Review of Critical Habitats

MANGROVES AND CORAL REEFS

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LIST OF TABLES

EXECUTIVE SUMMARY

1.0 Status of critical habitats in the BOBLME region

This review examines the issues related to critical/vulnerable habitats, namely mangroves and coral reefs. It will address the following related subjects:

A description of the current status of mangroves and coral reefs in the BOBLME region,

The effects of traditional ownership and customary use rights and the influence on them of changes in settlement patterns, community and economic development,

Shared and transboundary issues related to critical habitats,

The root causes of such issues and how they might be prioritized in terms of regional severity,

Knowledge gaps, policy distortions and institutional deficiencies that impede the development of solutions to transboundary issues associated with coral reefs and mangroves, and actions that could be taken to overcome these,

Priorities for comprehensive, cross sectoral ecosystem based actions based on regional needs,

How the countries in the BOBLME region can better understand the shared issues associated with critical habitats i.e., coral reefs and mangroves, and collaborative ways to address them,

Where recommended activities might be located so as to have maximum demonstration and replication value in the case of innovative activities, and where human need is greatest.

2.0 Mangrove Habitat

The complex mangrove ecosystem supports important coastal fisheries and provides direct sustenance to coastal communities from timber and other products. It is also an important center of biodiversity and has international wildlife value.

2.1 Status of mangrove habitat

With a few exceptions, mangrove habitats in the BOBLME region are degraded or threatened. The following table summarizes the situation for major mangrove forests in the region:

Country	Area , km^2 (year)	Satus	Condition
India Sundarbans	9630 (1989) of which 4263 km^2 are mangroves	Biosphere Reserve	Threatened
Bhitarkanika	675	Sanctuary	Mangroves reduced to only 25% of sanctuary.
Coringa	101 (1998)	Reserve Forest	Threatened
Pichavaram	11 (1987)	Reserve Forest	Stable
Vedharanyam Mangrove Swamp	17.3	Wild life sanctuary[2]	Threatened. 40% of mangroves seriously degraded
Andaman and Nicobar Islands	966 (1997)	Timber extraction banned	Threatened
Bangladesh Sundarbans	4016 (1985)	Reserved forest	Threatened
Chokaria	182	Converted to shrimp farms	≈ 100% Destroyed
Aforestation/reforestation	1043 (1994)	Plantation	575 km^2 in good condition
Myanmar Rakhine	229	Nominally protected	Threatened
Ayeyarwady	275	Nominally protected	10.6% reserved forest, remainder

			threatened
Tanintharyi	224	Nominally protected	Threatened. Rate of decrease 2.4% per annum.
Thailand West coast (Ranong, Pangnga, Phuket)	707	15% protected, 82% under sustainable use management	Recovering, increased from 1,320 km^2 in 1996 to 1,764 km^2 in 2000
East coast (Krabi, Trang and Setun)	1058		
Malaysia (1995 data) Kedah	80	99% forest reserve	Degraded
Perak	435	78% forest reserve	Sustainable harvesting on forest reserve
Selangor	151	76% forest reserve	Degraded
Johor	167	68% forest reserve	Degraded
Indonesia Aceh	594		70% converted to shrimp ponds
North Sumatera	868		Threatened
Riau	2,399		Threatened
West Sumatera	365		53% destroyed
Sri Lanka Batticaloa	16 (2003)		Undisturbed
Mullaitivu	10(2003)		
Jaffna	11(2003)		52% Reduction
Puttalam	5(2003)		85% Reduction
Other	19(2003)		Degraded
Maldives			

Scattered	Not available	Not protected	Threatened

2.2 Weakened traditional management

Mangrove forests and their products have traditionally contributed to the sustenance of coastal communities. A confluence of events in the last several decades has led to increasing pressure on mangrove forests and their resources Among these are:

Weakened traditional common property management,

Growing human population in coastal areas.

Development of brackishwater shrimp farming

The privatizing of mangrove forests evolved through the leasing authority of government. Multiple use common property resources were transferred to single use private control. Because of the poverty and political weakness of coastal peoples, external capital has generally been used to extract resources or develop coastal lands. Consequently, most of the benefits of development flow away from these communities. As commercial demand increased, common property values declined and the traditional rules governing access weakened. Traditional management regimes were replaced by state monopoly and control, which has led to total commercialization of resource extraction. At the same time, effective management regimes were not put in place.

2.3 Mangrove-human interactions

The populations of communities depending on the resources of mangrove habitats grow through natural increase and permanent migration. Seasonal migratory fishers also exploit timber and other resources . Usually there are few employment alternatives available to households in coastal communities, so as resources decline, the means of exploitation become more destructive. Growing demand for freshwater for agriculture is also affecting mangrove habitat, reducing biodiversity and causing diseases of the mangrove trees. Malaysia is an exception where urban employment opportunities draw young people away from fishing and timber harvesting. NGO's have played an important role in creating awareness of the value of mangrove forest in the Andaman Sea region of Thailand resulting in reforestation and a significant increase in mangrove habitat area as abandoned shrimp farms are reclaimed.

2.4 Shared issues

Common problems impacting mangrove habitats in the region are:

unregulated expansion of shrimp aquaculture,

degradation,

reclamation

Although extensive shrimp farming began in the intertidal zone, modern technology should have reduced exploitation of mangrove habitats for shrimp farm development. Nevertheless, destruction continues because of the low opportunity cost of occupying mangrove forest coupled with weak enforcement of existing laws and regulations intended to control shrimp farm expansion.

Unsustainable exploitation of living resources, pollution, siltation and salinization are degrading mangrove habitats. Selective harvesting of valuable commercial species of mangroves seriously reduces their populations and degrades biodiversity. Over fishing of high value species such as mud crab and shrimp fry may also be affecting biodiversity, reducing commercial species' populations and contributing to declining living standards. Heavy sedimentation in the Ayeyarwady Delta is predicted to lead to the demise of its mangrove forests within 50 years. It also reduces aquatic productivity. Salinization causes disease of some tree species and affects biodiversity. Oil pollution can directly kill trees as well as aquatic organisms.

Reclamation for agriculture and urban development has been an important cause of mangrove forest removal. Coastal development may affect freshwater flow into mangrove habitat, causing salinization.

2.5 Root causes

Growing population, poverty and landlessness put increasing pressure on mangrove forests. Faced with a shortage of alternative livelihoods, coastal inhabitants become increasingly dependent on the living resources of the mangrove habitat**.**

Unplanned shrimp farm development is a continuing threat. The drive for export earnings and weak enforcement of CZM regulations has encouraged inappropriate expansion of shrimp farms into the mangrove habitat.

Uncontrolled coastal development (resorts, highways, ports, etc.). Protective measures have not been effective in preserving mangrove habitat. Lack of awareness of its importance among planners and bureaucrats relegates mangrove habitat to "wasteland" status.

Government tenure of the intertidal zone and its right to lease coastal lands has weakened traditional access and management systems by supplanting common property rights.

2.6 Current mitigation efforts

Governments in the region have recognized the threats to mangrove habitats posed by uncontrolled expansion of shrimp farming, degradation and reclamation. Institutions, laws and regulations have been put in place, but with varying degrees of effectiveness.

Uncontrolled expansion of shrimp farming

Establish exclusionary zones such as coastal regulatory zones, shrimp culture zones, and outright prohibition in mangrove habitats and protected areas.

Licensing and permitting systems.

Reducing environmental impact by placing limits on technology and waste disposal.

Requiring green belts

Degradation and reclamation

Establish biosphere reserves, protected forests, managed forests and RAMSAR sites.

Declare fisheries resource conservation areas.

Replanting abandoned shrimp farms and establishing coastal green belts.

Encourage local participation in reforestation.

Collaboration with international conservation and environment organizations and NGO's.

Promote eco-tourism

3.0 Coral Reefs

Fringing and patch reefs are found around the BOBLME region. The Maldives is composed of atolls. Major threats include destructive fishing, siltation, unplanned tourist development and the effects of global warming.

3.1 Status of coral reefs in the BOBLME region

The following table summarizes the status of coral reefs in the region:

Country	Site	Reef type/Area km^2	% live coral cover	Major threats
India	Gulf of Mannar Marine Biosphere Reserve	Fringing and patch/66.5	3 to 52%	Intensive trawling, coral mining, blast fishing, overfishing of reef resources.
	Mahatma Gandhi Marine National Park, Andaman and Nicobar Islands	Fringing and patch	10% to 85%, varies among park islands	Siltation
Bangladesh	St. Martins Island	Patch	7.6% coverage on SE coast	Coral mining, sedimentation, overfishing
Myanmar	Thanintaryi			
Thailand	BOBLME area of Andaman Sea	Fringing/ 78.6 km^2	Good, 12%;fair,34%; poor,27%;very poor 23%	Destructive fishing, crown-of-thorns, bleaching, sedimentation, storms, tourist development
Malaysia	P. Langkawai, P. Sembilan, P. Pangkor, Port Dikson	N/A	N/A	Destructive fishing, land reclamation, shipping accidents.
	P. Payar Marine Park	N/A	N/A	Protected area, but potential threat from tourist development.
Indonesia	Riau	521 km^2	67% to 98% of reefs have been degraded	Mining, sedimentation, destructive fishing methods
	North Sumatra	N/A	Karang Island heavily	Coral mining

			damaged,18.7% coverage.	

3.2 Shared Issues

Among common threats to coral reef habitat in the region are:

Destructive fishing practices.

Siltation and pollution

Uncontrolled tourist development

Coral mining.

3.3 Root Causes

Weak enforcement, poor coordination among responsible agencies

Export driven fisheries for live reef food fish and marine ornamentals

Population growth. Land reclamation, deforestation, pollution, poorly planned development.

Depleted coastal fisheries. No alternative employment or fishery to turn to.

Lack of awareness of coral reef ecology and the importance of reefs.

Global climate change. Coral bleaching, rising sea level, starfish invasions, invasive species.

3.4 Current mitigation efforts

Establish marine protected areas

Collaboration with international institutions and NGO's

Establish national coral reef monitoring programs.

Encourage community participation in coral reef management.

Implementation of coastal zone management plans.

Bans on coral mining and destructive fishing practices.

4.0 Transboundary issues and root causes

The figure below summarizes transboundary issues confronting critical habitats and their root causes:

Major Problem	**Transboundary issue**	**Main Root Cause**
Mangrove habitat loss	• Sedimentation • Oil spills • Invasive alien species • Contiguous habitat • Sea level rise	1,3 2, 4 2, 4 1,2,3,4,5 4,5
Coral reef degradation	• LRFF/Ornamental overfishing • Oil spills • Sedimentation • Invasive alien species • Coral bleaching • Sea level rise	2,3,4,6 2,4 2,4 2,3,4,5 2,4 2,4,5

Main Root Causes	
1.Population growth	• Lack of alternative employment • Dependence on natural resource extraction. • Poverty and disempowerment • Unsustainable agriculture practices • Uncontrolled migration into coastal zone
2. Weak institutions	• Inadequate funding for enforcement • Weak international enforcement • Low capacity at local level of government. • Political interference in management decisions • Poor coordination among national institutions
3.Poor stakeholder participation	• Weak traditional resource management • Weak commitment to stakeholder participation • Lack of public awareness of environmental issues
4. Inadequate knowledge	• Lack of research capability • Need for base line resource assessment
5. Global warming	• Increasing carbon dioxide emissions by industrialized countries • Unpredictability of long term effects
6. International luxury seafood market	• No controls in importing country • Lack of consumer awareness in importing countries • No export control

4.1 Knowledge gaps, policy distortions and institutional deficiencies

Invasive alien species. Awareness of the dangers of invasive alien species needs to be increased in the region. International and regional collaboration needs to be strengthened to ensure critical habitats are periodically monitored for the presence of invasive species. Taxonomic skills and literature resources also require upgrading. Common policies and regulations on ballast water discharge are lacking.

Shared habitats. There is a need to assess what is known of shared stocks which use a common habitat at some point in their life cycle. A framework needs to be constructed for coordinating critical habitat conservation and rehabilitation between countries sharing such habitats.

LRFF/Ornamental over-fishing. Issues raised by the trade in LRFF and ornamental over-fishing are 1) the extent of knowledge of which species are over exploited, 2) how to stop destructive fishing practices, and 3) reduce demand for LRFF and wild marine ornamental fish.

Oil spills. , South Asian countries do not have the capability to deal with spills of more than 100 tonnes Although Thailand has established response centers in the Gulf of Thailand, it does not have facilities in the Andaman Sea region The need to strengthen International participation Participation in international protocols and conventions under IMO could be increased. Modeling and predictive capacity on a regional basis can be improved.

Sedimentation. Newly accreted (char) lands pose management problems in the upper Bay of Bengal. Community based planning and participation in management decisions has not been fully developed. The need to strengthen and protect the rights of access to char lands of landless coastal people . Viable coping strategies need to be identified and implemented.

Sea level rise. Long range policies and plans need to be developed to cope with rising sea level. Coastal zone management plans must take into account the effects of sea level rise. Consideration needs to given to sources of outside technical and financial support to deal with the effects of rising sea level. Research on the impact of global climate change on the regional and national level needs to be strengthened.

5.0 Cross sectoral ecosystem actions

Stemming and reversing the loss of critical habitats in the region while meeting the needs of coastal people will be a long term challenge for the BOBLME region. Actions that can be taken to confront the challenge are:

Strengthen community based management systems

Identify viable alternative employment options

Rehabilitate damaged ecosystems

6.0 Regional collaboration on shared issues

The objective of regional collaboration would be to identify solutions to the problems raised by issues common to BOBLME member states. Modalities could include :

Exchange of experience. Specific sites or projects would be identified where issues have been successfully addressed. Study groups could be formed with participation by stake holders from the BOBLME countries concerned with the particular issue.

Examples which have addressed some of the shared issues are:

Closed system shrimp culture above high water mark in Thailand

Mangrove habitat rehabilitation in the buffer zone of the Sundarbans, India

"Biorock" reef restoration, Maldives

Community based reforestation of abandoned shrimp farms, Thailand

Community based coral reef management (COREMAP), Riau, Indonesia

Implement collaborative activities. Activities can be designed to test solutions to common issues. The following general characteristics should be considered in the design of the activity:

Limited area

Clearly defined objectives

Establish success criteria and how they will be measured.

Maximize opportunities for exchange of regional expertise through offices of BOBLME project.

Communicate progress and problems through BOBLME website or newsletters.

7.0 Demonstration activities

Activities are suggested which will address some of the critical habitat issues common to the region. These include uncontrolled shrimp farm expansion, mangrove forest degradation and coral reef destruction.

Shrimp aquaculture management. Components of the project are an ICZM plan developed with stakeholder participation and demonstration of low environmental impact shrimp

aquaculture. Closed system shrimp culture above mean high water will demonstrate sludge removal and processing, as well as follow ASEAN, FAO and GAA best management practices. Reforestation of the degraded intertidal zone will restore ecological function and absorb dissolved nutrient effluent from the demonstration shrimp farm.

Mangrove habitat rehabilitation. This activity targets degraded habitat, demonstrates sustainable forestry practices and alternative livelihood development as a means of reducing pressure on the habitat. Given the time required for mangrove rehabilitation, alternative income sources will be critically important. It is also critically important that high priority be given to the transfer of ownership to the CBO's because of the long time frame for rehabilitation. Responsibility for management should be undertaken by CBO's working together with local government

Improved management of marine protected areas. MPA's are an important means of conserving critical habitat, especially coral reefs. MPA's have been established in most of the BOBLME countries, but their effectiveness varies considerably. Problems include intrusion of local fishers, weak to non-enforcement of MPA regulations, and lack of coordination among responsible government agencies. MPA management can be improved by involving local communities in management, strengthening enforcement of conservation regulations, planning tourism development to minimize environmental impact and reducing dependence on reef resources. If the BOBLME project undertakes an activity in coral reef conservation, it should develop ties with the UNDP/GEF conservation programme for the GMMBR in India to promote the exchange of ideas and expertise.

Coral reef rehabilitation. Although coral reef restoration is still experimental, it may be the only hope for severely damaged reefs that have been mined or subjected to blast and poison fishing. Mechanisms must be developed and strengthened that will stop destructive practices. Among these are more local control, using indigenous knowledge and management, reducing dependence on reef resources and improved monitoring.

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1 *Background*

The Bay of Bengal is bordered by several of the most populous nations and it is said that 400 million people inhabit the watershed of the Bay. The inhabitants of the nations bordering the Bay are nurtured by ancient and diverse cultures. Communities clinging to its shores and islands are closely tied to the living resources of its waters, yet many are barely able to eke out an existence. Population growth coupled with growing demand for seafood in a global marketplace is leading to unsustainable demands upon both its living resources and the habitats that support them.

Confronted with stagnant or declining fish landings and rapidly deteriorating ecosystems, the paradigm of development is shifting from one of resource exploitation to sustainable use. New approaches to resource management are being sought, moving away from a narrow sectoral focus to more integrated ecosystem-based approaches. Governments are beginning to recognize that effective resource management must place the communities of users , the stakeholders, in a pivotal role.

The Bay of Bengal Large Marine Ecosystem project (BOBLME) will demonstrate ecosystem based management of human activities, coasts and linked watersheds in the region (Sherman 2003). BOBLME's first regional workshop was held at Pattaya, Thailand in Febraury of 2003 and was attended by representatives of the seven member countries, FAO, UNEP/GEF and other international organizations as well as national representatives of Sweden and the United States. Four working groups were established, viz. coastal and marine living resources, marine environment and critical/vulnerable habitats, social cultural and economic aspects and fourthly, institutional, management and policy issues.

At the conclusion of proceedings, the working group on critical habitats ranked threats, identified critical habitats and summarized current and potential interventions and information gaps for the five highest ranked threats. Critical habitats in order of

ranking were mangroves, coral reefs, lagoons, sea grass and tidal flats. The top five problems impacting them were identified, in order of importance, as sedimentation and siltation, reclamation, coastal aquaculture, illegal fishing and oil pollution.

