, and which provide appropriate planning and regulatory frameworks to manage threats outside parks. Rather than focusing on enforcement, because of the large areas and the range of stakeholders involved, interventions tend to focus on encouraging partnerships and sustainable resource-use practices. Examples of such approaches include total watershed management, integrated coastal zone management, bioregional planning and integrated community and development projects. Supporting policies that enhance the effectiveness of conservation more broadly within the country include adoption of a National Biodiversity Action Plan, strategies for conservation of endangered species, laws to prevent the user of destructive fishing practices, and an effective regulatory framework to monitor and restrict coastal and marine exploitation and development.

It should also be noted that many countries have traditional marine tenure systems and traditional laws relating to marine resource use which can form the basis of highly effective conservation and sustainable marine resource use interventions. In other instances, local communities may have established voluntary reserves, or have areas that are effectively protected because of superstition or religious beliefs. It is important to recognise the extreme social, cultural and conservation value of such areas and to stress that such types of protected areas and management regimes need to be protected by relevant legislation. This is one area that is often overlooked in national planning frameworks.

Based on the WWF experience from the results of past and current efforts to establish effective conservation interventions with individual parks, the following strategic elements can be identified:

1. Scientific identification of priority sites for maintaining biodiversity and sustaining ecological processes.
2. Enabling policy instruments at national and lower levels to implement conservation measures, and political will to implement regulations (can include resource economics).
3. Effective management of a strategic network of protected areas and effective management of resource use practices more generally.
4. Innovative partnerships to provide sustainable funding and integration of private sector and other stakeholders in management efforts.
5. Sensitivity and complementarity to existing traditional practices and local culture.
6. Awareness-raising, education and co-management efforts with local communities and stakeholders to encourage participation and support in conservation efforts.

Regardless of the scale of conservation planning, whether locally or globally, implementation requires an appropriate policy environment. Paper parks, lack of political will and lack of suitable policy instruments are all common problems. In developing countries, success stories appear to be the exception rather than the norm. Throughout its network of project and offices, WWF is actively researching and testing ways to improve MPA policy and management, and address the root causes hindering marine conservation, whether at the local, regional or global scale.

2. Ecoregion Based Conservation (ERBC)

2.1 ERBC: a new WWF approach to enhance conservation

Although successes are being won at many individual sites, conservation organisations have recognised that they are generally loosing the battle to preserve biodiversity and ecological processes around the globe. In response, WWF is adopting Ecoregion Based Conservation

(ERBC), an integrated approach that works at large geographic scales, with long time horizons, and with comprehensive, and scientifically defined biodiversity goals. ERBC aims to maintain distinctive biological units, intact biota, keystone habitats and ecosystems, and large scale evolutionary and ecological processes. ERBC is conducted within a distinct ecoregion, defined as a relatively large unit of land or water that is biologically distinct from its neighbour and which harbours a characteristic set of species, ecosystems, dynamics and environmental conditions. The goal of ERBC is to conserve, and restore the biodiversity of an ecoregion – its species, habitats, and ecological processes.

Funding for conservation action is limited, so governments, donors and conservation groups need to be strategic and target the greatest amount of resources for protecting the areas richest in biodiversity. To accomplish this task, conservationists require a framework to ensure that the most distinct geographic areas are represented in a global conservation effort, and a plan, which can guide conservation activities in those representative areas. For WWF, the Global 200 is the analytical basis for prioritising. Ecoregion–based conservation is the plan of action.

The Global 200 identifies a series of ecoregions representing all of the major habitat types in the terrestrial, freshwater, and marine realms across all continents and ocean basins deserving greater emphasis because of their outstanding biological features. Conservation action to save species and habitats typically takes place at the country level. Patterns of biodiversity, such as the distribution of coral and mangrove populations, and ecological processes, such as fish migrations, do not follow political boundaries. Thus, ecoregions are used as the unit of analysis in creating the Global 200. WWF's ecoregions are defined as relatively large units of land or water containing a characteristic set of natural communities that share a large majority of their species, dynamics, and environmental conditions. Ecoregions function effectively as conservation units at regional scales because they encompass similar biological communities and their boundaries roughly coincide with the area over which key ecological processes most strongly interact.

