

Transboundary Diagnostic Analysis

VOLUME 1

ISSUES, PROXIMATE AND ROOT CAUSES



BAY OF BENGAL LARGE MARINE ECOSYSTEM PROJECT



Norad



Sida



Transboundary Diagnostic Analysis

VOLUME 1

ISSUES, PROXIMATE AND ROOT CAUSES

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This document was prepared after the Transboundary Diagnostic Analysis (TDA) Confirmation Workshop held in Phuket Thailand from 13 to 14 February 2012. The TDA is published in two volumes. Volume 1 describes the transboundary issues in the Bay of Bengal Large Marine Ecosystem (BOBLME) and their proximate and underlying root causes. These will be used to develop a Strategic Action Programme (SAP). Volume 2 contains background material that sets out the biophysical and socio-economic characteristics of the BOBLME; an analysis of the legal, policy and administrative context in the eight countries that border the Bay of Bengal; and an assessment of the status of marine living resources and the marine environment in the coastal areas of the BOBLME.

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- Eight national papers authored by Mohamed Ali (Maldives); Md. M. Maruf Hossain (Bangladesh); Leslie Joseph (Sri Lanka); Kungwan Juntarashote (Thailand); Myint Pe (Myanmar); Ishak Haji Omar (Malaysia); Sri Hartiningsih Purnomohadi (Indonesia); and Varadarajan Sampath (India);
- Five theme reports authored by Charles L. Angell (Mangroves and coral reefs); William Edeson (Legal and enforcement mechanisms); Ursula L. Kaly (Land-based sources of pollution); Garry Leonard Preston (Shared marine resources); and Philip Townsley (Coastal and marine livelihoods and food security);
- Three BOBLME workshops including background papers (BOBLME/REP/1, 2003), (BOBLME/REP/2, 2003) and (BOBLME/REP/2RW, 2004);
- A Preliminary TDA Framework written by Philomene Veerlan (2003); updates of the Preliminary TDA by Ben Cattermoul (socio-economic characteristics); Michael E. Huber (pollution); Hugh Kirkman (critical habitats), Martin Tsamenyi (legal, administrative and political context); and Derek Staples (biophysical characteristics, marine living resources and the causal chain analysis). The causal chain analysis was enhanced by the input of John Pernetta.

The process has been guided by national review groups (for the national reports), and an international scientific review group (for the regional theme papers), National Task Force (NTF) meetings and national workshops. Verification of the TDA was carried out by a thorough national TDA consultation process in 2011. Overall guidance for TDA development was provided by the former BOBLME Project Coordinator, Philomene Verlaan, the current BOBLME Project Regional Coordinator, Chris O'Brien, and the Chief Technical Advisor, Rudolf Hermes.

This publication was compiled and edited by Derek Staples and copy edited by Claire Attwood.

The designations employed, and the presentation of material in this publication, do not imply the expression of any opinion whatsoever on the part of the Food and Agriculture Organization of the United Nations concerning the legal status of any country, territory, city or area, or of its authorities, or concerning the delimitation of its frontiers or boundaries.

The Bay of Bengal Large Marine Ecosystem Project

In April 2009, the Bay of Bengal Large Marine Ecosystem (BOBLME) Project started work.

This five year project involving Indonesia, Malaysia, Thailand, Myanmar, Bangladesh, India, Sri Lanka and the Maldives, aims to improve the lives of the coastal populations through improved regional management of the Bay of Bengal environment and its fisheries.

The BOBLME countries have a combined total population of 1.78 billion people, equivalent to 25 percent of the world's population. The coastal population of the region is estimated to be 450 million people, equivalent to 50 percent of the world's coastal poor.

The BOBLME is rich in natural resources, including extensive mineral and energy resources; marine living resources that support major fisheries; and forest and land resources.

Fisheries production is six million tonnes per year, more than seven percent of the world's marine catch.

The LME supports a wide range of habitats, including extensive tracts of mangroves (12 percent of the world's mangroves), coral reefs (eight percent of the world's coral reefs) and seagrass beds. It is an area of high biodiversity, with a large number of endangered and vulnerable species.

The LME and its natural resources are of considerable social and economic importance to the countries that border the Bay of Bengal. Activities such as fishing, marine farming, tourism and shipping contribute to food security, employment and national economies. Marine living resources are extremely important to the coastal poor, particularly as a source of food.