This review will examine issues related to critical/vulnerable habitats, in particular, mangroves and coral reefs. It will address the following related subjects:

- A description of the current status of mangroves and coral reefs in the BOBLME region,
- The effects of traditional ownership and customary use rights and the influence on them of changes in settlement patterns, community and economic development,
- Shared and transboundary issues related to critical habitats,
- The root causes of such issues and how they might be prioritized in terms of regional severity,
- Knowledge gaps, policy distortions and institutional deficiencies that impede the development of solutions to transboundary issues associated with coral reefs and mangroves, and actions that could be taken to overcome these,
- Priorities for comprehensive, cross sectoral ecosystem based actions based on regional needs,
- How the countries in the BOBLME region can better understand the shared issues associated with critical habitats i.e., coral reefs and mangroves, and collaborative ways to address them,
- Where recommended activities might be located so as to have maximum demonstration and replication value in the case of innovative activities, and where human need is greatest.

2 *Status of critical habitats in the BOBLME region*

Critical habitat, when referring to endangered species, is the area essential for the conservation of the species . What does it mean to extend the definition to an entire ecosystem? A sustainable ecosystem must maintain its metabolic activity level, its internal

structure and organization and must resist external stress over time and space scales relevant to the ecosystem. (Sherman op. cit.). A critical habitat can be defined as one necessary to the sustainability of the ecosystem. Furthermore, they can be identified by the following criteria:

- Exceptional fisheries function and ecological value
- Particularly at risk
    - imminent threats
    - inherent vulnerability
    - rarity
- Individual species habitats or habitat systems.

Critical habitats perform multiple functions in support of ecosystem sustainability:

- Are centers of biodiversity;
- Serve as breeding and nursery areas;
- Moderate terrestrial influences such as nutrient runoff and sediment discharge;
- Food source
- Protect shorelines

2.1 Mangroves

Mangrove forests are an ubiquitous feature of the intertidal zone of tropical coasts. These forests form an ecosystem linked to the productivity of coastal fisheries. Kapetsky (1985) diagrammed some of the complex interactions through which the mangrove ecosystem supports a diverse assemblage of animal species and benefits human communities (Fig. 1}.

Numerous studies have shown the relationship between coastal fisheries and mangrove forest area. Kapetsky (*op.cit.*)estimated the median yield of finfish, shrimp and crabs from mangrove associated lagoons and estuaries to be on the order of 9.1 tons/km^2. More recently, de Graaf and Xuan (1997) estimated that 1 ha of mangroves produces 700 kg of marine fish catch. Ross (1975) calculated than a hectare of mangroves supported 150 to 175 kg of marine shrimp catch. It is apparent that a significant portion of Myanmar's fish production is dependent on mangrove forests. Most of the inshore catch is harvested by artisenal fishers, who benefit from the mangrove forest in indirect ways, as well (Fig. 1).

Aquaculture in the context of critical habitats is limited to low impact technology such as seaweed, small scale finfish cage culture and bivalve farming.

2.1.1 **Regional perspectives**

Mangroves are unevenly distributed around the coasts of the Bay of Bengal depending on topography, soil type and human or *anthropogenic* impacts. Even where they do not cover large areas, mangroves may have significant local importance in maintaining lagoon productivity and providing products for inhabitants of surrounding communities. However, forests of great regional and even global significance can be found in India, Indonesia, Bangladesh, Malaysia and Myanmar. Table 1 lists the more important mangrove forest sites, their area and condition. There are also patches of mangroves scattered along the coasts of BOB countries which are important as habitat and sources of food and materials for local communities. The effect of rising sea level has not been taken into account whenever a forest is considered "threatened" and will be addressed later.

2.1.1.1 Status of mangroves in BOBLME countries

Table 1 illustrates that most mangrove forests in the region are degraded or threatened by both natural and anthropogenic phenomena. Placing forests in reserves does not lessen actual or potential damage, particularly from exploitation by humans. The damage ranges from nearly complete, as in the Chokaria in Bangladesh, to casual intrusion that does not cause much visible damage, as in the Pichavarum Reserve Forest in India.

There are a few very notable exceptions to this discouraging trend. The area of mangrove forest on the Andaman Sea coast of Thailand is actually increasing. Strong community involvement in reforestation is an important element of the recovery, as is the natural reseeding of abandoned shrimp farms. The Matang Forest Reserve occupying 401 km^2 in the state of Perak in Malaysia is an outstanding example of sustainable harvesting and effective management. In fact, it has been managed for nearly 100 years, having been established as a reserve forest about 1906 (Lim 1998).

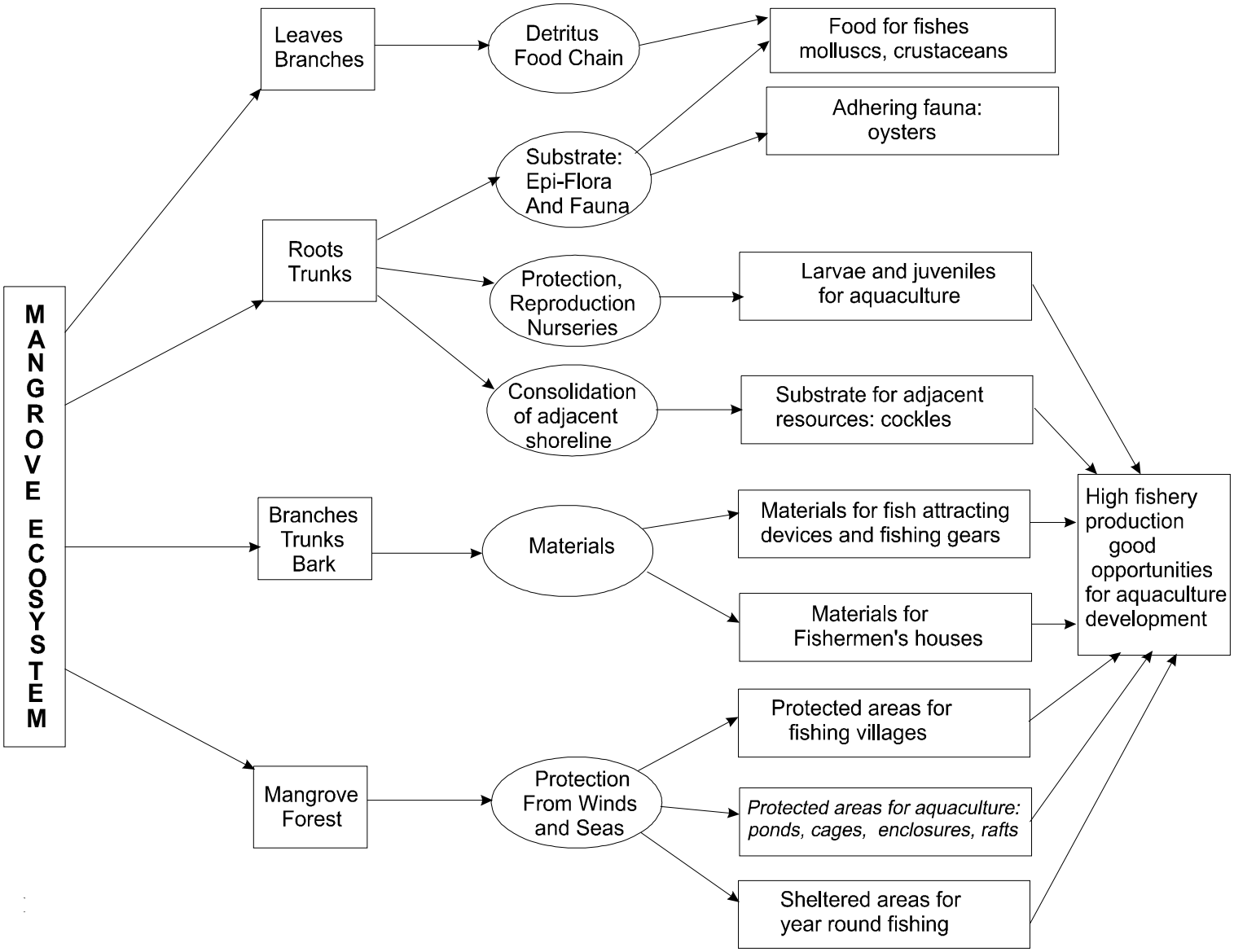

Figure 1 Interactions in the mangrove ecosystem (after Kapetsky 1985)

Table 1 Major mangrove forests in the BOBLME

Country	*Area , km²*	*Satus*	*Condition*
India			
Sundarbans	9630[1] of which 4263 km² are mangroves	Biosphere Reserve	Threatened
Bhitarkanika	675 [2]	Sanctuary	Mangroves reduced to only 25% of sanctuary.[7]
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East coast (Krabi, Trang and Setun)	1058[9]		
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			forest reserve
Selangor	151[10]	76% forest reserve	Degraded
Johor	167 [10]	68% forest reserve	Degraded
Indonesia			
Aceh	594[11]		70% converted to shrimp ponds
North Sumatera	868[11]		Threatened
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Sri Lanka			
Batticaloa	16 [12]		Undisturbed
Mullaitivu	10[12]		
Jaffna	11[12]		52% Reduction
Puttalam	5[12]		85% Reduction
Other	19[12]		Degraded
Maldives			
Scattered	Not available	Not protected	Threatened

Table 1 (cont.)

[1] Includes core area, manipulation zone and restoration zone. Core area is 1692 km^2 (Sampath 2003) [2] Sampath 2003 [3] Only a small portion is protected, but the entire area has been proposed as a Ramsar site. [4] Kumar 2000 [5] Hossain 2003 [6] Choudhury 2003 [7] www.indianjungles.com [8]U Myint Pe 2003 [9]Juntarashote 2003 [10] Omar 2003 [11] Purnomohadi 2003 [12] Joseph 2003

2.1.1.2 Weakened traditional management

Mangrove forests and their products have traditionally contributed to the sustenance of coastal communities. A confluence of events in the last several decades has led to increasing pressure on mangrove forests and their resources Among these are:

- Weakening of traditional common property management,
- Growing human population in coastal areas.
- Development of brackishwater shrimp farming

Table 2 summarizes some obstacles to the exercise of traditional access rights and management systems. A major limitation is the conversion of mangroves to shrimp farms. Denial of access occurs in two ways; first, by removal of the habitat and its replacement by a tenured farming system and second by denying access to adjacent waters with trespass laws and physical threats. All the BOBLME participants whose countries have extensive mangrove forests considered conversion to shrimp farms is a major concern.

Table 2 Issues of access in some BOBLME countries

Country	***Coastal lands ownership/traditional rights***
Bangladesh	Traditional right of access to the Sundarbans was through membership in village *samaj* dominated by local elite which controlled access. These rights were not formally regulated, but were the birthright of the community. The community had rules, customs and norms and sanctions for violators (Mitra 2000). Today ownership is vested in the state. Mangrove forests and water bodies are controlled by the government. Mangrove forests are regulated by Forest Department and leased to the local elites. which excludes the rural poor. Common property and access rights are no longer recognized in this tenural system (Barkat and Roy 2001). Newly accreted *char* lands are divided into plots, supposed to be allocated to landless peasantry. All emerging lands are to be planted with mangroves which become permanent plantations. Community rights to these lands are uncertain (Anonymous 2001).
India	Migratory fishers have been denied access to their traditional fish camps on Sundarbans coast in a conflict with private developer (Dey-Graff, R. 2002). Access denied to core area of biosphere reserves, but sustainable activities allowed in buffer zone. Numerous conflicts over right of access to traditional beach areas blocked by shrimp farm construction. Increase in land value for shrimp farming led to sales by marginal farmers (Vasudevappa and Seenappa 2002).
Malaysia	The population of active fishers has declined. Fishers have access to waters and aquatic resources of Matang forest reserve. Some villages on the fringe of the reserve forest use waters of reserve for mangrove friendly aquaculture (Lim 1998). Conflict in Penang between shrimp farm and tourism developers and fishers because of mangrove clearing (Idris, M 1997).
Maldives	Mangroves judged to be important, but aerial extent small. MoFA issues tree felling permits though the Island Chief, but there is no control over the size of trees felled (Kavinde 1999).
Myanmar	Coastal lands are the property of the government, which controls use and access through licenses and grants.
Sri Lanka	Conversion of mangroves to shrimp farms in Puttalam District displaced fishers, caused unemployment and reduced catches (Anonymous 1999;Anonymous 2003).

Thailand	Conversion of mangroves to shrimp farms grew rapidly from 1961 to 1996 (Fast and Piamsak 2003), but has practically ceased. Local communities and NGO's implementing replanting. Natural reseeding of abandoned farms. Some evidence of increased fish catches.

The privatizing of public lands including mangrove forests, evolved through the leasing authority of government. Thus, multiple use common property resources were transferred to single use private control. Because of the poverty and political weakness of coastal peoples, external capital has generally been used to extract resources or develop coastal lands. Consequently, most of the benefits of development flow away from such communities.

Mitra (2000) described in some detail the history of traditional management of the Sundarbans before it was subsumed by rent taking. As commercial demand increased, common property values declined and the traditional rules governing access weakened to the point of ineffectiveness Concurrently, the elites, whose main interest had been in controlling access to the forest, shifted to rent taking from the new resource extractors. The extractors increasingly came from areas far removed from the forest. At the beginning of the 21st century, impoverishment of communities that depend upon the Sundarbans is accompanied by increased exploitation and powerlessness. The traditional management regime has been replaced by state monopoly and control, which has led to total commercialization of resource extraction. At the same time, there is no effective management regime in place.

The Chokoria Sundarbans suffered from a similar process of transfer of common property and community rights to private interests. As the government had the right to lease land initially for timber and subsequently for shrimp farming, economic elites abrogated the right of access by local communities to forest resources. Within 20 years the mangrove forest disappeared and fisheries declined (Rosan 2003).

Conflict between conservation and fisherfolk arises when local communities are excluded from reserve forests. When no alternative income sources are available, poaching and a general breakdown of any management scheme are encouraged.

Coastal development, especially conversion to shrimp farms, may increase land values to such an extent that poor coastal fishers and farmers are forced to sell their land. With no alternative rural employment, ill equipped fishers migrate to urban centers.

2.1.1.3 Mangrove-human interactions

Causes of population changes in coastal areas include natural increase, seasonal migration and permanent migration. There may also be a reduction in active fishers, particularly as youth find alternative employment, although it is less common. The paucity of alternatives to extractive activities increases harvesting pressure on already degraded habitats..

India

Sundarbans

The Sundarbans fall within the district of 24 Parganas, West Bengal. The forest occupies about 41% of South 24 Parganas, whose population is 5.7 million growing at 2.8% per annum. About 3.1 million people live on the periphery of the Sundarbans and exploit the buffer zone.[1] Timber , fishing, honey, and shrimp fry collection are extractive activities. Because the soil is saline, only low yielding rice is grown in the rainy season. There are few alternatives to agriculture and exploiting the resources of the buffer zone associated with the Sundarbans Reserve Forest. In the dry season, fishermen migrate to the islands fronting the Sundarbans. Some of these fishers come from Orissa as well as the Hooghly River estuary.

Bhitarkanika Wildlife Sanctuary

There are 410 villages within the sanctuary and 43 new villages were established between 1961 and 1981[2]. Permanent migration into the sanctuary has led to conversion to illegal shrimp farms and illegal fishing. The adjacent Gahirmjatha Marine Sanctuary is a nesting ground for endangered turtle species. Illegal fishing by inhabitants of the sanctuary also

[1] http://www.wb.nic.in/dist/parganas.html

[2] www.indianjungles.com

threatens the turtles. Local NGO's are trying to develop alternative income generation but do not adequately address ecological issues.

Corringa Reserve Forest

There are 128,000 fisherfolk living in the district in which the reserve is located. About 10,600 people live around the reserve itself. No information is available on migration into or out of the forest vicinity. Timber harvest, mollusk and shrimp seed collections are extractive activities practices in the reserve. There is a program of mangrove reforestation which includes digging channels to improve water circulation. Local families are assigned sections of the channels for fishing.

Pichavaram

Surrounding villages are engaged in agriculture and fishing. Heads of households amount to 5024, of which an astounding 63% are unemployed. Illegal fuel wood collection and grazing are limited and have caused little damage. There are shrimp farms around the forest, but they were constructed inland of the mangroves. Restoration activities include digging channels to improve water circulation.

Vedharanyam/Muthupet Swamp

Data on migration into and out of the area is lacking, however 3,200 families depend on the swamp for their subsistence. Firewood collection and freshwater diversion are damaging the mangrove forest. Restoration canals have been constructed to encourage natural reseeding.

Andaman and Nicobar Islands

The current all island population is 400,000 (Whittingham, E et al. 2003). It grew at an average annual rate of 2.7% from 1991 to 2001, in part due to economic migrants from the mainland. Coastal villagers engage in damaging extractive activities including illegal collection of mangrove fruits for medicinal purposes, timber harvesting and conversion to rice paddies . Remedial measures include a ban on timber extraction from government forests, but this has shifted pressure to revenue forests. Sanctuaries, public awareness campaigns and reforestation are planned to rehabilitate and protect the remaining mangroves.

Bangladesh

Sundarbans

The Bangladesh Sundarbans are contiguous with the Sundarbans of West Bengal, India. In Bangladesh, about 2.5 million people inhabit villages around the forest. As many as

300,000 of them depend directly on the mangrove forest[3] The growth rate for the Bangladeshi population in general is 1.6% and because of high rural unemployment there is some rural –urban migration as people search for alternative income sources. Only 35% of those living in the impact zone (0-20 km around the SRF) own agriculture land (*Mitra op. cit.*). Up to 50,000 people a day enter the Sundarbans to cut timber, collect honey and catch shrimp fry. Migratory fishermen also enter the Sundarbans and establish camps during the dry season, engaging in illegal trapping and hunting (Roy 2001). The demand for irrigation water during the dry season has meant the diversion of 40% of the freshwater that would normally flow into the Sundarbans. Mangroves are dying and species succession is underway as a result.[4]

Chokoria Sundarbans

Demand for charcoal and salt from urban centers led to over harvesting and clearing of mangroves. The destruction has been completed by uncontrolled expansion of shrimp farms. It is estimated that, for the country as a whole, 67% of the rural –urban migration consists of coastal zone inhabitants forced to leave because of declining resources or access to them (Islam M.R. 2002). Regulations establishing green belts were ignored and local fishermen have reported declining catches (Ahmed, F. 1997).