2.2 Marine Protected Areas as a key component of a larger management framework

The main difference between conservation regimes oriented around a network of MPAs and marine ERBC is the greater involvement of partnerships and stakeholders in the decision-making process, and the use of the ecoregion rather than individual countries, as a biologically meaningful large spatial unit for planning. In the formulation of an ecoregional plan, of which the protected area network is only one component, policy makers and management practitioners from adjacent countries can learn and share experiences, and begin to build a consistency in their approach to conservation. It is hoped that by bringing a wider range of stakeholders to the table to formulate policy relating to conservation, and by involving stakeholders and partners early in the planning process there will be a greater buy-in to the process, and hence more support for implementation. This move to management of large spatial systems on longer temporal scales requires integration of policy and management instruments to address the multiplicity of threats impacting large-spatial systems, and should produce greater coordination among relevant agencies, with fewer gaps and loopholes.

An ecoregional approach also focuses attention on the broader social, economic, and policy factors that are essential to long-term success. Just as ecoregions often cross political boundaries, so too do the threats to biodiversity from the social, cultural and economic features of an ecoregion. Ecoregion-based conservation enables conservation organisations to take a more comprehensive approach to biodiversity conservation, without sacrificing sensitivity to local biodiversity issues and socio-economic conditions. This larger-scale, more integrated approach will enable WWF and its partners to better assess both the proximate and root causes of biodiversity loss and to design policy and management interventions at

appropriate levels. Moreover, it allows WWF to connect what it does at the local level with work, and to build new partnerships to carry out this work.

2.3 Examples where ERBC is being applied to marine ecoregions

WWF is in the early stages of implementing ERBC in a number of its coral reef ecoregions. Preliminary results from the Biodiversity visioning workshop for the Meso-American Reef ecoregion and stakeholder workshops in the Sulu-Sulawesi Sea Ecoregion already indicate that this approach offers a powerful tool for involving partners and accommodating their concerns in the decision and policy formulation aspects of conservation planning. Although the full ERBC process requires a considerable funding commitment and organisational framework, it is seen as a worthwhile investment if the end result is effective conservation management involving a wide range of stakeholders and partners.

In the Sulu-Sulawesi Sea, the Ecoregion approach has been adopted and championed by the Presidential Commission, a multi-agency government structure, for the Integrated Conservation and Development of Sulu-Sulawsi Seas. Multi-stakeholder workshops in the regions brought all the key players together from the private sector, government agencies, NGO representatives and academics. The process was presented, and feedback was collected to help refine the approach from the Philippine perspective. Consensus was built on the major issues that needed to be addressed.

In the Meso-American reef, a large biodiversity visioning workshop brought together scientific experts from the three countries, Mexico, Belize and Honduras, with key government officials from the marine resources management agencies, and outside academic experts specialised in particular taxonomic groups or ecological processes. The net result was an active debate on priority sites, species and seascapes for conservation, and the sense of sharing a common vision for the region.

3. A global approach to coral reef management

3.1 Global instruments

At the global level, there are relatively few institutional or policy instruments to raise the profile and improve the effectiveness of coral reef conservation. Due to the emergence of global issues such as climate change and coastal pollution as chronic threats to coral reefs, there is a need for a greater lobby within global political forums to mitigate these impacts and provide leverage on governments to increase allocation of resources and improve effectiveness of coral reef conservation efforts. There are three international policy protocols with provision for coral reef protection of global priority: UNESCO's Man and Biosphere Program, UNESCO's World Heritage program, and the RAMSAR Convention (Convention on Wetlands of International Importance), but these remain relatively under-utilised for coral reef conservation.