There are over 400 000 fishing boats operating in the Bay of Bengal and over 4.5 million people are employed in fisheries and associated activities. But rapid population growth, high dependence on aquatic resources for food, trade and livelihoods, and changing land use patterns are having major impacts on the marine ecosystem. It is not clear how much longer the Bay of Bengal will be able to support the needs and aspirations of the many sectors that use its resources, most notably the large population of coastal poor that depends on them for survival.

The Transboundary Diagnostic Analysis (TDA)

A TDA identifies, quantifies and ranks water-related environmental transboundary issues and their causes according to the severity of environmental and/or socio-economic impacts.

The TDA of the BOBLME draws on numerous studies and extensive regional and national consultations with stakeholders. Importantly, the TDA provides the scientific basis for the development of the Strategic Action Programme that sets out a strategy for the countries to collectively deal with transboundary issues.

Main areas of concern

The TDA of the BOBLME identifies three main transboundary issues:

1. **Overexploitation of marine living resources**
2. **Degradation of mangroves, coral reefs and seagrasses**
3. **Pollution and water quality**

A causal chain analysis was conducted on each of these areas of concern, resulting in the identification of priority issues and their underlying causes. A summary of the three areas is presented here. It should be noted that some important national issues may not be included in this TDA. A transboundary issue is defined as an environmental problem in which either the cause of the problem and/or its impact is separated by a national boundary; or the problem contributes to a global environmental problem and finding regional solutions is considered to be a global environmental benefit.

The TDA also reviews the driving forces at work in the BOBLME, such as the socio-economic, institutional, legal, administrative circumstances and the projected impact of global climate change on the region. These forces all pose a range of constraints and challenges and have the potential to influence the success of actions implemented to address the three main areas of concern. This information is also considered to be important for the development of the Strategic Action Programme.



The Bay of Bengal is an area of high biodiversity, with a large number of endangered and vulnerable species

Overexploitation of living marine resources

The major issues

1. **A decline in the overall availability of fish resources**
2. **Changes in the species composition of catches**
3. **A high proportion of juvenile fish in the catch**
4. **Changes in marine biodiversity, especially through loss of vulnerable and endangered species**

The transboundary nature of the major issues

- Many fish stocks are shared between BOBLME countries, through the transboundary migration of fish, or larvae.
- Fishing overlaps national jurisdictions, both legally and illegally – overcapacity and overfishing in one location forces a migration of fishers and vessels to other locations.
- All countries (to a greater or lesser degree) are experiencing difficulties in implementing fisheries management, especially the ecosystem approach to fisheries.
- BOBLME countries contribute significantly to the global problem of loss of vulnerable and endangered species.

The main causes of the issues

- High consumer demand for fish, including for seed and fishmeal for aquaculture
- Open access to fishing grounds
- Government emphasis on increasing fish catches
- Inappropriate government subsidies provided to fishers
- Increasing fishing effort, especially from trawlers and purse seiners
- Ineffective fisheries management
- Illegal and destructive fishing

Fisheries production in the Bay of Bengal is six million tonnes per year, more than seven percent of the world's catch

Degradation of critical habitats

The major issues

1. **Loss and degradation of mangrove habitats**
2. **Degradation of coral reefs**
3. **Loss and damage to seagrasses**

The transboundary nature of the major issues

- All three critical habitats occur in all BOBLME countries.
- Coastal development for several varying uses of the land and sea are common in all BOBLME countries.
- Trade in products from all the habitats is transboundary in nature.
- Climate change impacts are shared by all BOBLME countries.

The main causes of the issues

- Food security needs of the coastal poor
- Lack of coastal development plans
- Increasing trade in products from coastal habitats
- Coastal development and industrialization
- Ineffective marine protected areas and lack of enforcement
- Upstream development that affects water-flow
- Intensive upstream agricultural practices
- Increasing tourism

Pollution and water quality

The major issues

1. **Sewage-borne pathogens and organic load**
2. **Solid waste/marine litter**
3. **Increasing nutrient inputs**
4. **Oil pollution**
5. **Persistent organic pollutants (POPs) and persistent toxic substances (PTSs)**
6. **Sedimentation**
7. **Heavy metals**

The transboundary nature of the major issues

- Discharge of untreated/partially treated sewage is a common problem; sewage and organic discharges from the Ganges-Brahmaputra-Meghna River are likely to be transboundary.
- Plastics and derelict fishing gear can be transported long distances across national boundaries.
- High nutrient discharges from rivers could intensify large-scale hypoxia; atmospheric transport of nutrients is inherently transboundary.
- Differences between countries with regard to regulation and enforcement of shipping discharges may drive discharges across boundaries; tar balls are transported long distances.
- POPs/PTSs and mercury, including organo-mercury, undergo long-range transport.
- Sedimentation and most heavy metal contamination tend to be localized and lack a strong transboundary dimension.