Myanmar

Information on the relationships between rural communities and mangrove forests is sparse. It is known that villagers depended very much on mangroves directly or indirectly for fisheries. The strong demand for firewood and charcoal in Yangon resulted in unsustainable harvesting of mangroves in the Ayeyarwady Delta. The demand was in part due to shortages of alternative fuels like kerosene (Anonymous 1998). The elimination of large areas of mangroves has had serious effects on fish catches. More than half the population is landless and depends on access to aquatic resources (Than MS). The government has leased large areas of the delta for agribusiness, raising fears that land reclamation will cause wide spread flooding. Government policy also encourages the conversion of mangroves to rice production, contrary to Forestry regulations (Anonymous 2002). However, some community reforestation is underway.

[3] http://www.wcmc.org.uk/protected_areas/data/wh/sundarb.html

[4] http://www.wcmc.org.uk/protected_areas/data/wh/sundarb.html

Shrimp farming is concentrated in Rahkine, where 89% of the 27, 650 ha total is located. Here, shrimp farms were constructed on degraded mangrove forest, which effectively removes the area from potential reforestation. The government is encouraging shrimp farm development, so without adequate zoning and enforceable management regimes, mangroves can be expected to continue to decline.

According to Swe Thwin (2003), illegal logging and dynamite fishing are damaging critical habitat in the Myeik Archipelago. Some of this activity is indulged in by the Chao Lay, numbering about 10,000 formerly nomadic subsistence fishers.

Thailand

Malay speaking Muslim fisherfolk migrated from Malaysia to the Andaman seacoast area of Thailand many years ago. These communities increased exploitation of mangrove forest resources as overfishing by trawlers drove them inshore (Ong, J.L. 2002). Shrimp farm conversion and other development reduced mangroves by 42% from 1961 to 1996, but the area has shown a 33 % increase since 1996. Fisherfolk communities regained access to mangrove forests as shrimp farms were abandoned. *Community conservation areas* (CCA's) were established and reforestation undertaken. CCA's are managed by the fisherfolk who also interact with government agencies to get official recognition of the CCA's, which do not yet have legal status (Worah et al. 1999). NGO's such as the Yadfon Foundation have played an important role in regaining community control over mangrove resources.

Malaysia

There has been a marked decline in the fisherfolk population as education improved and alternative employment was generated by Malaysia's rapid development. The number of fishermen working on licensed vessels fell from 60,000 in 1980 to 31,000 in 2000 (Omar 2003). Conversion of mangroves to shrimp farms has engendered controversy, just as in other countries of the BOBLME region. A large shrimp aquaculture project in Kedah generated conflict between the shrimp company and farmers over land acquisition.

Only half of the 900 ha of mangroves on Penang Island are reserves and since 1966 mangroves have disappeared at the rate of 130 ha annually. The Penang Inshore

Fisherman's Welfare Association (PIFWA) promotes awareness campaigns. They have adopted a mangrove stand on Penang Island and are engaged in reforestation in an area zoned for development (Sangaralingam, M. 1998). However, between 500 and 600 fisherfolk households had to be resettled when mangroves were removed for industrial development.[5] Conversion to shrimp farms and reclamation for industrial development have taken 495 km^2.

An outstanding example of the integration of sustainable mangrove forestry, small scale fisheries and mangrove-friendly aquaculture is the Matang Mangrove Forest Reserve. About 1994 fishermen live adjacent to the reserve, which provides employment for 1000 to 1700 workers in timber and wood processing (Lim 1998). Fishers have unfettered access to the aquatic resources of the forest, but employ non destructive fishing methods. Small scale aquaculture includes cockles (*Anadara granosa*), finfish cage culture and crab fattening. Shrimp farming is not allowed in the reserve, although there are a few farms outside the border, but they total only about 12 ha. A good portion of the aquaculture is undertaken by the fisherfolk who live around the forest. The Reserve was established by the British colonial government in 1906 and has been sustainably managed for nearly 100 years. Although the forest supports 334 charcoal kilns, loggers have followed the harvesting regulations as laid down by the Forest District Office. No overharvesting of any note has occurred.

Mangroves in each state are included in forest reserves, which in the jurisdiction of the Federal Government. Sustainable management of these reserves is the responsibility of each state forestry department. Mangrove forests are open to anyone, but only low impact activities are allowed. Charcoal making, pole gathering, mud crab fishing and ecotourism are among these. Population pressure on Malaysian mangrove resources is low, perhaps accounting for the absence of customary law or *adat* issues.

Indonesia

Illegal clearing of mangroves and conversion to shrimp ponds is widespread and has generated conflict between shrimp farmers and fishers (Purnomohadi 2003). Acid sulfate problems are severe in North Sumatra and farms are abandoned after a few years when yields decline. Clearing for rice farming began about 30 years ago, followed by shrimp

[5] Dr. Ishak Omar personal communication

pond conversion.[6] Statistics show a decline in the area of shrimp ponds from 1997 to 2000 in NAD, North Sumatra and Riau, but the extent of replanting is unknown. Official figures show most fishing gear units to be increasing, which seems to indicate a growing number of fishermen. It is unclear if this is due to migration to coastal areas or simply because of natural population increase. Three of four provinces in the BOBLME region have shown relatively low population growth and net out migration with the exception of NAD and Riau. Migration to the industrial area of Batam can account for the increase in Riau (Anonymous b 2003). Data is lacking on the degree to which fisherfolk households have been affected by these broader changes.

Sri Lanka

Mangroves are not as extensive as in the continental states of the BOBLME region, but they are locally important as nursery grounds for commercial species wildlife, habitat and shoreline protection. Conversion to shrimp ponds has reduced mangrove forest considerably, particularly around Puttalam Lagoon, but almost half of the farms are illegal (Joseph 2003). Some homesteading encroachment has also occurred. Loss of access because of shrimp farm development has impacted the livelihoods of nearly 6000 households in the Puttalam District. Agricultural land has been lost in the northwestern province, amounting to around 640 ha, while almost half the communities around lagoons in the south have had to change their livelihoods because of degraded natural resources.

Some mangroves in the north and east have been damaged during the civil war, but mangroves found beyond the reach of shrimp farm developers are in good condition. NGO's were very active on the south coast encouraging opposition to shrimp farming. A Special Area Management Plan was implemented in Rekawa and although there were organizational and financial problems, the results were sufficiently encouraging to expand the program to other sites, some of which have mangroves. Other causes of mangrove degeneration include extraction of timber and firewood and for the brush pile fishery.

The population of Sri Lanka is growing at 0.83%[7], and while low compared to other countries in the region, increases demand for marine fish. Since 32% of the country's population lives in the coastal zone, the demand for settlement land increases year by year.

[6] Jakarta Post April 17 2001

[7] http://www.indexmundi.com/sri_lanka/population_growth_rate.html

Active fishers increased from 63,600 in 1989 to 114,200 in 2002 (Joseph *op. cit.*), which shows there are few alternative for the children of fisherfolk families. The annual catch per fisherman dropped from 2 tons to 1.2 tons during the same period.

Maldives

While there are no extensive forests, mangroves are widespread and thought to play an important role in reef ecosystems. Traditional uses include wooden boat nails and food In at least one instance, villagers planted mangroves as a source of emergency food (Kavinde, H. 1999) . Although these traditional uses continue on a limited scale, some mangrove stands have been reclaimed for development or used as waste dumps. The latter has increased as land becomes scarcer on crowded islands (Ali, M. 2003).

2.1.2 Shared issues

The terms of reference for this review define shared or common issues as similar issues concerning critical habitats that are present in two or more of the BOBLME countries even if the habitat or the effect of the issue does not physically straddle or cross the actual boundary (however defined) between two BOBLME countries.

Criteria for prioritizing shared issues is to some degree arbitrary, but for purposes of this review the following parameters have been considered:

- The degree of destruction or degredation associated with the issue and it's potential for posing a continuing threat to the mangrove habitats of the region,
- The likelihood that the issue can be addressed within a reasonable time.

The mangrove habitat is under threat in every BOBLME country , raising the following issues:

- unregulated expansion of shrimp aquaculture.
- degradation
- reclamation

2.1.2.1 Unregulated shrimp farm expansion

Shrimp farming has gone through a very rapid development phase from about 1980 through 2000 during which it was transformed from a low input land intensive system to a capital intensive high input one. Shrimp production from the BOBLME region grew

concurrently. In the take-off phase, the industry built on the experience of traditional brackishwater pond culture. It is an old technology based on entrapment of fry and juveniles by embankments constructed in mangrove forests. This was one of the reasons early shrimp farmers constructed ponds in the mangrove habitat. They also needed tidal flow for water exchange, but there was little understanding of the problems associated with mangrove forest soils.

A second reason was the low cost of acquiring intertidal land because it is controlled by the state. Since traditional rights no longer held sway, large expanses of mangrove forest could be leased for nominal rates. The capital intensive nature of modern shrimp farming excludes fisherfolk from participating. They have access to neither capital or knowledge needed and although numerous attempts have been made to facilitate the transfer of shrimp farming technology to fisherfolk, they often encounter difficulty. Even though the problems of acid sulfate soils are well known today, shrimp farms continue to expand into mangrove habitat in some BOBLME countries because the opportunity cost of intertidal land is low..

Governments and the public were unaware of the critical role mangroves play in coastal ecosystems, which only became apparent as they were replaced by shrimp farms. The environmental constrains on shrimp production were not well understood by farmers as well as researchers. Under pressure to produce ever increasing harvests for export markets, farmers raised seed stocking density to unsustainable levels. It did not take long before the carrying capacity of the system was exceeded and debilitating diseases arose. Viral diseases have decimated shrimp production and led to millions of dollars in losses, leaving abandoned farms in their wake.

Three technical innovations fueled the rapid expansion of shrimp farming: introduction of pump-fed systems, standardization of hatchery technology and the widespread availability of formulated dry pellet feeds. These advances provided the necessary support for the move out of the mangrove habitat to sites above the high water mark. Recent developments in closed or semi-closed pond systems can reduce the environmental impact even further by drastically cutting dissolved nutrient and particulate discharges.

Thai shrimp farmers have gradually moved out of the mangroves as failed intertidal farms were abandoned. Increasing mangrove area is a reflection of the shift. Closed systems spread as a reaction to viral diseases. The Department of Fisheries undertook demonstration projects to promote more mangrove friendly shrimp culture. On the other hand, the conversion of mangrove to shrimp farms continues in Indonesia, Sri Lanka and to a lesser extent in India and Malaysia. Myanmar may be the next country to see substantial loss of its remaining mangrove habitat to shrimp farm expansion. The reasons for this need to be more fully investigated, but are at least partially due to weak enforcement of coastal zoning regulations, the low opportunity cost of land in the intertidal zone, very short term profit horizon of investors and lack of knowledge and training on the part of shrimp farmers.

2.1.2.2 Degradation

Unsustainable exploitation of living resources, pollution, siltation, and salinization degrade the mangrove habitat. In some cases, complete destruction results, exemplified by the fate of the Chokoria Sundarbans in southeastern Bangladesh. The commercial value of mangroves depends on the species and use to which the timber will be put. An example of selective harvesting of high value timber can be found in the Sundarbans. The Rhizophoraceae are of minor importance, whereas the species preferred for commercial harvest is *Heriteria fomes*, or sundri, from which the Sundarbans derives its name. The other commercial species is *Exocaria agallocha* or gewa. Overharvesting has reduced these two species by 40% and 45% respectively (Akhtaruzzaman 2000) . Furthermore, increased salinity may be causing mortality of sundri. The role of each species in the ecosystem is not clear and requires further investigation to ascertain the effect of wholesale removal of a particular species. Illegal felling and poaching are also a problem in the Indian portion of the Sundarbans. These activities extend into the core are of the tiger reserve.

There are an estimated 440,000 shrimp fry collectors throughout Bangladesh. Studies of the by catch in the Sundarbans area of West Bengal have shown that usually only 1% or less by numbers of the organisms caught are the target species, *Penaeus monodon*. In that study there were 49 species of finfish and 11 species of crustaceans represented in the bycatch (Banarjee et al. 1993). The annual shrimp fry catch has been estimated at

several billion and in the process killing very large numbers of a wide variety of animals. The impact of this activity on biodiversity is unclear, but deserves further study.

Mud crabs (*Scylla spp.*) are an important resource for artisenal fishers but they are under heavy fishing pressure in most BOBLME countries. Both national urban markets and export markets create high demand. Catches are falling because of degraded habitat and overfishing. Experimental culture has been underway for several decades, but commercial application remains limited, mainly because of problems with hatchery seed production. There are no management measures in effect, so it is likely this valuable resource will continue to decline.

There are several ways that oil pollution can affect mangroves. Oil can kill the mangrove species that produce pneumatophores by smothering them. The species composition of the forest will be altered indirectly through high mortality of mangrove crabs. The entire food chain is damaged by the physical effects of oil as well as its biochemical effects. International shipping poses serious risks along the coasts of some BOBLME countries. Chronic pollution from harbors, local shipping and the gas and oil industry may also affect mangrove habitat.

Mangroves trap sediment in their roots, which results in a slow natural seaward progression of the forest. However, heavy sedimentation can rapidly raise elevation until it is no longer suitable for mangrove survival. Deforestation and unsustainable agriculture in the water sheds of the Ganges-Brahmaputra and Ayeyarwady Rivers are producing very large sediment loads. It has been estimated that the Ayeyarwady mangroves will disappear in 50 years (U et al.2001). Sedimentation rates greater than 1 cm/year is enough to kill some species by smothering aerial roots. [8] The hydrological regime can be radically altered by the filling up of channels, as happens in Bangladesh. High turbidity associated with siltation reduces primary productivity and may clog the gills of crustaceans and fish. Tin mining on the Andaman Sea coast was responsible for large discharges of sediment and although the industry is dormant, dredging could resume if the world tin market improves.

The complexity of reducing sediment and silt runoff is tied to the sources of runoff. The serious problem raised by the huge discharges from the Ganges-Bramahputra and

[8] www.fao.org/gpa/sediments/habitat2.htm#mangrove

Ayeyerwady Rivers originate in very large watersheds that cross international boundries. It does not seem realistic that the land use practices of the millions of stakeholders could be changed within the lifetime of most projects. Localized sources are much easier to address if we are dealing with a small watershed or particular destructive activities such as construction and mining.

2.1.2.3 Reclamation

Much mangrove habitat has been sacrificed to make way for coastal development. It may be direct destruction, for example, conversion to paddy, port construction, and tourist facilities. Indirect damage occurs when the hydrology of the forest is modified, as for example when freshwater flow is diverted for agriculture or blocked by highway construction.

Only 45% of the Andaman Sea mangrove area remained by 1993. Shrimp farm conversion had taken only 1% , whereas agriculture, road development, salt farms, mining and other uses were responsible for 36% of the decline. The area converted to non-shrimp uses amounted to 1,338 km^2 out of a total of 3,724 km^2 (Menasvetta 1997). . In fact, conversion of mangrove to agriculture uses, particularly rice production, was historically a major cause of habitat destruction before the spread of shrimp farming. For example, in the largest delta region of the world extending between India and Bangladesh, some 150,000 ha. of mangrove forest disappeared during the past 100 years, when areas were reclaimed for agriculture settlement sites, industrial estates and roads (Govindasamy et al.1997). Land reclamation for industrial and housing estates has reduced mangrove habitat along the west coast of Malaysia. Conversion to coconut plantations has been a cause of habitat loss in Sri Lanka. Some mangrove habitat has been reclaimed for tourist development in the Maldives and used for garbage disposal.

2.1.3 **Root causes**

The review of the relationship between mangroves and humans highlights negative impacts common to the BOBLME region, including:

- Growing population, poverty and landlessness put increasing pressure on mangrove forests. Faced with a shortage of alternative livelihoods, coastal inhabitants become increasingly dependent on the living resources of the mangrove habitat.

- Unplanned shrimp farm development is a continuing threat. The drive for export earnings and weak enforcement of CZM regulations has encouraged inappropriate expansion of shrimp farms into the mangrove habitat.
- Uncontrolled coastal development (resorts, highways, ports, etc.). Protective measures have not been effective in preserving mangrove habitat. Lack of awareness of its importance among planners and bureaucrats relegates mangrove habitat to "wasteland" status.
- Government tenure of the intertidal zone and its right to lease coastal lands has weakened traditional access and management systems by supplanting common property rights.

2.1.4 Current mitigation efforts

There are both institutional and technological components to effective habitat conservation and rehabilitation. An effective program integrates them into a management and development framework. Considering the institutional component in its broadest perspective, it includes traditional structures at the local or village level and non governmental organizations, as well as formal state institutions.

Uncontrolled expansion of shrimp farming

The following discussion concerns attempts to regulate shrimp aquaculture directly to reduce its environmental impact. Most of the countries in the BOBLME encourage shrimp aquaculture as part of export oriented development policies. Some have come to recognize the negative aspects of uncontrolled expansion and have taken measures to restrain it. There are several institutional levels from central government to local authorities which have some influence over coastal zone management in general, and shrimp aquaculture in particular.

<u>India</u>

Responsibilities for managing shrimp aquaculture and protecting mangrove habitat lie with both the central government and state authorities. At the national level, the Wild Life Protection Act bans aquaculture in protected areas and declared biosphere reserves (Vasudevappa et al. 2002). However, illegal farms have been established in some reserves. The Aquaculture Authority of India was established in response to a Supreme Court ruling banning aquaculture in the Coastal Regulatory Zone. It is charged with the responsibility

of preventing encroachment into mangroves. [9] State and district level committees have been established to implement shrimp farm licensing, which all shrimp farms must have. The following problems have been identified with the implementation (Hein, L 2000):

- The license system is still not fully operational; many of the shrimp farms have not yet acquired a license. As there have been very few closures of unlicensed shrimp farms, shrimp farms often have little motivation to apply for a license.
- There is insufficient consideration of the ecological and social environment in the granting of licenses, such as the coastal management zone in which the farm of the applicant is located, the current concentration of shrimp farms in relation to the carrying capacity of the local ecosystem (in terms of pollution, avoiding restricted access to land for nearby villagers), and the location relative to mangroves, coastal wetlands and protected areas.
- There are no clear requirements for shrimp farms to install water effluent treatment facilities or provide for buffer zones with adequate drainage.
- There is little enforcement of the current permission system; there is very limited field control of the precise location and the current land use of proposed farms, and insufficient monitoring afterwards on compliance with environmental and social requirements.