3.2 Scale and scope of CoralWeb

If the ecoregional method of focussing on broader, economic, social, and policy factors is assumed to be essential to long-term success, then a logical extension of this approach is to extend yet further the geographic scope to encompass networks of ecoregions. CoralWeb is an approach that, whilst working at the ecoregion level, adds a further global perspective to further enhance conservation actions. WWF has considerable experience in addressing reef resource and protected area management issues. In order to provide a learning forum within the organisation, and a platform for WWF and partners to address issues of global concern, WWF is launching the CoralWeb initiative, which aims to examine policy issues relating to

coral reef conservation at local, national, ecoregional, regional, and global levels, and to promote best practices and policy solutions built from our experience in the field.

CoralWeb is a new initiative, and a new type of initiative. It is a timely response to the need, as defined by both field and policy staff, to recognise persistent threats to coral reefs and their sustainable use by coastal communities. It is also a response to the need for a framework of action by which WWF can enhance its efforts and the resources we are already putting into coral reefs in a number of different ecoregions globally. It will not create layers of bureaucracy, but rather will tackle the problems of coral reef conservation at the multiple levels that are required in order to produce significant progress.

Successes are being achieved in many sites but the scale or cumulative impact of these successes comes nowhere near the magnitude of the threats to biodiversity. In many cases we are addressing the proximate threats, but not their root causes, thus questioning the sustainability of the success. In order to ensure that the outstanding coral ecosystems and biodiversity of the world persist well into the future, the collective actions of the broad conservation community must begin to match the scale of the threats. Projects need to expand into multifaceted programmes and yet retain greater flexibility to respond to crisis or opportunity and to build strategic partnerships.

The strength of the initiative lies in the drawing of strong links between existing field-based projects, programmatic policy work, Climate Change and Endangered Seas campaign and the work of other crosscutting units such as People and Conservation, Treaties and Monitoring and Evaluation. Staff at the field, regional, ecoregional and global level will work as a team together with partners from other NGOs, the private sector and members of the general public.

3.3 Geographical distribution

Currently the initiative encompasses 12 ecoregions of the 22 defined WWF Global 200 coral reef ecoregions. Criteria for the choice of these 12 regions included a defined biodiversity priority and current or expected WWF capacity present. The regions are currently:

- Meso-American Reef
- Southern Caribbean
- Greater Antilles
- Western Indian Ocean Islands
- East Africa Marine
- Sulu-Sulawesi Seas
- Great Barrier Reef
- Flores-Banda Seas
- Solomon-Bismarck Seas
- Fiji Barrier Reef
- Andaman Sea
- Cook Islands

3.4 Policy and co-ordination

A wide range of bold and far-reaching goals and objectives has been proposed. The majority of these can only be achieved by an initiative with the size, vertical and horizontal integration of CoralWeb.

The size of this initiative will facilitate opportunities to learn and increase the capacity and skills of WWF and partners. It is expected that not all regions will realistically be able to accomplish all goals, but because the initiative is large and broadly spread geographically, the regions will be able to report experiences and lessons learnt, back to the coordination team. These lessons, depending on local conditions, may be possible to apply to a range of situations. Without a coordination unit, free from the daily requirements of field officers, with the remit to provide this horizontal integration, such learning and application of knowledge would be difficult in smaller initiatives.

Vertical integration is not only the link between the ecoregions and WWFs global targets, or between field and policy staff, it is also the construction of links between WWF ecoregions and external partners who may work at levels not easily accessible to WWF. The advocacy, strategic planning and fund-raising power of such an integrated portfolio of projects will be far greater than that which could be derived from a diverse range of independent projects. A management team will therefore be required to maximise that potential, and thus realise the ambitions described by the mission: "healthy and productive coral reef communities supporting natural processes and the quality of human life".

The initiative is a framework rather than a complete programme of work. It is a highly flexible means to incorporate various projects and programmes in order to magnify their influence and value according to priorities determined by a range of WWF staff, stakeholders, partners and donors.