The main causes of the issues

- Higher consumption, resulting in more waste generated per person
- Increasing coastal population density and urbanization
- Insufficient funds allocated to waste management
- Migration of industry into BOBLME countries
- Proliferation of small industries



With the support of the BOBLME Project, the eight countries are now developing responses to these issues and their causes, for future implementation as the Strategic Action Programme



1. Introduction

1.1 Purpose of the TDA

In the context of a Global Environment Facility (GEF) Large Marine Ecosystem (LME) project, a Transboundary Diagnostic Analysis (TDA) identifies, quantifies (where possible) and ranks – according to the severity of environmental and/or socio-economic impacts – water-related environmental transboundary issues and their proximate and root causes. The TDA provides the scientific basis for the collaborative development of a Strategic Action Programme (SAP) that, in turn, forms the basis for the implementation of nationally and regionally coordinated activities to address the issues and their causes.

In April 2009, a five-year Bay of Bengal Large Marine Ecosystem (BOBLME) Project, involving Indonesia, Malaysia, Thailand, Myanmar, Bangladesh, India, Sri Lanka and the Maldives, commenced. It aims to improve the lives of coastal populations through improved regional management of the Bay of Bengal environment and its fisheries. One of the Project's major outputs will be a SAP, designed to protect the health of the ecosystem and manage the living resources of the BOBLME on a sustainable basis and thereby improve the food and livelihood security of the region's coastal population. This TDA is the primary input to SAP development. It supersedes the preliminary framework TDA (Verlaan, 2004) that was prepared under the GEF Project Development Fund-B (PDF-B) phase, in preparation for the BOBLME Project.

1.2 The development of the TDA

This document outlines the major water-related coastal and marine environmental issues as documented by various BOBLME studies and assessments, and perceived by the BOBLME countries. It identifies the transboundary elements of the issues and examines their main proximate and root causes; identifies major information gaps; and lays the foundation for potential areas for action, while also identifying major potential constraints and challenges that will need to be overcome. The preliminary framework TDA (Verlaan, 2004) consolidated the results and recommendations of extensive regional and national stakeholder consultations, and the reports and comments received between January 2003 and May 2004 (BOBLME/REP/1, 2003), (BOBLME/REP/2, 2003) and (BOBLME/REP/2RW, 2004). Main inputs included eight reports that were prepared by national teams under the leadership of a designated focal point (Ali, 2003; Hossain, 2003; Joseph, 2003; Juntarashote, 2003; Myint, 2003; Omar, 2003; Purnomohadi, 2003; and Sampath, 2003) and five theme reports completed by regional consultants on the basis of existing literature, new scientific findings and the national reports (Angell, 2004; Edeson, 2004; Kaly, 2004; Preston, 2004; and Townsley, 2004).

At the First Regional Workshop of the BOBLME PDF-B Programme development, held in Pattaya, Thailand, in February 2003 (BOBLME/REP/1, 2003), the BOBLME countries agreed that the Preliminary TDA should address the following three major transboundary environmental concerns or themes:

- **Overexploitation of marine living resources**
- **Degradation of mangroves and coral reefs**
- **Land-based sources of pollution**

At a subsequent preparatory meeting for the Second Regional Workshop of the BOBLME Programme held in Penang, Malaysia, in March 2004 (BOBLME/REP/2, 2003), the BOBLME countries requested the inclusion of ship-based sources of pollution (including dumping as covered by the London Convention [1972] and its Protocol [1996]), as the fourth transboundary environmental concern to be addressed in the TDA. To accommodate this, the TDA was expanded to cover all the main types of pollution and water quality issues.

The Preliminary TDA was presented at the Second Regional Workshop held in Colombo, Sri Lanka, in October 2004 (BOBLME/REP/2RW, 2004) and it was agreed that seagrass should be included as a critical habitat of concern in the BOBLME.

The three main themes that reflect areas of concern are, therefore, covered in this TDA:

- **Overexploitation of marine living resources**
- **Degradation of mangroves, coral reefs and seagrass**
- **Pollution and water quality**

The TDA development was also guided by national review groups (for the national reports), an international scientific review group (for the regional theme papers), National Task Force (NTF) meetings and national workshops. Leadership for this stage of the TDA development was provided by the former BOBLME Project Coordinator, Philomene Verlaan.