As might be expected, the success of implementation varies from state to state. In contrast to the problems identified above, CRZ provisions are being observed in West Bengal, reducing habitat damage by shrimp farming (Sampath 2003).

Some Indian and international NGO's are conducting anti-shrimp aquaculture campaigns and trying to organize boycotts of farmed shrimp in consuming counries. The boycott campaigns do not appear effective judging from the trends in imports by major consuming countries.

Sri Lanka

Approval of shrimp culture projects lies with a provincial scoping committee as authorized by the Provincial Environmental Act. Applications are evaluated by four different

[9] http://aquaculture.tn.nic.in/functions.htm

agencies dealing with environmental , socio-economic, scientific and industrial and irrigation and water resources aspects of the proposals. . If the farm is within the coastal zone (defined as the band from the sea inland to 300m), a permit from the Coast Conservation Department (CCD) is also required (Thomas, M.A. 2003). In spite of the permitting process, nearly 50% of shrimp farms operate illegally.

Fisherfolk on the south coast are very aware of the habitat destruction caused by uncontrolled shrimp aquaculture. NGO's were able to organize opposition to shrimp aquaculture in several communities on the south coast.

Bangladesh

The National Fishery Policy issued in 1998 includes measures to promote and manage shrimp farming. The establishment of shrimp culture zones is foreseen, but information on implementation mechanisms is not available (Hossain 2003). Measures are included to mitigate some of the negative effects of uncontrolled shrimp aquaculture. The Policy proposes to establish shrimp aquaculture management committees at thana, district, division and national levels. One of the functions of the committee is the implementation of laws relating to shrimp culture. The policy directs that shrimp farm sites should be selected in consultation with the Ministry of Environment and Forests to ensure they will maintain ecological balance (Anonymous 2001). The policy is new and effective implementation awaits future development.

NGO's play an important role in rural development in Bangladesh and dealing with shrimp aquaculture is no exception. Caritas has worked with small scale producers to organize more equitable shrimp farming. Some NGO's have supported opposition to ill planned shrimp farm projects (Ahmed, S.A. et al. 2002).

Myanmar

The Department of Fisheries specifies that shrimp farming shall be limited to secondary and degraded forests but technology is restricted to extensive or "improved" extensive farming. It also stipulates that a buffer zone should be established around these types of farms, but no criteria are given for it. Shrimp farming is allowed in tidal marshland. The

DoF prohibits intensive shrimp farming on the basis that it is too damaging to the environment (U Myint Pe 2003). However, the definitions of these different culture technologies are somewhat flexible and usually based on the stocking rate, that is, number of seed stocked per m^2.

Thailand

All shrimp farms must be registered with the Dept. of Fisheries. and obtain operating permits. The permit stipulates design criteria and pond water discharge limits with the intention of reducing pollution. The design criteria vary with the size of the farm. Provisions are made for inspections of discharge water and sludge. The latter cannot be discharged into receiving waters. The Ministry of Science Technology and the Environment has issued a management plan dealing with sludge disposal and zoning. The shrimp culture zone is defined as the area behind mangroves but still in the intertidal zone. Shrimp farms cannot border on agriculture land, communities, or industries and cannot impact a conservation area (Anantanasuwong D.2003). An important provision is the requirement of land title, since titles are not given in mangrove habitat.

Malaysia

The Department of Fisheries prepared guidelines for environmentally friendly aquaculture in response to declining fisheries caused by mangrove destruction (Anonymous 1997). Farms over 50 ha must prepare an environmental impact assessment as a condition of project approval. They are also required to maintain a "green belt" of 50-60 m on the seaward side of their farm. Some states have identified aquaculture "zones" but it is not clear how much is open water and how much has been set aside for shrimp culture. It is not known on what basis the zones were established.

Indonesia

Permits for shrimp farms are issued by regency authorities, but information on the conditions for permits in the BOBLME is lacking. A green belt is required on both coastal and riparian shores. The width is determined by a formula based on the tidal range and varies from 50 to 200 m on the sea coast and 10 to 20 m along river banks (Purnomohadi

2003). However, newspaper reports indicate shrimp farms continue to destroy mangrove habitat (Anonymous b 2001).

Maldives

There is no shrimp farming, although there was some interest.[10] The environment of the country does not seem conducive to profitable shrimp aquaculture, but it is conceivable that an attempt could be made to supply the local tourist market. The pros and cons should be carefully weighed, particularly since it is likely an exotic species would be introduced.

Degradation

The problem of degradation is attributed to overexploitation of the living resources of the mangrove habitat and changes in its biological and physical characteristics as a consequence of human activities. Attempts to ameliorate habitat degradation include set asides in reserves and protected forests, managed forestry, fisheries regulations, watershed management and community-based control of the resources of the mangrove habitat. The following discussion summarizes approaches to conservation around the BOBLME region.

India

The government established a program known as "Conservation and Management of Mangroves" within which a National Committee on Mangroves advises management programs at 15 sites through the country. Among others, the sites include Sunderbans, North Andaman, Nicobar islands, Coringa, Krishna Estuary, Godavari Delta, , Bhitarkanika, Peechavaram in Orissa and Pt. Calimere in Tamilnadu.[11] Each state establishes "Steering Committees" to draw up management action plans for the sites within its jurisdiction. Research is coordinated through a Research Sub-Committee within the Ministry of Environment and Forests.

[10] Hassan Maniku personal communication

[11] http://www.icfre.org/nfrp/fria2.3.html

The Sundarbans and the Gulf of Manner were named biosphere reserves in 1986 and are recognized by UNESCO under their "Man in the Biosphere" program. The core zone corresponds with the Project Tiger Area, focusing international attention on the Sundarbans. No activities are allowed in the core zone, leaving rehabilitation and sustained management to the buffer and impact zones. Forest guards attempt to stop poaching in the core zone. Mangrove aforestation in degraded areas is undertaken by forest staff , concentrating on the sundari. The Social Forestry program has replanted 19,000 ha since 1989 (Sampath 2003). Eight villages are involved in the program. Aforestation is supported by education and awareness campaigns in villages around the Sundarbans.

Eco-tourism is promoted in the Sundarbans and other protected mangrove forests in India. An evaluation of the industry would be useful to measure its effects on local employment and the degree to which it is promoting conservation at the local and national levels.

Important mangrove forests have been proposed as Ramsar sites at Bhitarkanika Sanctuary (Orissa), Point Calimere Sanctuary (Tamil Nadu), and Andaman and Nicobar Islands. A legal and institutional framework is in place for mangrove habitat conservation (Kumar, R. 2000), but it is difficult to deal with growing population pressure around the fringes of protected areas.

NGO assistance to communities for mangrove conservation appears to be limited, judging from resources available on the world wide web

Bangladesh

The Bangladesh portion of the Sundarbans is a reserve forest and can be exploited for timber, so sustainable forestry is critical to habitat conservation. The forest is managed as one large block with felling restrictions as the primary management measure. Concern for the Bengal tiger has drawn international attention to the Sundarbans and international organizations are playing an increasing role in directing the management of the forest.[12] It is proposed to extend the Wildlife Reserves and create a National Park. Management plans

[12] www.pupilvision.com/upper sixth/mangrove.htm.

have been updated and several donor funded projects have been implemented.[13]. The Asian Development Bank supported biodiversity conservation in the Sundarbans, but the project is on hold. The "Sustainable Environment Management Programme" (SEMP) in the Ministry of Environment and Forests is the follow-up to an earlier project that resulted in the formulation of the National Environmental Management Act, NEMA. SEMP priorities were identified by local people and it now has 26 component projects and involves 21 government agencies and NGO's. The project has a strong orientation toward improving women's lives. One of the components is sustainable resource management in brackish water areas, implemented by CARITAS.

International NGO support for expanding the coastal mangrove belt is exemplified by the OISCA-Japan, which provided volunteers and financial support working directly with community leaders. As of 2002, their mangrove belt project had been extended 50 km with a width of 100 m.[14]

A ban on shrimp fry collection went into effect in 2000 as concerns about its effect on fisheries and biodiversity increased. However, the law will be very difficult to enforce because of the large number of fry catchers in the country and the lack of any viable alternative employment (Moral and Sicar 2003) It is also often the only source of income for thousands of rural women.

Myanmar

Through the auspices of UNDP/FAO, the Forest Department allowed 19 villages within forest reserves to set up and manage community forests. The villages were given a 30 year land grant as a basis for the plantation. More than 4000 ha had been established by the end of 2001. The CBO's responsible for the forests have been effective in establishing plantations and managing existing mangrove forest.

A "mangrove service network" (MSN) in the Forest Department was founded in 2001 with the assistance of personnel trained by UNDP/FAO. The goal of the MSN is to support

[13] www.ramsar.org

[14] http://oisca.org/e/topic/0309bang.htm

CBO's formed under recently concluded UNDP/FAO projects. It will also act as a liaison organization with donors, NGO's and the private sector to promote development activities.[15]

Thailand

Sustainable use of coastal resources and environmental protection are embodied in action plans formulated under the Ninth National Economic and Social Development Plan (Juntarashote K. 2003). The action plans will considerably improve the coastal environment if the can be implemented as planned. In summary, the ways in which the objectives of the Plan are to be achieved are:

1. Protect conservation zones by promoting sustainable utilization:

- Complete zoning of mangrove areas,
- Set up a mechanism for mangrove forest management to reduce conflicts between government and local people,
- Local participation in reforestation programs,
- Declare marine protected areas and fisher resources conservation area as well as establish fishing zones and management for small scale fisheries.

2. Rehabilitate coastal resources through:

- establishing a Sea Rehabilitation Plan covering conservation, rehabilitation and utilization of coastal and marine resources, tourism and small scale fisheries,
- Eliminate the use of destructive fishing gear,
- Establish coastal zones to protect coral reefs, sea grass beds and seaweeds,
- Restore erosion damaged beaches,
- Provide waste disposal and treatment facilities along the coast.

There is specific mention of mangroves in several of the action plans. For example, the second phase of the Environmental Quality Management Plan calls for the rehabilitation and preservation of deteriorated mangrove forests. The Environmental Quality

[15] http://www.earthisland.org/map.map.html

Management Framework calls for "strict" control of mangrove forest utilization by government offices and the rehabilitation of denuded forests as part of the implementation strategy.

The environmental action plan for the provincial level includes research, management, legislation and monitoring. The plan calls for reforestation of denuded and abandoned mangrove forests among other management measures to protect the marine environment. Action plans are to be implemented between 2002 and 2006. There are no current international cooperation project dealing directly with mangrove habitat management.

Malaysia

NGO's make an important contribution to mangrove habitat management on the west coast of Malaysia. The Penang Inshore Fishermen's Welfare Association (PIFWA) in collaboration with the Consumer Association of Penang replant mangroves as an annual celebration. About 27,000 seedlings have been planted so far.

The Matang Mangrove Forest Reserve is perhaps the only example of sustained mangrove forest management in the BOBLME region.

Some recent policy innovations may improve mangrove habitat conservation, but enforcement capacity remains weak (Omar, H. I. 2003). A National Policy on the Environment was endorsed by the Ministry of Science, Technology and Environment in 2002. However, the National Coastal Zone Policy is still in the formulation stage. Once finalized, the policies will have to be translated into legislation at the federal and state levels, along with improvements in monitoring and enforcement capacity.

Forestry Department regulations allow clear cutting mangroves, but require that 7 mother trees per ha be left and a 3 meter wide river bank and coastal strip should be left for regeneration and shore protection. Penalties for violations of any forest regulation have been substantially increased. The amended Forestry Act directs the police and armed forces to monitor forestry activities.[16]

[16] http://webclub.kcom.ne.jp/ma/yamasho/sfm/malay-c&i03.htm

Malaysia has worked with FAO to develop an integrated regulatory system for aquaculture in the short to medium term without attempting to enact a new comprehensive aquaculture act. This involves enacting new regulations under the existing Fisheries Act, introducing a voluntary Code of Responsible Aquaculture Practices for inland cage culture and shrimp farming, supported by incentives, and strengthening institutional structures to ensure the ongoing formulation and monitoring of aquaculture policy at federal and state levels (FAO 1997).

Indonesia

Seventeen national level agencies have some authority in dealing with mangrove habitat conservation (Anonymous 2000b). The key agencies are the Ministries of Forestry, Marine and Fisheries, Agriculture, Environment and Home Affairs, of which the key Ministry is Forestry. These ministries operate at the national level, but under decentralization, responsibility for management of the coastal zone falls to local government. However, the role of provincial and regency governments in managing coastal and marine resources is not yet well established. Furthermore, community participation needs to be strengthened (Purwako et al. MS) .

NGO's are a relatively recent phenomenon in Indonesia and few deal with marine resource conservation. There is little information available on their activities in the BOBLME region. An example of international cooperation is the partnership between Mangrove Action Project (US based NGO) and Yayasan Laksana Samudera to map the mangroves of Riau Province. The work is funded by another NGO, Global Catalyst Foundation.[17]

Sri Lanka

The Coast Conservation Department (CCD) adopted strategies in 1990 to promote a more integrated approach to coastal zone management (Joseph *op. cit.*). A key element is the Special Area Management Plan. Special Area Management (SAM) planning is a locally based process of integrated management at specific sites. The local community is taken as the major stakeholder in co-management between the government and local resource users.

[17] http://www.earthisland.org/map/mngim_indonesia.htm

The results of the first initiative in 1991 were positive, leading to the extension of SAM's to additional sites. The current program runs until 2005 (Joseph *op. cit.*). The CCD and Forest Department are identifying mangrove habitats requiring urgent attention. The work is planned on a long term basis and has been given high priority.

NGO's and CBO's are undertaking mangrove habitat rehabilitation through the Small Fisher Federation in Puttalam and Hambantota districts (Joseph *op. cit.*). Fisherfolk around Rekawa Lagoon collaborated with Colombo University to try to increase shrimp catches by stocking the lagoon with juveniles obtained from hatcheries. Studies indicated that the stocking was an effective way to increase shrimp catches.[18] Perhaps the results will lead to interest in other culture-based fisheries.

Donor funded projects aimed at improving coastal zone management with potential direct impact on mangrove habitats are listed in Table 3 ((Joseph *op. cit.*). .

Table 3 Donor funded CZM projects

Project Name	***Duration***	***Donor***	***Implementing /Executing Agency***	***Objective***
Hikkdaduwa CZM	2000-2004	AUS AID	NWSDB, Hikkaduwa Pradeshiya Saba	Improve environment by sustainable waste management
Hambantota ICZM Phase II	2002-2004	NORAD	CCD	Promote sustainable use and development of coastal resources.
Coastal Resources Management	2000-2005	ADB/Netherlands	CCD	Enhance environmental protection contribut to povery reduction among fisherfolk by establishing sustainable systems for management of coastal resources.
Conservation of biodiversity	2000-2005	UNDP	CCD/MFOR	Ensure conservation and sustainable use of the biodiversity of

[18] http://www.sustainablecoasts.com/Project%20examples/Stock%20enhancement.htm

through integrated collaborative management in the Rekawa, Ussangoda and Kalametiya coastal ecosystems				globally significant site by collaborative management involving local communities, NGO's and government agencies.
Regional technical assistance for coastal and marine resource management and poverty reduction in South Asia.	2001-2003	ADB	IUCN/CCD/MENR	Promote cooperation among participating countries towards strengthening the management of environmentally sensitive coastal and marine resources.
Aquatic resources development and quality improvement	2003-2009	ADB	NAQDA/MFOR	Improve food security and poverty alleviation by promotion of market drive sustainable management of inland fisheries and aquaculture development
Eastern province coastal communities development	2003-2009	ADB	Provincial council/MFOR	Poverty alleviation and economic development in three districts through sustainable livelihood development and sound management of natural resources.

Maldives

The concept of protected areas was introduced at the behest of the tourism industry. Protected areas were established for coral reefs, but to date nothing has been done to protect the scattered mangroves. No reports of mangrove related NGO activity were

uncovered. The role of mangroves in the reef ecosystem needs to be explored further (Ali, M. 2003). However, Maldivians are well aware of mangroves, as illustrated above.

2.2 Coral reefs

2.2.1 **Regional overview**

2.2.1.1 Status of coral reefs in BOBLME region

The predominate threats to coral reefs in the short to medium term are of human origin. These include illegal and destructive fishing, siltation caused by poor uplands management and mining, and unplanned tourist development. Extensive damage has been caused by periodic warming of the ocean, attributed to global warming. Pollution and pollution related disease are threatening some reefs.

The distribution of reefs is very uneven around the region. Bangladesh has only one reef, although of interesting structure. Shallow reefs along the east coast of India are limited to the Gulf of Mannar and the Andaman and Nicobar Islands. Fringing reefs are extensive on the south east coast of Myanmar, extending further south into Thailand. Coral reefs are also found around the islands straddling the Thai-Malaysian border and continue south around Langkawi, Extensive reefs are found along the Straits of Malacca, Aceh and West Sumatra. Important reefs fringe the coast of Sri Lanka, while the Maldives is an atoll nation.

The following table summarizes the situation of important reefs in the BOBLME region by country. The reader will note that in some cases data on aerial coverage is not available.

Table 4 Summary of coral reef status in the BOBLME region

Country	***Site***	***Reef type/Area km^2***	***% live coral cover***	***Major threats***
India[19]	Gulf of Mannar Marine Biosphere Reserve	Fringing and patch/66.5	3 to 52%	Intensive trawling, coral mining, blast fishing, overfishing of reef resources.