Further proof of the importance of the policy and coordination team is evident from the resources needed to achieve all four goals of CoralWeb:

1. "A global coral reef constituency is actively engaged." This will require the services of communications specialists and strong professional advocacy to inform, collaborate with, and motivate the public, politicians, local stakeholders and other established coral conservation partners.
2. "Governments develop effective policies and programmes that reduce climate change, pollution, and over- and destructive exploitation of coral reefs and associated resources and species." In order to achieve this goal, lessons learnt will need to be synthesised from around the regions and from these lessons reliable, science-based policy must be crystallised. Further, these policies will need to be communicated in a usable, tangible form to the authorities so that they have a chance of inspiring national or international policy or legislation. A high level of advocacy at national and international fora is commonly required to gain acceptance for proposed policies.
3. "Industries and artisanal practices impacting coral reefs are well regulated, culturally efficient and ecologically sensitive, and support local economies sustainably." A central P&C team will need to lobby for acceptance of suitable practices and standards and will need to advise on the applicability of such standards. Strong links will need to be built-up with major coral-impacting industries and standards institutions. Such work would be out of the remit of ecoregion-based staff.
4. "Globally representative areas of coral reefs are well managed and maintained". Scientific research programmes in partnership with other institutions, systems for monitoring and evaluation of results, and a horizontally and vertically integrated framework for learning

and sharing lessons will need to be established by the P&C team. Management guidelines will need to be developed.

3.5 Building on existing capacity

A further strength of the CoralWeb initiative is that it is nested within, and utilises existing structures, organisation and processes. Management by the policy and coordination team will ensure that existing structures do not stifle innovation and conservation benefits, but rather maximise the efficiency with which they are achieved. In this way funding organisations can be confident that they are sponsoring real advances in reef conservation not merely management realignment and capacity building within WWF.

By using existing structures and competence within the network, not only is the buy-in of CoralWeb increased, but the need for line and project management in addition to that required to conduct the fieldwork is minimised or eliminated. The dedicated administrative capacity of the initiative will therefore be lean whilst the magnification capacity will be appropriate to the high-level objectives.

Because CoralWeb is a framework, and because of the scale of the policy development, advocacy and communications work that must be conducted, the initiative will need to work closely with existing, highly experienced organisations to achieve shared objectives. It is more important that the objectives are achieved, than who achieves them, so the initiative also prioritises the assistance to, and capacity building of, partners. Great care will be taken to ensure that this framework does not compete for resources with existing and planned initiatives, both within and external to WWF. Rather, it will hopefully further focus attention and additional resources, and galvanise support globally.

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Summary of Discussion of Panel IV

Heidi Wittmer

The first part of the discussion dealt with policy options especially concerning MPAs and on co-ordination and implementation at higher than national levels. The second part focussed on possible contributions of research.

The options for policy discussed linking coral reef management more directly to the Convention on Biological Diversity, likewise to declare international sanctuaries. Both measures facilitate accessing international funds. Environmental Impact Assessment was considered an important entry point for sustainable development since it constitutes a formal and already well established procedure, which could be extended to cover additional variables. Another strategy discussed was to include objectives for marine areas more explicitly in development plans.

In the discussion three preconditions for successful MPAs were stressed:

- The need to establish a proper knowledge and data base before introducing MPAs,
- The need for administrative capacity building and
- The need to take a financial approach towards MPAs.

The possibilities of setting up regional networks of MPA policy makers, implementers and scientists were discussed. PERSGA (compare Younis this panel) can be considered as such an example. Participants stressed that it is never late to begin efforts of co-ordination and environmental management at a super-national level. Social and political constraints to approaches of regional collaboration, however, were not only discussed but became evident in the discussion.