There was a long gap (five years) between the publication of the Preliminary TDA and the initiation of the main GEF BOBLME Project and it was therefore necessary to review the Preliminary TDA and identify the gaps and updates that were needed. The review examined both the content and the process used to develop the Preliminary TDA, based on material available to the BOBLME Project office (Staples, 2009). Because the Preliminary TDA was based on a comprehensive series of theme papers, national papers and consultative fora and meetings, it provided good background material. However, it was acknowledged that more work was needed to provide the scientific evidence that supported the inclusion of the priority issues, and a more rigorous causal chain analysis was necessary to identify the proximate and root causes of these issues. The review also outlined a process for finalizing the TDA. It recommended that each section be re-written and, where appropriate, updated by regional experts and that these revisions be subjected to national scrutiny and endorsement. The re-write was carried out during July and August 2010 and the draft TDA was presented in summary to the Regional Workshop on BOBLME TDA National Consultation Planning (Bangkok, August 24-25, 2010). At the workshop, each country presented a "roadmap" setting out a plan for seeking national validation of, and agreement to, the TDA. In general, it was thought that this could be achieved by April 2011.

The national consultations took place in 2011 in all BOBLME countries. All countries validated the thrust and conclusions of the TDA but also requested various changes and updates. These were incorporated into the TDA in early 2012. Some countries requested an expansion of the scope of the TDA (changes to the high priority issues), especially in terms of the habitats to be covered, but as agreed in the TDA confirmation meeting held in Phuket on 13-14 February 2012, no changes were made to the issues that the SAP will address. However, it was noted that the links between habitats make consideration of related issues possible. Many of the recommendations made by the countries included actions for addressing the issues and these will be incorporated in the development of the SAP. These national consultations also provided an additional opportunity for stakeholder inputs and a broad range of stakeholders were involved.

The national consultations highlighted many regional differences, both between countries and between provinces/states within the larger countries (e.g. Indonesia and India) and the difficulty of making generalizations. Along the coast of India, for example, there are very diverse ethnic, cultural and language groups, each with their own set of issues and causes. As far as possible, these differences have been acknowledged. However, it was noted that the TDA is a consensus document that identifies the major priority transboundary issues, as agreed by regional consultations. Thus, it is not possible to cover every issue in every state or province.

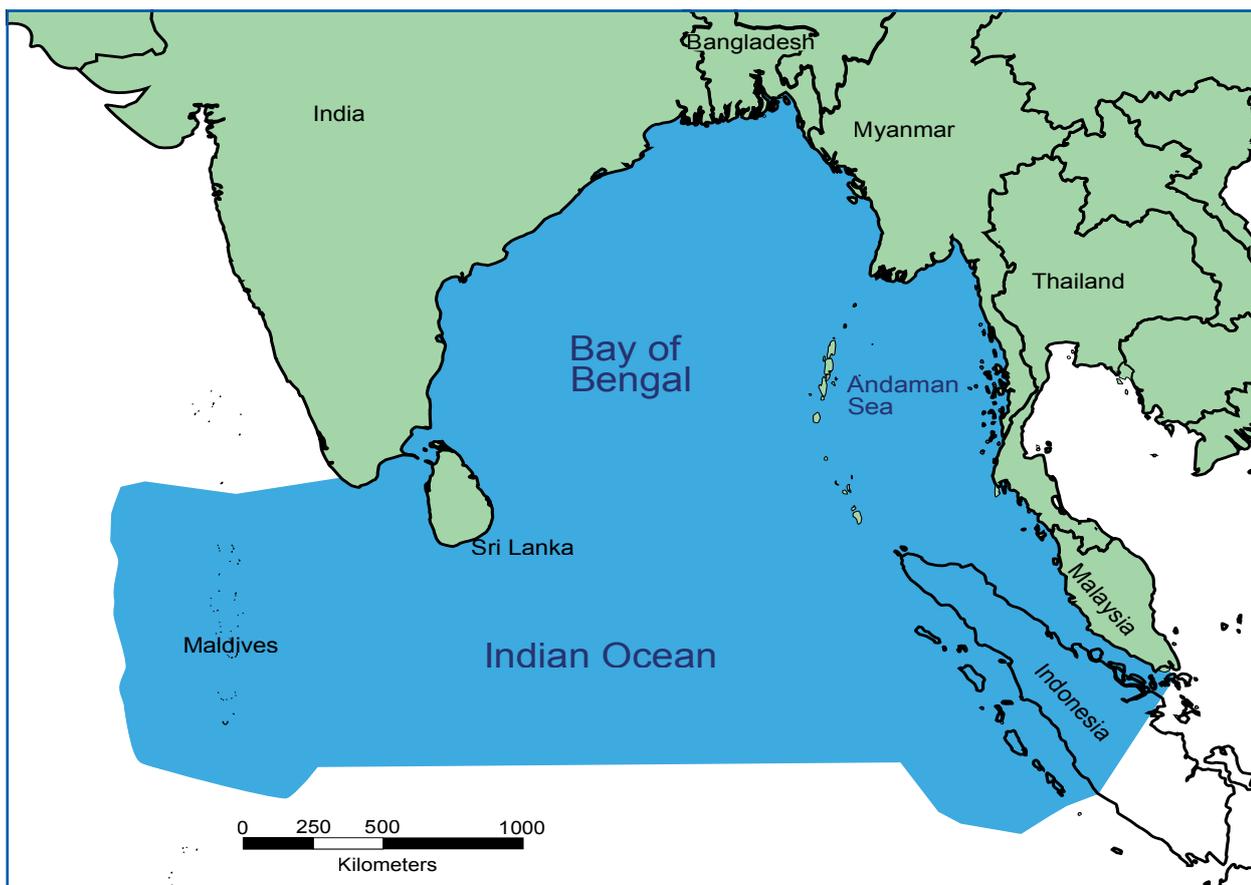
The TDA is presented in two volumes. Volume 1 describes the transboundary issues in the BOBLME and contains a causal chain analysis that identifies the proximate causes of the issues, and the underlying root causes that can be used to develop a SAP. Volume 2 contains background material that sets out the biophysical and socio-economic characteristics of the BOBLME, an analysis of the legal, policy and administrative context pertaining to the eight countries of the region, and an assessment of the status of the marine living resources and the coastal and marine environment of the BOBLME.