[19] Sampath 2003

	Mahatma Gandhi Marine National Park, Andaman and Nicobar Islands	Fringing and patch	10% to 85%, varies among park islands	Siltation
Bangladesh	St. Martins Island	Patch	7.6% coverage on SE coast	Coral mining, sedimentation, overfishing
Myanmar	Mergui Archipelago[20]	Fringing	N/A	Blast fishing
Thailand[21]	BOBLME area of Andaman Sea	Fringing/ 78.6 km^2	Good, 12%;fair,34%; poor,27%;very poor 23%	Destructive fishing, crown-of-thorns, bleaching, sedimentation, storms, tourist development
Malaysia [22]	P. Langkawai, P. Sembilan, P. Pangkor, Port Dikson	N/A	N/A	Destructive fishing, land reclamation, shipping accidents.
	P. Payar Marine Park	N/A	N/A	Protected area, but potential threat from tourist development (Buang 2003).
Indonesia[23]	Riau	521 km^2	67% to 98% of reefs have been degraded	Mining, sedimentation, destructive fishing methods
	North Sumatra	N/A	Karang Island heavily damaged,18.7% coverage.	Coral mining
	West Sumatra	N/A	Most reefs degraded to some extent.	Destructive fishing methods
Sri Lanka[24]	Bar Reef Marine Sanctuary	N/A	Almost 100% mortality from coral bleaching, some new growth in 2002.	Bleaching, destructive fishing, anchoring

[20] http://141.84.51.10/riffe/reefcheck/Burma2003report_en.shtml

[21] Juntarashote, K. 2003

[22] Omar 2003

[23] Purnomohadi, S. 2003

[24] Joseph. L. 2003

	Kandakuliya	N/A	New growth after bleaching, but destroyed by Halimeda	Bleaching, destructive fishing, anchoring
	Hikkadua Marine Sanctuary	N/A	Decreased from 47% live coral coverage to 12% after bleaching.	Sedimentation, anchoring, pollution, uncontrolled tourist activity
	Weligama	N/A	Decreased from 92% to 54% after bleaching	Sedimentation, pollution, uncontrolled tourist activities, anchoring.
	Rumassala	N/A	Decreased from 45% to 23% after bleaching	
	Great Basses and Little Basses Reef Marine Sanctuaries	N/A	Un-degraded	Overfishing
Maldives[25]	Nation wide	26 atolls, 1200 coral islands, 202 inhabited.	High coverage up to 70% but coral bleaching caused losses up to 80% on some reefs (Rajasurya et al. 1998).	Coral mining, oil pollution, domestic waste, overfishing, bleaching, sea level rise

2.2.1.2 Human-coral reef interactions

Coral reefs in the BOBLME region face challenges brought on by both nature and humans. Anthropogenic challenges arise from growing and impoverished coastal population and demands for the economic products of the reef. Governments and communities are increasingly aware of the loss that occurs with the decline in coral reef health. International commitment to saving this habitat of global significance is supporting the peoples of the region in this effort. A brief discussion of human-reef interactions follows, focusing on each of the BOBLME member states.

[25] Ali, M. 2003

India

Significant coral reefs are found in the Gulf of Mannar and in the Andaman and Nicobar Islands. Both are degraded by human activity, but the nature of the activities and their effects on the local population are different to some extent.

Gulf of Mannar

The Gulf of Mannar Marine Biosphere Reserve (GOMMBRE) was established in 1989 and covers 21 islands and the zone between 6 to 9 m depth. The coast fronting the GOMMBRE has 49 villages, with a population of nearly 54,000. Of these, 13,500 are active fishermen (Sampath 2003). Women as well as men are involved in harvesting reef resources. In fact, about half the income of female-headed households derives from marine resources, principally seaweed and shells (Whittingham et al. 2003). There are some villages whose womenfolk dive for sea cucumbers and shells. The exploitation of resources has been propelled to unsustainable levels by the development of commercial markets. The cost of acquiring improved technology (trawls, crab nets) excludes the poorest fishers and generates conflicts between commercial and artisanal fishers. The fisherfolk also recognize that the resources provided by the reef are in decline. The declaration of the GOMMBRE will deny access to fisherfolk if its restrictions are effectively enforced. It could have a particularly devastating effect on female-headed households.

Andaman and Nicobar Islands

The extensive area of islands and reefs, open access, and the high productivity of coral reefs has minimized conflicts between stakeholders. There are two marine parks in the Andaman Islands, the Mahatma Gandhi Marine National Park and the RJM National Park. The parks have caused some displacement of fishers, increasing pressure on reef resources adjacent to the parks and nearer settlements (Whittingham op. cit.). There are the beginnings of eco-tourism, but its benefits have not yet spread beyond the few businesses engaged in it.

Fisherfolk began migrating to the islands in 1960, adding to migration of agricultural settlers. Permanent migration is no longer permitted, but there is seasonal migration of

Bengali fishers. As the population of the islands grew and uncontrolled timber harvesting began to threaten the islands' rain forests, the Supreme Court issued an order which has restricted extractive activities on land, stopped migration and removed families who have encroached on forest reserves. The restrictions on timber felling and sand mining should reduce the impact of siltation on reefs. Whittingaham op.cit. (2003) maintain the very structural nature of coral reefs has kept out large scale mechanized fisheries. However, poaching by Thai, Burmese and Indonesian fishermen is reported to be a problem.[26] They take sea cucumbers, shells and timber. There is also a danger that foreign vessels will poach fish for the live trade using cyanide.

Bangladesh

St. Martin's Island is the lone shallow reef in the country, located in the far southeast corner. The island covers an area on only 8 km^2, yet it is home to 6,000 inhabitants, who depend on fishing. The fisherfolk migrated from the mainland. The dominant species in the catches are not reef fish, consisting of clupeids, catfish, ribbonfish, perches and croakers. St. Martin's has scientific interest because of its geology and unique algal mat coral association.

The island is seriously threatened by coral mining and collection for the tourist trade. Uncontrolled waste disposal and lack of sewage treatment are major sources of pollution (Hossain, M. M. 2003). Poor land management and pesticides use on the mainland contaminate the waters around the island. The island is promoted as a tourist destination, encouraging coral and shell collection by the inhabitants of the island. A tourist hotel has already been built on the island. It may be fortunate that tourist development is limited by the lack of freshwater.

Myanmar

The majority of coral reefs are found in the Myiek Archipelago, Thanintharyi . The archipelago contains 800 islands on a shallow continental shelf. Little information is available on the status of coral reefs in the Myiek islands, but it has been reported that there is little human impact yet.[27] There is concern that agricultural plantation and road construction projects could lead to pollution by sediments and pesticides. Overfishing

[26] http://www.hindu.com/2000/09/29/stories/0429201e.htm

[27] www.marinasia.com

could be a problem as there appears to be little monitoring of activity. There are about 2,500 Chao Lay nomadic sea people who are related to similar groups inhabiting the Andaman Sea Islands of Thailand. The Chao Lay eke out a subsistence economy based on reef resources.

Thailand

Coral reefs of the Andaman Sea region surround about 130 small offshore islands as well as islands nearer the coast. The good condition of the offshore reefs reflects the more difficult access to them as compared to the near shore reefs, which are in poor condition. The offshore islands are inhabited by the Chao Lay, or Sea Gypsies.[28] They number about 7000 and are nomadic subsistence gatherers, leaving little damage to the reefs as they shift from island to island. Some sub groups have settled along the coasts of Phuket Island and Phang Nga, while others wander among the southern islands in Myanmar (see above). The Chao Lay are gathers and do not fish with nets or other gear, which is why they leave little impact. There have been some problems with integrating their life style into the Marine Protected Areas that they normally frequent, particularly Surin Island. There is also some concern about the effects of tourist development on their traditions and life style. About 60% of the reefs in the Andaman Sea region are threatened by human activity. The main threats are overfishing and destructive fishing practices, sedimentation and pollution emanating from coastal development. Marine based pollution as from oil spills and ballast water discharges is a significant threat to 85% of the reefs in Thailand.

Malaysia

Over-fishing and destructive fishing methods are not serious threats to reefs on the west coast. Other anthropogenic sources are major problems and include tourist development, sediment and pollution from coastal development and pollution originating from the heavy ship traffic along the west coast. Conservation and preservation is limited to the establishment of the Pulau Payar Marine Park in Kedah. Yet even the park is threatened with tourist development in the form of 15 luxury chalets to be constructed on the main island (Buang, S. 2003). Pulau Pangkor reefs have been damaged by an outbreak of sea urchins attributed to pollution and careless behavior by tourists. Turbidity is an early sign of eutrophication from sewage runoff. P. Pangkor is close to the mainland and easily

[28] www.unesco.org/csi/pub/papers2/surin2.htm

accessible (Tan, C.L. 2003). The coral patches around P. Langkawi are also being damaged by uncontrolled tourist activity and illegal coral collection for the tourist trade.

Indonesia

The causes of coral reef destruction in the BOBLME region of Indonesia vary in source and intensity. The worst conditions are found in Riau where most fishers exploit reef resources (Purnomohadi, S. 2003). From 67% to 98% of the reefs are seriously degraded . Cyanide and bombs are widely used in Indonesia and the BOBLME area is no exception. In fact, the use of cyanide is increasing because of the high prices of grouper and Napolean wrasse in the live fish trade. The markets are in nearby Singapore, Hong Kong, Taiwan, China and Japan. There are large scale poison vessels roaming throughout the country, particularly in remote areas (Hidayati 2003). Sediment from sand mining is another serious concern..

In West Sumatra, migratory fishers from North Sumatra fish with cyanide as well as traditional gear. Artisanal fishers here still use sail and apparently have prohibitions against damaging the reef. They do not use poison or other destructive gear. The traditional fishers of North Sumatra value coral reefs and base their fishing practices on a detailed ecological knowledge base. These are fishers who do not have access to modern technology and have difficulty competing with those using modern gear. They do not have the authority, or it is not recognized, to halt destructive fishing practices, particularly divers using cyanide. The cyanide fishers are tied to the export markets through middlemen who finance them. These problems have been exacerbated by the economic crises and weak enforcement. Reefs within 4 km of the coast fall under the jurisdiction of regency and provincial governments, which currently lack the capability to implement conservation measures and enforce regulations.

Sri Lanka

Both population and industrial activity are concentrated in the coastal zone. Although comprising 24% of the land area of the country, it supports 32% of the population, 66% of industry and 80% of the tourist infrastructure (Rajasurya et al. 1998). Sri Lankans rely on fisheries for the bulk of their protein intake, so the condition of inshore fisheries is critical to food security. In fact, about 90% of fishermen are exploiting coastal fisheries, which produce 72% of the catch (Rajasurya op. cit.). Lime is in high demand in the construction industry and to a lesser extent in agriculture so that coral mining has provided employment from the beginning of the colonial era until the present. Coral is mined from inland, old

reefs as well as the living reefs along the coast. Laws protecting coral reefs are difficult to enforce and alternative employment schemes have failed (Premeratne, A. MS).

Alternative employment schemes included fishing and agriculture and toddy tapping. Most participants returned to coral mining within a short time. There are examples of fishers turning to coral mining when their local fishery declined to uneconomical catches. Extensive erosion is threatening beaches exposed by removal of the reef.[29]

Destructive fishing methods are widely used in both the food fishery and marine ornamental fish trade. Blast fishing, poison and inappropriate nets are the culprits. Apart from coral mining and destructive fishing methods, other causes of coral reef degradation are unplanned tourist development, inappropriate tourist behavior (walking on reefs, anchoring glass bottom boats on reefs), and untreated sewage runoff,

Maldives

The 1190 islands of the Maldives are sprinkled over 60,000 km^2 of the Indian Ocean, yet only 202 are inhabited. The country is ninth in the world in population density, above Bangladesh. It also has one of the highest growth rates in the world at 3.2%.[30] As an atoll nation, Maldives depends on its marine resources for basic food needs and economic development. Tourism has been a key element in economic growth and because sport diving is a major component, measures have been taken to protect reefs. Marine protected areas are part of the strategy of conservation. However, poaching has been reported on reefs near tourist resorts (Amir 2003).

Populations shifts in response to economic opportunity have increased pressure on reef resources around the most developed atolls. Garbage disposal, ground water contamination and sewage runoff are degrading reefs. There is some evidence that bacterial diseases of coral may originate from domestic sewage runoff, although there is no record yet of these diseases in the Maldives, The microbe responsible for the disease produces symptoms that can be confused with coral bleaching (Nesmith, J 2002).

[29] Sri Lanka National Report BOBLME

[30] http://www.unescap.org/stat/statdata/maldives.pdf

Men are more mobile than women in seeking employment in developed islands as opportunities arise in the tourist and government sectors. In fact, male employment in fisheries actually declined from 1985 to 1990, but it was countered by gains in other sectors (Kavinve, H.S. 1999). The growth of the cash economy inevitably increases exploitation of reef resources. Ornamental fish exports began in 1979 and although 100 species are traded, only 20 species comprise 75% of the total. Some of these are endemic to the Maldives.[31] and are already locally over-exploited.[32] Selective removal and over exploitation risks destabilizing the reef ecosystem by decreasing biodiversity. The large predators, groupers, are selectively fished to supply the tourist hotel market and live fish export trade. Indeed, declines in export quantity and value indicate over-fishing. Sea cucumbers have been over-exploited in response to demand from China and SE Asia. Sea cucumber fishers move from atoll to atoll, leaving decimating local stocks in their wake. The most valuable species are the first to go, with subsequent over-fishing down the value scale. There are no reports of blast or poison fishing, but some damage to reefs is done by bait fishing, both by the gear and anchoring of the bait fishing boats. Information on methods used in taking ornamental fish was not available, but are presumed to be non-destructive. The mechanization of the fishing fleet and its ability to exploit uninhabited atolls will increase the management challenge.

An important issue for the future of local participation in coral reef resource management is the loss of traditional knowledge as the economy "modernizes." Active fishers are aging as alternatives emerge for better educated young men. It is estimated that 23 to 32% of fishermen are over 50 years of age and that the numbers of active fishers will decline considerably over the next 20 to 25 years (Kavinde op.cit.). Because of the marked differences in gender roles in Maldivian society, traditional knowledge of marine resources resides with the male members of the community.

2.2.2 **Shared issues**

From the above discussion of human-reef interactions, it is apparent that several issues affecting coral reef conservation are common to the BOBLME regioin. Among these are

[31] Maldives National Report BOBLME

[32] http://www.rrcap.unep.org/reports/soe/maldives_biodiversity.pdf

destructive fishing practices , siltation and pollution, unplanned tourist development and coral mining. The intensity of each problem varies greatly from country to country, but common causes can be identified.

2.2.2.1 Destructive fishing practices

Fishing methods can damage reefs mechanically by inappropriate gear or the use of explosives. Potassium cyanide poisoning has become widespread in response to the demand for live fish and marine ornamentals. Over-fishing degrades the biodiversity of the reef, engendering instability and increasing susceptibility to invasive species. For example, over-fishing of herbivores will cause a shift in the algal community with ripple effects through the reef ecosystem. Cyanide fishing is widespread in Indonesia and is proving very difficult to stop. Declining catches and lack of alternative employment drive fishermen to use increasingly destructive methods just to try to stay even economically.

2.2.2.2 Siltation and pollution

Deforestation and inappropriate agricultural practices produce high runoff and accompanying sediment loads. Urban development has similar effects. Construction activities on the shore generate coral killing suspended sediment. Reefs in the once heavily forested Andaman and Nicobar Islands are particularly threatened by siltation. In Sri Lanka, coastal erosion leaches sediment into coastal waters. Ironically, some of the erosion is the result of reef destruction by coral mining. The coral reefs of Thanintaryi, Myanmar, are said to be in good condition, but careless development will increase siltation and agricultural runoff of pesticides. Removal of protective mangrove forest on the landward side of reefs increases sediment discharge by removing the holding capacity of the root systems of the trees.

The effects of organochlorines on invertebrates such as corals are not well known, but they do cause reproductive and immunological abnormalities in vertebrates. Even if they do not directly affect corals, their residues accumulate in fish flesh raising public health concerns.

Agricultural fertilizer runoff can alter the algal abundance and species composition, lead to eutrophication and destabilization of the reef ecosystem. Sewage treatment is the rare exception in the region so as coastal populations inexorably increase, the threat of

eutrophication from sewage-derived nutrients will probably increase. Sewage bacteria are known to cause coral disease as well (see above).

2.2.2.3 Uncontrolled tourist development

Tourist infrastructure development and activities in support of tourism impact the very coral reefs upon which tourism depends. Planners and government officials may be unaware of the ecological importance of coral reefs, nor of their economic value as intact ecosystems. Inappropriate locations, poor design and untreated waste discharge degrade adjacent reefs. Concentrating tourist development in limited areas will increase its impact on the surrounding habitat. Uneducated tourists and tour operators trample over reef flats, while the boats and anchors rip up the reef. Siting tourist development within protected areas makes enforcement of conservation measures difficult and may damage the coral reefs adjacent to the development.

2.2.2.4 Coral mining

Expanding coastal population and the consequent demand for building materials supports coral mining in several countries in the BOBLME region. Only the Maldives government has had some success in greatly reducing this destructive practice by subsidizing the import of alternative materials. Attempts to find alternative livelihoods in Sri Lanka have failed. It is very difficult for coral miners to shift to an activity like agriculture, forfeiting short term income for the uncertainty of agriculture and the indebtedness that accompanies the need for finance between crops. When livelihoods are at stake, laws and regulations will not be respected.

2.2.3 **Root causes of coral reef degradation**

Several of the root causes of coral reef degradation are similar to those impacting the mangroves habitat, but there are also causes unique to the habitat because of the sensitivity of corals to environmental change. Root causes include:

- Weak enforcement. Encroachments into MPA's are tolerated, traditional management regimes have been weakened, poor coordination among myriad concerned agencies, lack of funds to support coastal patrols.
- Export driven fisheries for live reef food fish and marine ornamentals

- Population growth. Land reclamation, deforestation, pollution, poorly planned development.
- Depleted coastal fisheries. No alternative employment or fishery to turn to.
- Lack of awareness of coral reef ecology and the importance of reefs.
- Global climate change. Coral bleaching, rising sea level, starfish invasions, invasive species.

2.2.4 Current mitigation efforts

Attempts to conserve coral reefs in the BOBLME region center around the establishment of protected areas (PA's). These may be internationally recognized biosphere reserves or nationally established marine protected areas or parks. Legal and regulatory frameworks have been put in place to protect reefs both inside and outside PA's. International and national NGO's encourage community participation, sometimes supported by government policy. International NGO's such as the World Wildlife Fund have established centers in some of the BOBLME countries and are actively engaged in coral reef monitoring and conservation projects.