How scientists can influence policy, was the next question raised. A large number of contributions focused on what needs to be researched including surveys establishing "what we have", and continuous monitoring of data on natural and/or human impacts on coral reefs. Several contributions argued for holistic approaches including biophysics and socio-economics. Participants also suggested conducting more joint research taking into account mangroves, sea grass beds and coral reefs. This seems especially pertinent when evaluating the externalities of economic development on marine resources as well as when comparing different models of institutional design. Apart from this more general research a role for research was identified in the evaluation of the effectiveness of different levels of intervention. So research should not only help to provide general information for policy formulation but also play a role in helping policy makers to evaluate and improve their interventions. This can be done for example by improving monitoring and thus allowing an immediate feed back on the success of different measures.

In order to improve the policy relevance of current research it was suggested, "to hear what needs policy makers have". This suggestion is not as trivial as it first sounds. Policy makers and the research community are currently not well connected in most countries. The Philippines are an interesting exception, since PCAMRD (compare Zaragoza & Hermes panel 3) was created to facilitate the interaction between policy makers and research on marine areas including coral reefs. The presentation has shown potentials and shortcomings in the present situation, some of which were elaborated in the discussion. One important shortcoming was the fact that a considerable amount of case studies both successful and not

has not been evaluated and the lessons to be learnt have accordingly not been made available to policy makers.

Even though PCAMRD is probably not unique as a government agency whose role encompasses both policy formulation and research (R&D) facilitation, it also utilises this linkage in promoting the application of research results, e.g. in the assistance in the formulation and implementation of coastal management plans. In the Philippines this usually occurs on the municipal level, because this is where the responsibility lies, thereby constituting a prime example for the effects of decentralisation and devolution strategies as well. Additionally the institution trains coastal managers. This set-up implies good preconditions for the information flow between policy, research and implementation. Institutional links between research and policy are much weaker in most other countries.

It was also stressed that policy makers could often not afford to wait for a good level of scientific knowledge on a given matter. A possible solution was seen in the application of less data intensive management approaches, or at least management approaches suited to the constraints that exist in many developing countries in terms of the capacity to gather and analyse complex or large amounts of information. Research could help to improve such management methods. Participatory research was also considered to have important potentials for improving the policy relevance of research results, especially but not exclusively in the fields of stakeholder participation, better adjusting to the needs of local communities, and questions of institutional design. To offer training in participatory methods for locals is another suggestion in this context.

Working Groups

The objective of the discussions in the working groups was to identify priority areas for future co-operation. With this goal in mind each group focused on a specific thematic area and analysed the relationships within science, as well as between science and policy makers on the one hand and science and implementers on the other. The specific objectives consisted in identifying missing links and areas that require more attention. Thereby recommendations and proposals for the content and organisation of future research co-operation were to be derived.

Working Group 1: Technical Options[a]

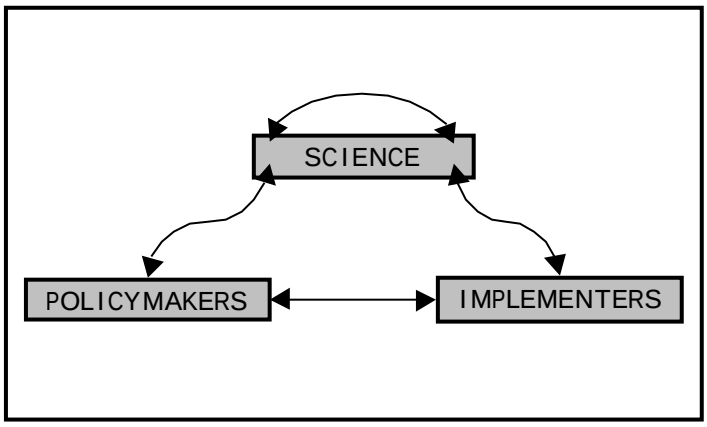
Objectives

This working group tried to identify main actors, areas of activity, key aspects as well as major gaps between science and policy in the implementation of coral reef restoration.