International collaboration

The Marine Aquarium Council (MAC) is an international NGO that has established and promotoes a certification program to ensure sustainable harvesting of marine ornamental fish. Certification is done through an accredited third party. MAC collaborates with UNEP's World Conservation Monitoring Center to set up the Global Marine Aquarium Data Base. It partners with Reef Check and the International Marine Life Alliance to develop monitoring and certification of collectors.

Current research on culture of marine ornamental organisms and commercial development could reduce pressure on reef stocks, provided at least some of the technology can be transferred to fishers. The collection of wild larvae may be the best technology to pursue this avenue of development. Indeed, some cultured organisms have already entered the trade.

Apart from the effects of global warming, one of the most serious challenges is the unhindered trade in live reef food fish (LRFF). For example, most of the poisoning

activity in Indonesia is to supply this market. Surveys in Hong Kong have shown that consumers are willing to reject LRFF when they are informed of the conservation problems posed by this industry. On going research and development of farming LRFF will help to stop the cyanide fishery by providing alternative supply, making it easier to institute bans on cyanide caught fish in importing countries. WWF is conducting awareness campaigns in Hong Kong and is collaborating in a monitoring and detection program there.

Most countries in the BOBLME region have taken measures to protect coral reefs through establishing protected areas, stopping (or trying to stop) destructive fishing, mining and over-fishing.

Bangladesh

There are several internationally funded projects in southeastern Bangladesh that address issues affecting St. Martin's Island::

- Coastal and Wetlands Biodiversity Management at Cox's Bazaar and Hakaluki Haor (BGD/99/G31). A GEF funded project. Includes programme for the conservation of coral reefs, sea-grass bed and turtle nesting areas.

- Aquatic Resources Development, Management & Conservation Studies of the Fourth Fisheries project; A GEF Grant No. TF 022832BD covers the Coastal Biodiversity in the Cox's Bazaar District.

- Empowerment of the Coastal Communities for Livelihood Security (BGD/97/017); a UNDP/FAO Project with a Component on Coastal Biodiversity and Natural Resources Conservation, which also covers St. Martin's Island.

India

The Gulf of Mannar Marine Biosphere Reserve was established in 1989 and is recognized by UNESCO. Fisherfolk are excluded from the reserve, but continue to access its resources. Adequate alternative employment generation has not progressed (Whittingham et al. 2003).

The Supreme Court decision to stop upland deforestation and reduce population pressure on resources in the Andoman Nicobar Islands is being implemented.

The Coral Reef Monitoring Network within the Ministry of Environment and Forests. monitors reef condition, undertakes training/capacity building, is establishing a data base network, and tries to integrate research and management.

India participates in the Planning and Coordination Committee of International Coral Reef Initiative (ICRI).

The all India coordinated project for conservation and management of coastal and marine biodiversity started in 1999. It includes the survey and inventory of coastal and marine biodiversity on both coasts, establishes database and documentation centers for priority areas at specialized east and west coast institutions and is setting up a network between these centers. It undertakes training and capacity building in taxonomy of coastal and marine organisms to fill current gaps in this field

Through its Centre for Environmental Law and the BHCP, WWF-India has taken up a project for developing a handbook on environmental law and policies for the Andaman and Nicobar Islands.

India is active in various international cooperation projects and programs. India is a focal point for GCRMN and the ICRI. Projects include the India Australia training and capacity building project on coral reefs, the UNDP/GEF project on Gulf of Mannar and Andaman and Nicobar coral reefs, and the inclusion of the Gulf of Mannar in the World Network of Biosphere Reserves by UNESCO. Also, WWF is working with local communities in the Andaman and Nicobar to set priorities for coral reef conservation.

Thailand

Twenty-one Marine National Parks have been established and the Marine National Parks administration has been re-organized into a Marine National Parks Division to focus on the parks.. Community Conservation Areas allow fisherfolk set aside coral reefs for protection from fishing.

The CHARM Project works in Phang Nga, Krabi, Trank, Phuket to design and establish coastal habitats and resources co-management framework and procedures to serve as models. Dept. of Fisheries, Land Development, Office of Agricultural Economics, National Parks, Wildlife and Plant Conservation, Harbor Department, Marine Promotion Commission, Marine Coastal Resources, Policy and Planning of Resources and Environment, the Tourism Authority of Thailand and NGO's.

National Action Plans for Coastal and Marine Environment and Living Resources Protection attempt to balance conservation and development. The plans focus government attention on coral reef and mangrove conservation and rehabilitation. These plans represent a long term commitment but their effectiveness will depend on funding level, enforcement, and community involvement. Coral reef directed strategies include MPA's, declare land use zones, conserve or rehabilitate depleted fisheries, provide budget and facilities for law enforcement, monitoring with remote sensing, control construction activities, and ensure development activities follow laws and regulations.

Malaysia

The Marine National Park at Pulau Payar was recently established to protect the reefs around several small islands. No exploitation of any kind is allowed within the park.

An ICZM framework has been adopted to control development and protect marine ecosystem. The National Policy on the Environment, 2002 promotes environmental protection and the National Policy on Biodiversity, National Coastal Zone Policy is in the process of formulation.

Indonesia

The ADB Reef Resource Management Project covers North and West Sumatra and Riau . It supports institutional strengthening, community based resource management and development and runs from 2002-2009.

The Coral Reef Rehabilitation and Management Program. (COREMAP) is a national project in support of integrated coral reef management. It attempts to integrate government, NGO's, business, universities and local communities in awareness building and

community-based management COREMAP provides seed funds and village grants for CBM and includes development of alternative income generation. The project has established a program of monitoring, control and surveillance (MCS) to strengthen the legal framework at a demonstration site in Riau. The project needs improvements in implementation and funds disbursements.

A national system of Coral Research, Information and Training Centers (CRITIC) was set up in April 2000 and a branch established in Riau. The objective of CRITIC is to set up research and information centers and provide national and regional training. Reef health monitoring is emphasized at the Riau branch (Hidayati, D. 2003).

Sri Lanka

The CCD adopted an ICZM strategy in 1990 to improve management of coastal resources. Several measures have been taken to conserve coral reefs, including marine reserves at Bar Reef and Hikkaduwa. The administration of the Hikkaduwa reserve has had problems because of the heavy use of the area by the tourist industry. SAMP's under CRMP have been put in place at Bar Reef, Hikkaduwa and Rekawa, but need long term support.

Ban on lime kilns in the coastal zone, but enforcement weak.

On-going coral reef research by NARA, Universities of Colombo and Rahuna.

Membership of Sri Lanka in the GCRMN supported by IOC/UNEP/IUCN.

Participation in CORDIO. SIDA, World Bank, WWF, FRN ,MISTRA. Monitors biophysical, socio-economic impacts of reef degradation. Focuses on solutions including rehabilitation, management options and alternative employment.

Declaration of coral reef areas as Fisheries Management Areas, export restrictions on threatened marine fish species.

Maldives

- The tourist industry is supporting enhancement projects including coral accretion experiments, turtle breeding and tagging, sponsoring environmental education for

students, sponsoring waste disposal initiatives for neighbor islands, supporting environmental activities undertaken by local communities.

- Awareness and education activities are broadcast by the mass media. At the local level, esource management and environmental improvements undertaken by Atoll Development Committees.
- Prohibitions on overexploited or endangered reef species such as red and black coral and giant clams are in place. There are species quotas on the export of marine ornamental fish and a ban on shark fishing in tourist zones.
- Fourteen marine protected areas were recently established in the central atolls.

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3 *Transboundary issues.*

The TOR for this review define "transboundary issues" as those "concerning those critical habitats that two or more countries have in common and that are either likely to require collaborative interventions by the countries concerned or for which a single country intervention would achieve maximum demonstration/replication value for the BOBLME region as a whole."

The major problems facing critical habitats in the BOBLME region are mangrove habitat loss and coral reef degradation. Many, if not most, issues confronting these critical habitats are local or national, as described in previous sections. However, there are region-wide challenges which meet the transboundary definition. Fig. 2 illustrates the relationship between major problems, transboundary issues and root causes. The figure shows that four of nine transboundary issues may affect both critical habitats.

Figure 2 Transboundary issues and root causes

Major Problem	**Transboundary issue**	**Main Root Cause**
Mangrove habitat loss	• Sedimentation • Oil spills • Invasive alien species • Contiguous habitat • Sea level rise	1,3 2, 4 2, 4 1,2,3,4,5 4,5
Coral reef degradation	• LRFF/Ornamental overfishing • Oil spills • Sedimentation • Invasive alien species • Coral bleaching • Sea level rise	2,3,4,6 2,4 1,2,3,4 2,4 2,4,5 1,2,4,5, 2,4,5

Main Root Causees	
1.Population growth	• Lack of alternative employment • Dependence on natural resource extraction. • Poverty and disempowerment • Unsustainable agriculture practices • Uncontrolled migration into coastal zone
2. Weak institutions	• Inadequate funding for enforcement • Weak international enforcement • Low capacity at local level of government. • Political interference in management decisions • Poor coordination among national institutions
3.Poor stakeholder participation	• Weak traditional resource management • Weak commitment to stakeholder participation • Lack of public awareness of environmental issues
4. Inadequate knowledge	• Lack of research capability • Need for base line resource assessment •
5. Global warming	• Increasing carbon dioxide emissions by industrialized countries • Unpredictability of long term effects
6. International luxury seafood market	• No controls in importing country • Lack of consumer awareness in importing countries • No export control

3.1 *Sedimentation*

Two aspects of the issue are the huge sediment loads of the major rivers of the upper Bay of Bengal, namely the Ganges-Bhramaputra and the Ayeyerwady rivers and their watersheds. Deforestation and unsustainable agriculture practices on steep slopes are causing rapid soil erosion and high rates of sedimentation which threaten mangrove habitat and affect the productivity of coastal waters. Alleviation of increasing sediment loads depends on the success of erosion control measures taken in the watersheds of these great rivers. Cooperation among the co-riparian countries will be necessary to formulate any permanent solutions to the sediment problem. A second component is mismanagement of watersheds which may straddle the borders of several countries or whose runoff affects the marine environment of a neighboring country.

The second aspect is sediment produced by local sources, for example, tin mining, that is carried into the coastal waters of a neighboring state. Poor water shed management in one state may also cause high sedimentation which can be carried into an neighboring state. Deforestation, urban development and unsustainable upland agriculture are examples of watershed deterioration that increase runoff.

3.2 *Oil spills*

BOBLME participating countries have placed a high priority on developing responses to oil spills and to participating in regional organizations whose mandates are the prevention and amelioration of oil spills. Among these are:

Action plan for the protection and management of the marine and coastal environment of the South Asian Seas Region. Bangladesh, Maldives, India, Sri Lanka, Pakistan.

Capacity building, seminars and training courses to implement the Regional Oil Contingency Plan and assist member states develop national plans.

South Asian Cooperative Environment Programme (SACEP). Acts as secretariat for the South Asian Regional Seas Programme. Its mission is "to promote and support the conservation and management of the environment, both natural and human, in the member

states of the South Asian Region in a co-operative manner, to achieve sustainable development."

Oil Watch. Network of environmental, human righs, religious and local organizations to support and strengthen local initiative in the struggle against negative impact of oil and gas exploitation in tropical countries. Members include India, Sril Lanka and Bangladesh.

International Tanker Owners Pollution Federation (ITOPF). Ship owners association. Technical services including response to oil spills. Maintains data base on member countries.

International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (MARPOL 73/78). The MARPOL Convention is the main international convention covering prevention of pollution of the marine environment by ships from operational or accidental causes. It is a combination of two treaties adopted in 1973 and 1978 respectively and updated by amendments through the years.

Oil Spill Prevention and Response (OSPAR) Project for ASEAN. This involves the stockpiling of oil spill response equipment throughout this region (initially in Port Klang, Port Dickson and in Singapore). The project was initiated by the Japanese Government and is being implemented with assistance from the Petroleum Association of Japan. The total cost of the project is over US$ 10 million.

There already is a high degree of cooperation among some of the BOBLME countries and there are several regional and international organizations that provide a framework for cooperation. However, a great deal has to be done to improve response capability. Detecting small scale illegal dumping is particularly difficult.

3.3 *Invasive alien species*

Judging from the sparse mention in the national reports of the risks posed by alien species, their danger seems to be under appreciated in the region. Some authorities believe exotic or non-native species, as they are sometimes termed, are the leading cause of species extinction after habitat destruction.[33] One can point to several well known examples from

[33] www.eces.org/ec/bioinvasion/general.shtml

temperate waters which have caused enormous damage. There are some records of exotic species in tropical waters, for example, several have been identified in Hawaii (Coles and Eldredge 2002). Invasive alien species are considered a major threat to the Great Barrier Reef of Australia because of the large discharges of ballast water around the reef. Indeed, 15 introduced species have been found in Queensland ports (Haynes, D. 2001).

Introductions may be accidental or intentional. Accidental introduction is mainly via discharged ballast water or fouling organisms on ship bottoms. Dumping marine aquaria into local waters may introduce exotics. This is how *Caulerpia toxifolia* was introduced into the Mediterranean and it has decimated sea grass beds over a wide area.

The Global Ballast Water Management Program (GloBallast)set up by The International Maritime Organization (IMO) undertakes measures to reduce the risk of invasive alien species through the discharge of ballast water . Voluntary guidelines have been developed for member countries that emphasize risk reduction as opposed to ballast water treatment. Ballast water treatment is still under study, but there are some promising technologies under consideration. India participates in GloBallast, and has established a task force, pilot sites (Mumbai), implemented a national work plan and is reviewing legislation. She is also exploring cooperation with other countries in the BOBLME region.

Some coastal states have enacted legislation that requires ballast water exchange far off shore or discharge into approved facilities while in port. The state of California (USA) has enacted comprehensive legislation to control ballast water discharges. Washington state (USA) also has legislation to minimize invasive species from ballast water discharge, but it is not as comprehensive as Califoria's. BOBLME countries do not yet have specific legislation to address this critical problem. However, enacting legislation without the necessary institutional strengthening will probably not accomplish much.

The Global Invasive Species Program (GISP) was established to address global threats caused by invasive alien species (IAS), and to provide support to the implementation of Article 8(h) of the Convention on Biological Diversity, the CBD. GISP can be an source of support to BOBLME countries but a major issue is the lack of taxonomic capacity needed to develop reliable data bases.

Intentional introductions can and are being made by aquaculturists. These introductions are often made without proper EIA studies or monitoring by authorities. The Pacific white shrimp (*Litopenaeus vannamei*) has been introduced into Indonesia with little consideration for possible negative impacts. A viral disease of *L. vannamei* has been detected in Indonesia , illustrating the dangers of uncontrolled importation of exotic species for aquaculture.[34] Malaysia has banned its import and ordered shrimp farmers who are rearing the species to get rid of it. There is some brackishwater culture of tilapia hybrids in the region, despite the lack of knowledge of the fate of escapees. The trade in marine ornamental organisms is another potential source of exotic species introductions.

Global climate change may also be an agent for the spread of species beyond their normal range into previously unexploited habitats. Regular monitoring of critical habitats will be needed to ascertain the extent to which this may be occurring .

3.4 *Shared habitat*

Habitats may straddle the boundaries of two or more countries. The Sundarbans is one example, but there are also mangrove forests lying across the borders of Malaysia and Thailand and Thailand and Myanmar. Even mangrove habitat loss in a neighboring country may have repercussions on fish stocks, since come migratory species use mangroves as nursery areas. Although coral reefs may be within the national boundaries of one nation, they may be providing recruitment of organisms to "downstream" reefs in a neighboring country.

India and Bangladesh are establishing a joint strategy for biodiversity management of the Sundarbans. This effort is being supported by the UN International Partnership Fund, UNESCO and UNDP. Full funding is expected from the Ted Turner UN Foundation.[35]

3.5 *LRFF/Ornamental over-fishing*

The live reef food fish (LRFF) and marine ornamental fisheries are in response to international markets and in both cases they are luxury goods. On a per kilo basis, marine

[34] http://www.enaca.org/Health/News.htm

[35] "Experts meet on Sundarbans biodiversity strategy" The Daily Star May 13, 2002.

ornamentals can reach thousands of dollars of retail value. The marine aquarium industry through its international association, the Marine Aquarium Council (MAC) has undertaken a certification program to reduce destructive fishing practices. MAC is developing a Memorandum of Understanding with the Ministry of Marine Affairs and Fisheries in Indonesia and has hired a full time coordinator. However, there are not yet any certified collectors or collecting sites in any of the BOBLME countries.

Unfortunately , there is no comparable organization to ensure sustainable harvesting of LRFF. It is very difficult to control cyanide fishing (the main method of LRFF fishing) in widely scattered islands and atolls, so action will probably have to be taken at the consumer level. Consumer surveys in Hong Kong have indicated an awareness campaign could reduce LRRF consumption (Chan N.W.W. 2000).

3.6 *Global warming*

The International Panel on Climate Change (IPCC) develops climate models to predict changes in average atmospheric temperature as global warming proceeds. Current models indicate a range of increase between approximately 2^o and 4^o C by 2100 AD. Recent periodic episodes of increased sea temperature associated with ENSO events are believed to be associated with climate change.

3.6.1 **Sea level rise**

IPCC estimates mean sea level has risen between 10 and 20 cm during the past century and predicts it will rise between 9 and 85 cm by 2100 as the climate warms.[36] There is still a great deal of uncertainty in the amount of sea level rise, but rise it will. Mangrove forests will shrink or disappear , depending on the extent of the rise. Fringing reefs are likely to be inundated, leading to accelerated coastal erosion. For atoll nations like the Maldives, sea level rise is a survival issue. Indeed , in the Pacific, residents of Tuvalu are already being evacuated. Apart from the loss of mangroves and declining fisheries, the effects on coastal peoples in the region are likely to be severe. About 150 million people live on the low elevation coastal lands on the Indian coast of the Bay of Bengal and they will be severely impacted by inundation and storm surges..