Although the common understanding of coral reef restoration and the sustainable use of this ecosystem clearly depicts the strong involvement of the local, coastal communities depending on this resource the participants of this working group explicitely focussed on the interactions between science and policy.

Results

National and international, scientific institutions play a key role in the implementation of coral reef restoration and sustainable use of this ecosystem. Since they are not necessarily the active part in e.g. the implementation of restoration techniques and in the conduction of socio-economic projects the relation between science and policy has to be enlarged by another co-operative partner



Coral reef restoration and the sustainable use of this resource by a variety of stakeholders has to be implemented on an interdisciplinary level. In this respect "SCIENCE" as depicted in the diagramme above is not restricted to the key disciplines Marine Biology or Oceanography of coral reefs but instead summarizes all scientific fields involved including Socio-Economy,

[a] Results summarised by Lothar Schillak

Economy, Geosciences, etc. . To facilitate the relation and interactions with the policymakers all involved scientific disciplines should have a sound base of communication between each other for the continuous and rapid exchange of information.

Towards policymakers science will then be able to specify missing links, to define areas of need, to give recommendations and to help with the identification of projects for coral reef restoration and sustainable development.

The implementer (governmental institution, non- governmental institution, scientific institution or local communities) will play the active part in the implementation of restoration techniques and socio-economic programmes.

The table below presents a brief, synoptical overview of logic steps (i.e. activity, cf. col.1), necessary for the implementation of technical options for coral reef restoration and sustainable dvelopment as elaborated by the participants of the working group.

Each activity (col.1) is further defined with key aspects (col.2), involvement of major co-operation partners (col.3) and its main orientation (col.4). Column 5 finally gives a estimation of how much input is still needed to optimize the co-operation between the partners described in the diagramme above. The ranks range from (+++) : no further input needed via (++), (+), (0), (-), (- -) to (- - -) : the interactions and co-operation between the partners need to be revised and optimised to a large extent.

1	2	3	4	5
Activity	**Key Aspects**	**Involvement**	**Orientation**	**Rank**
Inventory of Damage	resource evaluation survey public participation support	Science Policy	LCCs[1]	- -
Identification of Causes	local/regional/global natural socio economy halt/reversal/control Y/N	Science	LCCs	-
Prevention Measures	local options regional implementation Y/N	Science Policy Implementers	MPAs[2]/LCCs	- - -
Restoration of Damage	scope finance zero-options priorities impacts	Science Policy Implementers	MPAs/LCCs	- - -
Monitoring	Effectiveness indicators	Science Policy Implementers	MPAs/LCCs	-

[1]) LCC : Local Coastal Communty; [2]) MPA : Marine Protected Area

The **Inventory of Damage** has been defined to be starting point for each implementation of coral reef restoration and sustainable development of the coastal area. It should include the evaluation of the resource, a scientific survey of biotic and abiotic factors within the ecosystem and needs the support from local communities as well as from local and regional institutions and sectors (e.g. tourism). Science and policy are involved in this activity, which is mainly directed towards the local coastal communities depending from the coral reef areas.

The **Identification of Causes** as second major step should consider the natural as well as socio-economic conditions on the local level and place them into the regional and global frame. The key question to be answered with this step is : Can the causes which led to the degradation of the coral reef area, be halted, reversed and controlled in future ? The identification of causes will mainly be the task of science and is clearly directed to the local coastal communities

The definition of **Prevention Measures** as step 3 clearly depends on the facts and findings of the preceding steps. It should concentrate on the options available on the local level and consider the transfer to the regional level and their implementation, too. The definition of prevention measures leading to coral reef restoration and sustainable use of this ecosystem in future strongly demands the interactive co-operation of the partners science, policymakers and implementers. In difference to the preceding steps this activity is not only directed to the local coastal communities but also to the restructuring of existing and possible establishment of new marine protected areas.

The **Restoration of Damages** represents the active implementation of the facts and findings of the preceding steps. It needs the set-up of priorities, the definition of a scope of activities and a sustainable base of finance which ensures the effectiveness of the restoration activities after their implementation phase. This step should also address the impacts on the ecosystem and describe the zero option, i.e. future development without any restoration activity. Similar to the preceding step it demands the close co-operation between the partners and is directed to local coastal communities as well as to marine protected areas.

The **Monitoring** represents the last step in the implementation of technical coral reef restoration and sustainable coral reef development. It should be planned as a long-term activity and control the effectiveness of the restoration activities by means of predefined indicators. Science, policymakers and implementers are involved and the monitoring activities cover the local coastal communities as well as the marine protected areas.

Based on the experience of each of the participants of this working group the presented activities (1)Inventory of Damage, (2)Identification of Causes, (3)Prevention Measures (4)Restoration of Damages and (5)Monitoring as logic steps for the implementation of technical coral reef restoration and sustainable development of coral reef areas were ranked. It was agreed that none of the steps is sufficiently coordinated between the major partners science policymakers and implementers in any country at present. Especially the steps (1)Inventory of Damage and above all (3)Prevention Measures and (4)Restoration of Damages urgently need a strong input for the optimisation of the co-operation between the partners science, policy and implementers.

Conclusion

Following the discussions between the participants of this working group and with a look to the commonly formulated results, the reason why so many coral reef areas decline also is a result of an insufficient, ineffective or missing communication between science and policy in most of the countries. To seek not only for optimisation in the co-operation between science

and policy but also to try and establish an understanding of natural – including social – processes on the one (political) side and an understanding of political processes on the other (scientific) side should be one of the priorities for the future activities to halt and reverse the degradation of coral reefs worldwide.

Working Group 2: The Human Dimension[a]

Topics to be developed by this working group included the issues discussed in panels 1 and 3.

The working group concentrated on two issues:

How to better ensure that research results are useful for policy makers and applicable in a given society.

How to involve the perspective of the affected coastal communities.

Making research more useful to policy makers

A wide range of issues was discussed in this context including: The **identification of values** that actually motivate action in a society is an important prerequisite for a better understanding of what policies have a chance of being successfully implemented in a specific context. It is important to keep in mind that these values differ widely between different societies, often even within them.

Understanding the underlying social processes and **analysing the institutional context** in a given country can also contribute considerably to the design of policies with a high probability for successful implementation. These tasks constitute opportunities where social science research can help to improve the results in research, policy and implementation. Social scientists should work together closely with the other groups involved especially when formulating their research questions in order to ensure that the results are usable for natural science researchers, policy makers as well as implementers.

A further area where researchers could contribute to the impact of implementation is in assessing existing training modules with an eye to **improving local capacity building**. This recommendation should be relevant for practically all research projects.

Coral reefs and associated ecosystems are affected by related sectors activities like tourism and fisheries but also by inland activities like agriculture or deforestation, etc. Identifying and analysing such inter-sectoral linkages **requires interdisciplinary work involving both natural and social sciences**. This is due to the fact that both the causal factors and the resulting impacts consist of natural as well as socio-economic variables. For example the impacts can be physical as the siltation of reef areas due to erosion, or the pollution due to industrial development. Impacts can also be economical as changes in relative prices due to lower yields on degraded agricultural land or involve both physical and socio-economic impacts like the migration to coastal areas due to the lack of income earning opportunities inland. The causal relations responsible for such impacts consist of socio-economic (like population increases or increased industrial development) as well as natural factors like erosion or drought. In many cases the relationships between the different variables are complex. With increasing complexity of these relationships the importance for research to compile and break down the results into recommendations that can be understood and directly used by policy makers increases. It is important, however, to keep in mind that research can

[a] Results summarised by Heidi Wittmer

and should not make the value decisions involved in policy formulation but present policy makers with different options and their implications.