[36] www.ipcc.ch

Responses to sea level rise include [37]:

a. Retreat. The coastal zone is abandoned as ecosystems shift landward. It may simply be too expensive to protect the coastal zone.
b. Accommodation. No attempt is made to keep sea water out, but people continue to use the land at risk. Options include construction of flood shelters, erecting buildings on pilings, converting flooded lands to fish farms, or farming flood or salt tolerant crops.
c. Protection. Dikes and seawalls are constructed to protect the land from seawater intrusion. "Soft" solutions such as sand dunes and vegetation can also be used to try to maintain existing land uses.

3.6.2 Coral bleaching

The most severe coral bleaching event ever observed occurred during 1997-98, affecting coral reefs over most of the Indian Ocean and Bay of Bengal region. The degree of bleaching and affected taxa varied geographically and with depth. Bleaching was associated with global warming in view of the high sea surface temperatures and the fact that 1998 was the warmest year on record in the 20th century (Anonymous c 2001). The degree of recovery has also varied considerably.

Westmacott et al. (2000) recommend the following measures to help reefs recover from bleaching and reduce stress on the reef:

1. Marine Protected Areas (MPAs) will play a key role by helping to maintain sources of coral larvae to damaged areas. MPAs can also protect those areas where corals are struggling to recolonise damaged areas. Management actions in relation to MPAs, that will contribute to reef regeneration include:

• Identifying reef areas with least damage within MPAs and reviewing, and revising where necessary, zoning schemes and boundaries to ensure that healthy reefs are strictly protected.

• Ensuring that existing MPAs are effectively managed.

[37] www.yosemite.epa.gov/oar/globalwarming.nsf

• Developing a more strategic approach to the establishment of MPA systems, including consideration of *sources* and *sinks* and inclusion of a wide geographic spread and variety of MPA types.

2. Reef fisheries may be negatively affected on reefs that have suffered major mortality and are losing their physical structure (and thus unable to support a diverse and abundant fish community). A precautionary approach can be taken by giving specific attention to the following:

• Establishing no-fishing zones and limitations on fishing gear to protect breeding grounds and provide fish with a refuge.

• Considering specific protection measures for species that can contribute to reef regeneration, such as algal grazers, or that might be affected by coral bleaching, such as coral-eating fishes.

• Enforcing legislation prohibiting destructive fishing practices.

• Monitoring the catch composition and size to evaluate the success of management strategies and implementing new strategies if necessary.

• Developing alternative livelihoods for fishing communities as needed.

• Limiting entry of new fishermen to a fishery through licensing schemes.

• Regulating coral collection for the curio and aquarium trades.

3. Tourism in areas with bleached reefs can be maintained through the provision of other activities, both related and unrelated to the reef. Some management options include:

• Maintaining healthy fish populations for divers and snorkelers through creative use of zoning to reduce pressure from over-fishing and frequent tourist visitation.

• Involving tourists in the bleaching issue by offering opportunities for participation in monitoring programmes.

• Emphasizing other attractions for tourists, both on land and in the water, besides coral reefs.

• Reducing the impacts from tourism operations in general, such as direct damage to corals from divers and snorkelers or from boat anchors, and indirect damage from coastal activities that support the tourist industry.

• Encouraging tourists to contribute financially to recovery and management efforts.

• Conveying information to the public through outreach and education.

4. Integrated coastal zone management (ICZM) will be crucial so that bleached reefs can be managed within the context of the land-use decisions being made in adjacent drainage

basins. From the perspective of coral bleaching, particular aspects of ICZM that need emphasising include:

• Establishing MPA systems within an ICZM framework.

• Implementing measures to promote sustainable fisheries.

• Implementing mechanisms to promote environmentally sound construction and other forms of land-use and coastal development.

• Regulating land-based sources of pollution.

• Managing shipping and other vessels to reduce damage to reefs from physical impacts or spills.

• Protecting the coastline from erosion.

3.7 *Knowledge gaps, policy distortions and institutional deficiencies*

The resolution of transboundary issues will require regional coordination on questions of policy and law and international collaboration to overcome existing gaps in knowledge. Problems generated by global warming are particularly difficult to confront; developing coping strategies may be the only answer, at least in the short term.

3.7.1 **Invasive alien species**

The problem of invasive or alien species should be given more attention in the region, given their potential for damaging critical habitats. Awareness of the problem should be increased among stakeholders including the marine science community in the BOBLME region, fishers and government officials concerned with the marine environment. Detection of the presence of invasive species will require the development of taxonomic expertise coupled with regular surveying.

Marine parks and protected forests as well as disturbed habitats can be targeted for surveys. Usually responsibility for critical habitats is spread among several ministries and often expertise in a particular problem may be lacking or limited . For example, aquatic biologists are found in fisheries and environment organizations, while botanical expertise may be restricted to forestry departments or universities. There is also indigenous knowledge of the flora and fauna; fishers and harvesters may be sensitive to changes that

may occur as the result of the presence of invasive species, so there needs to a way to access and utilize indigenous knowledge. A management structure should be developed to coordinate and focus expertise on the problem of invasive species. If invasive species are found, regular monitoring of its population and its ecosystem effects will be required.

On a regional level, BOBLME countries can develop a coordinated policy and legal framework on ballast water discharges and the movement of commercial exotic species. Assistance from the IMO and OIE should be sought to facilitate the development of policy and law.

3.7.2 Shared habitat

Martosubroto and Willmann (2003) point out that habitat loss has transboundary implications when fishers from two or more countries target a shared stock, especially if management effectiveness varies among the countries.

- There is a need to assess what is known of shared stocks. For example, which species use mangroves or coral reefs during some part of their life cycle in one country, but are targeted by multi-national fishers?
- How can critical habitat conservation and rehabilitation be coordinated between countries sharing such habitats? An example of India and Bangladesh coordinating efforts to save the Sundarbans was given in a previous section. Can this model be applied in other cases, for example mangrove habitats in the Andaman Sea shared by Thailand and Myanmar?

3.7.3 LRFF/Ornamental over-fishing

Issues raised by the trade in LRFF and ornamental over-fishing are 1) the extent of knowledge of which species are over exploited, 2) how to stop destructive fishing practices, and 3) reduce demand for LRFF and wild marine ornamental fish. Among the remedies that might be employed are the following:

- Expand reef surveys to ascertain which species have been over-fished, the extent of reef damage and what, if any, rehabilitation measures can be taken.
- Explore to what extent mariculture can replace capture of LRFF. A critical issue is the transfer of mariculture to fisherfolk communities. Problems include life style change,

income support, credit and financing, and training. Extensive development of hatcheries may also be necessary since the use of wild fingerlings should be strongly discouraged. There are models in the region which may be useful. As an example, the marine fish hatchery at Gondol, Indonesia spawns their brood stock and the eggs are then sold to local hatcheries, which rear them to fingerling size.

- How can fisherfolk communities become more involved in fisheries management? Inadequate enforcement of conservation regulations including activities in MPA's and the use of destructive fishing methods was frequently mentioned. Limited budgets and personnel are part of the problem. Even if these shortcomings can be remedied, more community involvement is essential. Fisheries management agencies need to deepen their knowledge of traditional management systems and how they can be revived and strengthened. Collaboration with university anthropologists and rural sociologists will be important in this effort. The return of the commons to local control is another approach so that fisherfolk communities assume responsibility for the resources upon which they depend. The role of local NGO's in education and organization will be important, but NGO's themselves may require education and training in some of the technical issues.
- Strengthen ties with international NGO's to undertake public awareness campaigns in consuming countries to try to reduce demand for LRFF. Collaboration with the Marine Aquarium Council needs to be expanded, especially the certification programme. MAC itself has partnered with UNEP to establish the Global Marine Aquarium Database. Indonesia, Maldives and Sri Lanka are participants.
- The BOBLME project can support fisheries research institutions of participating countries to strengthen collaboration with organizations like the Hawaii Institute of Marine Biology for the introduction of simple methods of ornamental fish culture based on the collection of wild larvae. Artificial breeding can also be an option provided that local communities can be involved in some phase of the rearing process,

3.7.4 **Oil spills**

Large oil spills on the high seas are uncommon, but oil from vessel groundings can readily spread into neighboring states. Strengthening regional cooperation will improve the chances of containment and clean up. Several shortcomings should be addressed to improve the capability of containing large oil spills:

- The International Tanker Owners Pollution Federation Limited (ITOPF) considers that with the exception of India, South Asian countries do not have the capability to deal with spills of more than 100 tonnes. [38] Malaysia, with aid from the government of Japan, has established oil spill response centers under its marine department.[39] Thailand has established response centers in the Gulf of Thailand, but does not have facilities in the Andaman Sea region .
- The need to strengthen international collaboration. Not all of the states in the BOBLME region are Signatories to the International Convention on Oil Pollution Preparedness, Response and Cooperation (OPRC) in the BOBLME region include India, Malaysia and Thailand. The IMO recently approved the International Convention on Oil Pollution Preparedness, Response and Cooperation Hazardous and Noxious Substances Protocol (OPRC-HNS), one whose objectives is to foster international cooperation in dealing with spills of all kinds. BOBLME states are not yet participating in this protocol.
- Improve modeling and predictive capacity on a regional basis. Some countries are developing GIS databases for the identification of sensitive habitats and prediction of the effects of oil spills on them. There is a need to expand the integration of remote sensing and GIS analysis to develop predictive models.

3.7.5 Sedimentation

Section 3.1 described two components of the sedimentation as they affect transboundary concerns. One of these was identified as the huge sediment loads of the major rivers of the upper Bay of Bengal. Strategies have been developed for coping with monsoonal and flash floods, but not much attention has been given to the consequences of sedimentation, particularly as it might affect the Sundarbans, the mangroves of the Ayerawady Delta and the communities that depend on them. Questions that arise are:

- What is the best way to deal with newly accreted (char) lands? Among alternatives that need further exploration are 1) Allow colonization by natural vegetation in the hopes of stabilizing the chars, 2) Development as silvipisciculture units or fish farms.
- What are appropriate mechanisms for community planning and participation ? .

[38] www.itopf.com/regional_profiles

[39] www.itopf.com/country_profiles

- The need to strengthen and protect the rights of access to char lands of landless coastal people
- How can coordinated coastal zone planning between concerned states help develop coping strategies?
- Viable coping strategies need to be identified and implemented. Just as in the case of sea level rise, sedimentation in the large river basins is of such magnitude that the only viable strategy may by one of coping with its consequences.

3.7.6 Sea level rise

Long range policies and plans need to be developed to cope with rising sea level. Some of the gaps that must be filled are [40]:

- National coastal planning. Coastal zone management plans must take into account the effects of sea level rise. Management should reduce risk to humans and at the same time recognize the need to protect important ecosystems. Coastal areas at risk need to be identified as well as ecosystem functions if there is a one meter rise in sea level. The effects of adaptive response on these ecosystems should be assessed. Nations should ensure that coastal development does not increase vulnerability to sea level rise. In addition, emergency preparedness and coastal zone response mechanisms need to be evaluated.
- International cooperation. States should seek technical and financial support to deal with the effects of rising sea level. This includes assessing coastal resources at risk and increasing the capacity to deal with the problem through education, training and technology transfer.
- Research, data and information. Research on the impact of global climate change on the regional and national level needs to be strengthened. BOBLME states can strengthen links with international organizations (IOC, WMO and UNEP) to participate in an international ocean observing network that will improve assessment and monitoring of changes in the Bay of Bengal and coastal areas surrounding it. BOBLME states need to encourage the sharing of information of sea level rise, global climate change and their impacts on adaptive options.

[40] www.yosemite.epa.gov/oar/globalwarming.nsf

3.7.7 Coral bleaching

The consequences of coral bleaching include impacts on biodiversity, socio-economic consequences and indirect effects of ocean warming associated with climate change including disease, sea level rise and storm surges (IUCN 2000).

Although some effects of bleaching on biodiversity have been documented, a more detailed picture of changes in flora and fauna needs to be developed and particularly how these impacts will affect fisheries management and rehabilitation efforts. The reasons for variations in recovery from coral bleaching are often unclear and require further investigation.

Socio-economic impacts require further investigation and documentation. For example, bleaching may cause a shift to lower value herbivorous fish, which will increase pressure on reef resources as fishers attempt to compensate for reduced income. Ecotourism will be affected by wide spread bleaching.

In view of the limited resources available to most countries in the region, monitoring and mitigation efforts can be enhanced in several ways:

- Develop monitoring programs that involve local stakeholders,
- Improve coordination between public agencies with responsibilities for coral reef management,
- Build technical capacity at the local level with international financial support,
- Collaborate with ICRI to develop regional monitoring programs and data bases incorporating satellite and GIS technology. The BOBLME project could play an important financial and technical supporting role.

4 *Priorities for cross sectoral ecosystem actions*

Stemming and reversing the loss of critical habitats in the region while meeting the needs of coastal people will be a long term challenge for the BOBLME region. In order of priority, actions that can be taken to confront the challenge are:

- Strengthen community based management systems

- Identify viable alternative employment options
- Rehabilitate damaged ecosystems

4.1 *Strengthening community based management systems*

Stakeholder participation in management of natural resources has assumed increasing importance. However, as noted above, traditional knowledge and management systems have become weakened in modern times. Much has already been lost as young people are drawn to urban centers in search of employment. Community based management systems can be strengthened by:

- Strengthening resource management capacity at the village level. Integrate traditional and scientific knowledge. Increase participation in management decisions. Increase knowledge through local seminars, street theater, comic books or other means of culturally relevant communication techniques. Primary and secondary schools can be enlisted through teacher training and community outreach programs. BOBLME can serve as a venue for sharing information and experience among communities around the region.
- Support local and national NGO's working with resource management issues.
- Return control of the commons to local communities.

4.2 *Improving local government capacity*

Considerable responsibility for the management and development of coastal marine resources falls on local governments in several BOBLME countries as pointed out in previous sections. For example, in Indonesia this would be at the kabupaten (regency) level or the provincial level in Sri Lanka. There is a need for training and awareness building for local officials and community leaders that develops an appreciation of the economic value of critical habitats. Appropriate training in integrated coastal zone management will improve the quality of development planning. Educated local government officers will be more sensitive to development issues and can counter pressure by business interests to exploit or develop the resources of these habitats in unsustainable ways Among the ways in which this might be accomplished are:

- Establish stakeholder-based management groups for specific at risk critical habitats. This will encourage communication between local government and user groups. An

important function of management groups will be coordination between the often diverse agencies and institutions with resource management responsibilities over critical habitats.

- Expertise in resource management at the local level is in short supply. There is a need for dedicated staff to deal with critical habitat issues. Expertise can be strengthened through in service training and inter provincial workshops focused on specific problems.
- Improve access of local governments to information through internet resources. and regional databases.

Environmental education at the primary and secondary school levels plays an important role in raising community awareness of issues facing the sustainable use and conservation of critical habitats. Scientists and educators can develop packets of teaching materials appropriate for primary and secondary schools. Periodic environmental workshops for teachers can be part of environmental curriculum development.

4.3 *Identifying sustainable alternative employment options*

Finding and developing alternative employment for communities dependent on natural resource extraction faces many difficulties. Fishers and other resource extractors subsist on short term income from sales of the products obtained from reefs and mangrove forests. In the case of fishers, timber and honey harvesters and the like, the income is often on a daily basis. There is heavy dependence on money lenders to tide the family over periods of poor fishing or seasonal lulls. It is very difficult to shift into agriculture or aquaculture, activities which require income support until regular harvests begin. Probably what is called for in many cases is a gradual shift away from dependence on critical habitat resources to alternative income sources. An important ancillary condition of successful alternative employment development is insuring that coastal resources are sustainably managed .

An important strategy is to encourage out-migration from communities dependent on critical habitat resources through improved education. There is a need to strengthen vocational education at the secondary school level so as to prepare students for industrial and white collar jobs in the private sector. Well trained teachers and properly equipped shops and laboratories are an integral part of good vocational training and will require sustained support from donor agencies, education authorities and NGO's.

4.3.1 Alternatives for mangrove dependent communities

- Fodder and food production based on halophytic crops. Examples are *Salicornia*, which yields fodder, edible oil and high protein meal. Salt tolerant acacias yield timber and fodder for animal husbandry. Small animal husbandry may offer income generating opportunities for women. Silvipisciculture systems may be possible if a trench and dike system can be constructed. Cropping systems such as the above may be applicable in buffer zones which have been highly degraded and on higher elevation saline soils.
- Managed mangrove timber harvests. The long experience of the Matang Forest Reserve in Malaysia shows that sustainable mangrove harvesting is possible. However, the administrative structure for the Matang Forest management was established during the colonial era. Fortunately, the value of the forest was recognized after independence and sustainable management continues to the present day. Unfortunately, sustainably managed forests are rare in the region because management has emphasized short term revenue generation. Part of the process of reversing the decline of mangrove habitat will be the return of the commons to local control, a scenario in which community based management will be a key element of sustainable timber harvesting.
- Mangrove-compatible aquaculture. Mud crabs (*Scylla spp.*) are a valuable product of the mangrove habitat, but are commonly over fished. Commercially viable seed production has been developed by SEAFDEC at Iloilo, Philippines. Mangrove friendly culture techniques have been developed in Sarawak, Malaysia. Mud crab culture offers opportunities for specialization in nursery rearing, grow out, marketing and feed production. Apart from the seed production problem, feed availability and cost must be carefully considered. Low value by catch is usually used, but supplies may be seasonal. . An important advantage of mud crab culture is the well developed marketing network in most of the region.

Bivalve mollusk farming has very low environmental impact, but is very market dependent. Good markets exist in Thailand and Malaysia and perhaps in urban centers in Indonesia. Tourist based opportunities may exist in other countries. Culture technology is simple and low cost, but seed supply and sanitation are major problems. Hatcheries can solve the seed problem, but are viable only for high value species. Most coastal

waters in the region are contaminated with fecal coliform bacteria, so depuration will be required. Depuration adds cost and may be too complex to use at the farmer level.

Small scale finfish cage culture is an aquaculture technology with limited environmental impact, provided indigenous species are used. It is widely practiced in Thailand, Malaysia and Indonesia. Potential problems include introduction of exotic species, effects of interbreeding of hatchery bred escapees with wild fish, cost and availability of suitable feeds, financing, marketing and training. Disease is also a risk and there are few aquatic veterinarians to diagnose disease and provide treatment guidelines. Salt tolerant tilapia have potential for cage culture and are already farmed in some of the BOBLME countries. The tilapias are exotic species and little is known of the fate of escapees although a search of the literature did not reveal any problems. The risk of ecological impact can be reduced if monosex or sterile triploid fish are cultured.