Progress is being made in this area as the trend to integrated coastal management programs often accompanied by research components or the trend to eco-regional research projects, for example analysing the dynamics of watersheds illustrate. Participants agreed that coral reef research has much to gain by becoming even more involved in such broader research efforts and ensuring from the phase of research design that results will be made available in a policy relevant form. Again, involving policy makers and implementers throughout the process especially in the formulation of the research agenda can improve the usefulness of the results.

Other examples for specific research questions for joint research between natural and social scientists include:

- The analysis of co-management arrangements,
- Conflict resolution among multiple stakeholders and
- identifying factors for success (or failure) of MPAs.

Including the perspective of coastal communities

Getting the perspective of the communities involved can also be considered a promising strategy in order to improve the policy relevance of research results. Additionally it is important to ensure that conservation occurs in the context of sustainable development. The process of getting this perspective has several dimensions like:

Improving communication,

Integrating traditional knowledge,

Defining the roles of different knowledge systems (traditional and scientific), especially finding out where they conflict with and where they complement each other.

Getting a community perspective might go even further by letting communities propose the agenda (even for research). While this last objective is clearly not feasible in most cases of research projects, it might yield very interesting results should it be possible to fund such an effort.

Working together more closely with implementers should yield best results for all the above-mentioned options of achieving a better understanding of the communities' perspective. Implementers usually have direct contacts to the communities involved and are much more able to take on long term responsibilities than research projects are.

Creating an environment for research in which communities participate more actively facilitates analysing many issues that involve human decision-making. An illustrative example discussed by the working group is the question what kind of gear is used by whom and why in fishing. An improvement of this understanding is important complementary information to the studies of natural scientists assessing the effect of different gear on fisheries. Together these results will allow designing relevant fishing policies in an environmentally sustainable and at the same time more equitable way.

Working Group 3: Marine Protected Areas[a]

Recommendations for the relationships

(a) Within Science (especially between social and natural sciences)

(b) Between Science and Policymakers and

(c) Between Science and Implementers

The group identified the following missing links:

Lack of co-ordination between different scientific disciplines;

Difference in priorities between scientists and policymakers;

Lack of integrative models embracing physical and social sciences.

It is common practice to apply a ranking based on a set of criteria when identifying an area for MPA establishment. This requires research-generated information on biophysical and socio-economical parameters that, if available at all, may be of widely differing quality and quantity and more often biased towards resources and environment. Compromises are usually made in the application of these criteria. Even among the biophysical disciplines, it is probably still very rare that an area is selected based on its potential as source or sink, utilizing information on current patterns and reproduction cycles.

At the same time, the natural scientist has to accept that criteria such as manageability and acceptance can be more crucial for sustainability than ecological criteria and should therefore receive priority.

Concerning areas of need; the group recognised co-operation and communication (among scientists, policymakers and implementers "practitioners"), plus the information level necessary for making the process work, as areas of action through the following measures:

1. Strengthening the use of social sciences involves co-op, COM, and Info.

2. Identification of hindrances to flow of communication covers co-op and COM.

3. Facilitating information systems concerns COM and info.

4. Enhancing the role of education at all levels embraces COM and info.

5. Identification plus collation of key research areas info.

In order to provide more useful information to policy makers, scientists still have to pursue the improved documentation of "functioning" or "effective" MPAs (i.e. those with proven impact on resource status and likewise successful, sustained management systems). An important aspect is here the proper identification of the impact of restoration measures as compared to the overall impact of MPA management.

Once this kind of information is available, proper channels for information flow to policy makers need to be identified, tested and institutionalised. The chances for reception and, in turn, utilisation by the policy makers of the provided information for the intended conservation or management measures can be enhanced. Specially designed education tools for the targeted high-ranking officials should be designed and utilised in order to provide the necessary background information on complex ecological, economic and social issues.

As proposals, the group has come up with these points:

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[a] Results summarised by Zien Elabdin Hassan, Rudy Hermes & Helge Vogt

- Formation of a scientific advisory board for ministries.
- An improved use of social sciences based methods on MPAs.
- To review and document traditional management systems of MPAs.

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