- Silvipisciculture, or *empang parit*. Empang parit is a traditional fish culture system in Indonesia. The system incorporates varying ratios of mangrove to water surface area. The most common model is an area enclosed by a dike with a peripheral ditch surrounding a central platform. The central platform is inundated at low tide and is planted with mangrove species. Water exchange is by tidal flow through screened sluice gates. The aquatic productivity of the empang parit is inadequate without inputs of nutrients and seed stock. Nutrient input can be in the form of animal manure from sheep or goats reared in pens placed over the water surface. The fry of milkfish, shrimp, and salt tolerant tilapia can be stocked. Commercial species of mangrove planted on the central platform are managed as sustainable wood lots. Mud crabs may be grown in pens established on the platform. Empang parit may be suitable for highly degraded mangrove habitat or for establishment on newly accreted lands. However, a thorough financial analysis is required because the cost of dike construction is high.

4.3.2 Alternatives for coral reef dependent communities

Whittingham (op. cit.) provide a lucid discussion of the problems of developing alternative income sources for coral reef dependent communities. Among these are:

- Income diversification and occupational migration can increase short and medium term risk for poor folks. An important role for development agencies is to take on some

of this risk by supporting the uptake of sustainable income alternatives or to enhance existing opportunities.

- Alternatives have to be closely linked to the resources of the poor and to the requirements of local markets. The seasonal context of traditional occupations and the shocks and changes endured by poor communities have to be taken into account.
- Support from development agencies is often not long term enough to support the adaptation of communities to alternative livelihoods.
- A systematic approach is needed that looks holistically at livelihoods and develops solutions in partnership with target groups.
- Local livelihoods need to be thoroughly understood and time must be allowed for developing a dialogue to foster mutual understanding, planning development and evaluation.

Coral reef dependent communities may be isolated and have access to few resources beyond those provided by the reefs. In this situation, access to markets is a serious constraint. Poor soil, limited land area and scarce freshwater restrict agricultural options. There are options based on the sustainable use of reef resources which have had some success or have potential. The following is not meant as a "shopping" list, but rather a review of some of appropriate technologies and problems which have to be overcome for them to be sustainable.

- Culture of ornamental fish based on the collection of wild larvae (Mankin 1999). Issues include technology transfer, support for rearing facilities and developing an efficient marketing structure through collaboration with local and international traders. Certification through the Marine Aquarium Council (see above) should be an integral part of an ornamental fish culture programme.
- Seaweed farming. Carageenophytes are widely cultured and have been incorporated in several alternative income projects for reef dependent communities. Although demand for carrageenan is growing at about 5% annually, there are issues of processing quality at the farm level and proper culture techniques to ensure high quality raw material. Agarophytes have potential in some countries, although they are not as widely cultured in tropical waters. Seaweed farming also offers economic opportunities for women in both farming and processing.

- Sea cucumber culture. Juveniles produced in hatcheries can be used to restock depleted resources and to establish culture-based fisheries. A number of problems still exist with the logistics of culturing holothurians, as evidenced by the aquaculture efforts of Pacific Island nations, in areas such as broodstock management, maturation and conditioning, spawning, larval rearing, settlement, grow-out, harvesting, and fattening

4.4 *Ecosystem restoration and rehabilitation*

Restoration and rehabilitation strategies vary with the degree of human intervention and the objective of the activity. Table 5 shows five levels of restoration (Kaly, U.L.; G.P. Jones MS).

Table 5 Categories of ecological restoration

Type	*Definitioin*
Complete restoration	Return to pre-disturbed condition
Pre-emptive restoration or habitat banking	Restoration of an unaffected portion of an ecosystem to off-set expected damage in an area undergoing development
Rehabilitation	Re-establishing selected ecological attributes
Enhancement, re-allocation or creation	Establishment of an alternative ecosystem in place of an existing natural or damaged one.
Natural recovery	Natural processes with no human intervention or stress removal

The first step is to establish the objective of the intervention. Time and funding constraints will probably influence the level of restoration or rehabilitation. Consideration must also be given to protection of the selected site once the intervention has been completed. If the site is already a protected area, improvements in enforcement will be necessary, lest the intervention be for naught. Increased efforts in providing alternative livelihoods for communities dependent on resource extraction may be required.

4.4.1 **Mangrove habitat**

Kaly and Jones (op.cit.) suggest a framework for restoration organized around a three step process:

1. Describe the natural state of the ecosystem and define *a priori* the desired outcome of a restoration, including setting success criteria. These criteria should include quantitative data on physical and biological features.
2. Develop restoration technology. Interventions can range from natural regeneration to construction of earthworks, acid sulfate soil amelioration, nursery propagation, species selection, etc.
3. Assess success. Success can be measured by cost and speed of recovery of the intervention as compared to sites left to regenerate naturally. Quantitative measurements of system function of the restored system might be the best measure of success.

Mangrove rehabilitation projects typically re-establish a limited number of species. However, if the replanting is undisturbed, species diversity will increase with time (Ellison 2000). Ellison (op. cit) also points out that it is important to incorporate multiple stakeholders during the planning phase and that projects should have multiple uses and serve multiple constituencies.

Melen et al. (2000) propose a mangrove protection and management strategy based on the following components:

1. Assignment of users or property rights.
2. Apply appropriate regulatory techniques including prohibitions on conversion and cutting, utilization regulation, limits on exploitation and compartmentalization employing rotation and enforcement of forest laws.
3. Use non-regulatory techniques including public education, training on mangrove rehabilitation, habitat enhancement, research and monitoring, community organizing, special pilot projects and alternative livelihood interventions.

4.4.2 Coral reefs

Reef restoration is a relatively new area of research. Research should be encouraged; however, costly rehabilitation programmes may be a risk rather than a cure (Westmacott op. cit.) . Artificial rehabilitation should not be considered if human stressors continue to impact the reef. When considering restoration options, managers should consider the following questions:

• What are the objectives of the restoration project?

• What is the scale of the restoration project?
• What will be the *cost* of the project, and is it affordable?
• What is the success rate of the method being proposed,
and which method will be most cost-effective at the site?
• What will be the long term viability of the programme?
• Is there scope for the local community and reef users to become involved?

Rehabilitation technology includes coral nurseries in undisturbed reefs with transplanting to disturbed sites, "Biorock ™", and submergence of concrete structures to provide new setting sites. The restored site will require continued protection and monitoring that will require participation of local communities of reef users.

Several lessons were learned from coral reef restoration projects in Thailand (Yeemin et al. 2000):

1. Restoration projects may be restricted to limited areas due to their high cost.
2. Restoration projects should only be undertaken in areas where conditions are good for coral growth and reproduction.
3. Projects should be done in degraded reefs where there are obstacles to natural coral recruitment.
4. Restoration projects should be done in small areas where they can be more easily monitored.
5. Projects should be focused on long term success.
6. Local communities need to be included in project planning and implementation.
7. Restoration technology needs to be simple and low cost.
8. Techniques for using natural planula larvae should be used, such as artificial substrates and coral cultivation.
9. Natural coral fragments should be used to increase survival rates.
10. Prevention and mitigation of coral reef degradation are more effective than restoration.

5 *Regional collaboration on shared issues*

The objective of regional collaboration would be to identify solutions to the problems raised by issues common to BOBLME member states. Modalities could include :

- Exchange of experience. Specific sites or projects would be identified where issues have been successfully addressed. Selected sites might be those where only one particular issue, for example, uncontrolled shrimp farm expansion, was addressed. All available documentation on these projects would be digitized and placed into a database managed by BOBLME or other regional center. Study groups could be formed with participation by stake holders from the BOBLME countries concerned with the particular issue. The study group would look at the history of the site, analyze how solutions were identified and implemented, including the legal and institutional framework and discuss how these solutions could be implemented in their respective countries. On-site observation and interaction with local stakeholders should be an important part of the experience exchange.

Examples which have addressed some of the shared issues are:

  - Closed system shrimp culture above high water mark in Thailand
  - Mangrove habitat rehabilitation in the buffer zone of the Sundarbans, India
  - "Biorock" reef restoration, Maldives
  - Community based reforestation of abandoned shrimp farms, Thailand
  - Community based coral reef management (COREMAP), Riau, Indonesia

- Implement collaborative activities. Activities can be designed to test solutions to common issues. The following general characteristics should be considered in the design of the activity:

  - Limited geographic area
  - Clearly defined objectives
  - Establish success criteria and how they will be measured.
  - Maximize opportunities for exchange of regional expertise through the good offices of BOBLME project.
  - Communicate progress and problems through BOBLME website or newsletters.

5.1 *Activities*

Activities are suggested which will address some of the critical habitat issues common to the region. These include uncontrolled shrimp farm expansion, mangrove forest degradation and coral reef destruction. A common thread running through these activities is the prominent role given to CBO's. This reflects the consensus of many analysts of the problems of critical habitat management as well as the successes documented in the literature.

Another commonality is the inclusion of a coordinating committee or local management authority, one of whose functions is to bring together the diverse NGO's and government institutions with responsibilities for critical habitat management. The problem of uncoordinated policy and programs was often pointed to as a management problem. Coordination is especially important at the local level to avoid working at cross-purposes. Local management authorities are an important means of bringing the "end-users" represented by CBO's together with critical habitat managers. CBO's need to be an integral part of planning as well as implementation , rather than included as an afterthought.

Suggestions are given for possible activity sites, taken from information given in the national reports. However, detailed on-site evaluations will be required to ascertain their suitability. Evaluations should include environmental surveys, RRA's to identify stakeholders and develop modalities for local participation, and studies of local institutions with the goal of identifying their capabilities and needs.

1. Shrimp aquaculture management. Components of the project are an ICZM plan developed with stakeholder participation and demonstration of low environmental impact shrimp aquaculture. Closed system shrimp culture above mean high water will demonstrate sludge removal and processing, as well as follow ASEAN, FAO and GAA best management practices. Reforestation of the degraded intertidal zone will restore ecological function and absorb dissolved nutrient effluent from the demonstration shrimp farm.

Objectives:	Control shrimp farm development. Reduce environmental impact of shrimp aquaculture Reduced conflict with local communities.
Success criteria:	Integrated coastal zone management plan developed and implemented. New shrimp farms restricted to supra-tidal zone.* Shrimp farm effluent standards established and enforced.
Site selection:	Intertidal zone with abandoned shrimp farms or degraded mangroves contained within local administrative boundaries. Supra tidal zone with saline soil unsuitable for agriculture. Potential for transfer of shrimp aquaculture technology to local community.
Modalities:	Set up stakeholder based management authority sanctioned by local government. Management authority coordinates with CBO's or works with communities to organize them. Build data base for target area including water quality data, vegetation, topographic and usage maps. Identify and demarcate zones based on actual and potential use Management authority coordinates with BOBLME project to draw on regional expertise to design demonstration shrimp farm and provide guidelines for reforestation. Management authority identifies mangrove-friendly aquaculture options. Management authority contracts construction and operation of demonstration shrimp farm to local groups. Provincial or national fisheries department assists with aquaculture options. Legal and regulatory framework implemented at the local level to enforce and maintain zoning.

* Elevation above mean high water.

Malaysia and Thailand gave a high priority to controlling shrimp farm development, but the issue of shrimp farm encroachment on mangroves is an important issue in other BOBLME countries as well. Fisheries authorities in Thailand and Indonesia have worked to develop shrimp culture systems that minimize environmental impact. One should look for a location where a transect of the coast shows degraded mangroves and abandoned shrimp farms or brackish soils with poor agricultural productivity. Such areas might be found in the Kuala Mudah area of Kedah, Malaysia.

2. Mangrove habitat rehabilitation. This activity targets degraded habitat, demonstrates sustainable forestry practices and alternative livelihood development as a means of reducing pressure on the habitat. Given the time required for mangrove rehabilitation, alternative income sources will be critically important. It is also critically important that high priority be given to the transfer of ownership to the CBO's because of the long time frame for rehabilitation. Responsibility for management should be undertaken by CBO's working together with local government.

Objectives:	Rehabilitate degraded mangrove habitat Demonstrate stakeholder based management Evaluate alternative livelihoods
Success criteria:	Local stakeholder committee takes responsibility for habitat management Ecological function restored. Sustainable alternative livelihoods increase household income.
Site selection:	Identify degraded mangrove habitat contained within local administrative units. The selected area must be in the public domain.. Surrounding communities depend on mangrove resources. Household income should be near the official poverty level. Suitable sites might be found in a buffer zone surrounding a protected forest or in a degraded reserve forest.
Modalities:	Topographic, vegetation and usage maps prepared by mangrove specialists and socio-economist. Socio-economic survey of mangrove-dependent communities around the selected site(s) to identify household needs. Undertake mangrove conservation education programme targeting all stakeholders and including primary and secondary school teachers and students. Work with local NGO's to form community-based management organization. Develop mangrove replanting schedule and/or design hydraulic improvements (if required) to facilitate natural reseeding. Working with CBO's, identify alternative livelihood possibilities. Identify technical, financial and marketing constraints. Support income generating activities with training and financial support including microcredit schemes. Work with relevant authorities to transfer habitat ownership to CBO's. CBO's with assistance from forestry specialists develop long term management plan for sustainable timber harvest.

The Bhitarkanika mangrove ecosystem in Orissa, India is suffering from increasing pressure from surrounding communities which depend on the resources of the ecosystem. The proposed activity could possibly be integrated into the comprehensive management plan now under development for the Bhitarkanika reserve area. Chokoria, Bangladesh is another location of interest. It represents an extreme case in which mangrove destruction is nearly complete. In both India and Bangladesh there is considerable NGO expertise which can be utilized.

3. Improved management of marine protected areas. MPA's are an important means of conserving critical habitat, especially coral reefs. MPA's have been established in most of the BOBLME countries, but their effectiveness varies considerably. Problems include intrusion of local fishers, weak to non-enforcement of MPA regulations, and lack of coordination among responsible government agencies. MPA management can be improved by involving local communities in management, strengthening enforcement of conservation regulations, planning tourism development to minimize environmental impact and reducing dependence on reef resources. If the BOBLME project undertakes an activity in coral reef conservation, it should develop ties with the UNDP/GEF conservation programme for the GMMBR in India to promote the exchange of ideas and expertise.

Objectives:	Reduce human impact on MPA
	Improved local management capacity
Objectives (cont.)	Enforcement of regulations.
	Controlled tourist development.
Success criteria:	Community based organization established for reef management
	Intrusion and illegal fishing halted.
	Alternative livelihoods generating income for poor households.
Site selection:	Survey coral reef MPA's in the region to identify management problems.
	Select one or more MPA with management problems.
Modalities:	Establish coordinating committee which will bring together national and local government agencies responsible for MPA administration together with NGO's and representatives of reef dependent communities.

Identify and demarcate transition and buffer zones around MPA and specify activities to be permitted in these zones in accordance with guidelines for marine biosphere reserves..
Train NGO's and fisheries officers in reef-friendly mariculture technology.
Undertake detailed study of alternative livelihoods for poor households in collaboration with reef dependent stakeholders.
Provide technical and financial support for alternative livelihood startups.
BOBLME facilitates coordination and joint monitoring between international NGO's and CBO's.
Strengthen enforcement capacity with training and surveillance equipment.
Conduct review of MPA legislation followed with recommendations for revisions to address reef resource ownership issues and improve MCS.

National marine parks in the Andaman Sea region of Thailand are facing management problems, which could be addressed by this activity. Among these are Tarutao, Ao Phang Nga, Mu Ko Surin ad Mu Ko Lanta. One could look at potential activity sites in the Riau Archipelago of Indonesia. There could be opportunities to collaborate with the COREMAP project.

4. Coral reef rehabilitation. Although coral reef restoration is still experimental, it may be the only hope for severely damaged reefs that have been mined or subjected to blast and poison fishing. Mechanisms must be developed and strengthened that will stop destructive practices. Among these are more local control, using indigenous knowledge and management, reducing dependence on reef resources and improved monitoring.

Objectives:	Restore ecological function Reduced pressure on reef resources Destructive activities stopped.
Success criteria:	Recolonization and growth of new coral Destructive fishing methods stopped. CBO and local authority responsible for restoration and protection.

	Income generation through reef friendly mariculture
Site selection:	Select reef or reefs in poor condition from destructive fishing, over exploitation, or mining.
Modalities:	Set up local management authority for targeted reef(s). Authority to be stakeholder-based. Select NGO to work with CBO's with restoration, monitoring and surveillance and alternative livelihoods. . Survey reef to quantify nature and extent of damage. Undertake awareness and education program in communities exploiting resources of target reef (s). Convene panel of international experts in coral reef restoration to recommend best methodologies. Conduct socio-economic survey of target communities to identify alternative income strategies. Contract CBO's to implement reef restoration protocols as identified by expert panel. Authorize CBO's to undertake monitoring and surveillance.

Examples of degraded reefs awaiting rehabilitation can be found in most of the BOBLME countries. The reefs of the Riau Archipelago in Indonesia have suffered from destructive fishing, sand mining and siltation from upland development. A survey of the most important reefs would be called for in the site selection process to determine if rehabilitation would be feasible. Purnomohadi (2003) reported that reef fishers of West Sumatra still incorporate traditional knowledge in their practices, but reefs are threatened by destructive fishing practices. Possibilities for rehabilitation might be discovered here, as well.

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List of Abbreviations

ASEAN	Association of Southeast Asian Nations
CBO	Community based organization
(I) CZM	(Integrated) Coastal zone management
FAO	Food and Agriculture Organization of the United Nations
GAA	Global Aquaculture Alliance
GEF	Global Environmental Facility
GMMBR	Gulf of Mannar Marine Biosphere Reserve
ICRI	International Coral Reef Initiative
IUCN	International Union for the Conservation of Nature
LRFF	Live reef food fish
MCS	Monitoring, control and surveillance
MPA	Marine protected area
NGO	Non governmental organization
OIC	International Organization for Epizootics
RRA	Rapid rural assessment
UNDP	United Nations Development Programme
UNEP	United Nations Environment Program