2. Scope and characteristics of the BOBLME

The BOBLME, as defined for the purposes of the BOBLME Project, includes the Bay of Bengal itself, the Andaman Sea, the Straits of Malacca and the Indian Ocean to 2° S. It is based on the delineation of the world's LMEs by NOAA¹ but moved slightly south to include the Maldives and northern Sumatra in Indonesia (Figure 2.1). As well as the high seas area, it comprises the coastal areas, islands, reefs, continental shelves and coastal and marine waters of the northern part of the Island of Sumatra in Indonesia (Provinces of Aceh, Riau, North Sumatra and West Sumatra); the west coast of Peninsular Malaysia; the west coast of Thailand, Myanmar, Bangladesh; the east coast of India; the Andaman and Nicobar Islands of India; Sri Lanka; and the Maldives.

Figure 2.1 The BOBLME as defined for the BOBLME project.



Source: Sea Around Us Project and the BOBLME RCU.

The BOBLME at a glance

Area

Total maritime area = 6.2 million km²
 Total area of countries' EEZs = 4.3 million km²
 Total area of high seas = 1.9 million km²
 Combined length of coastline = ~14 000 km

Productivity

Primary production concentrated in coastal areas and major rivers.
 Low elsewhere.

People

Total population of countries* = 1.8 billion (25% of the world)
 Population of the coastal zone = 450 million

Fisheries

Employment in fisheries = 4.5 million
 Number of fishers = 2.2 million
 Number of fishing boats = >415 000
 Total fisheries production = 6 million tonnes
 Value of fisheries production = USD 4 billion

*This refers to the total population of all countries involved in the BOBLME Project. It does not imply that their entire populations have impacts on or are impacted by what happens in the Bay of Bengal. Only a small proportion of Indonesia and Malaysia's populations is involved, and about half of India's population. (All other facts refer to the area of the BOBLME as defined.)

¹<http://www.lme.noaa.gov/>

2.1 Biophysical characteristics

The Bay of Bengal covers 6.2 million km² with depths ranging between 2 000 and over 4 000m for most of its central area. The continental shelf around its perimeter is mostly narrow. The very deep Java Trench is a feature of the south eastern side of the Bay, from the Andaman Islands in the north to the coast of Sumatra in the south, with depths reaching over 5 000m. About 66 percent of the BOBLME lies within the EEZs of BOBLME countries, the remainder being the high seas area; thus a lot of the BOBLME is subject to national jurisdiction. The BOBLME countries with the greatest area of EEZ within the BOBLME as defined are, from largest to smallest: India, Maldives, Myanmar, Sri Lanka, Indonesia, Thailand, Bangladesh and Malaysia. The BOBLME is not as productive as the adjacent Arabian Sea LME because of stratification. Thus the areas of high primary production are concentrated in the coastal waters. Average sea-surface temperature is 28.6°C and has been rising slowly. The current average temperature is 0.5°C higher than it was in 1957.

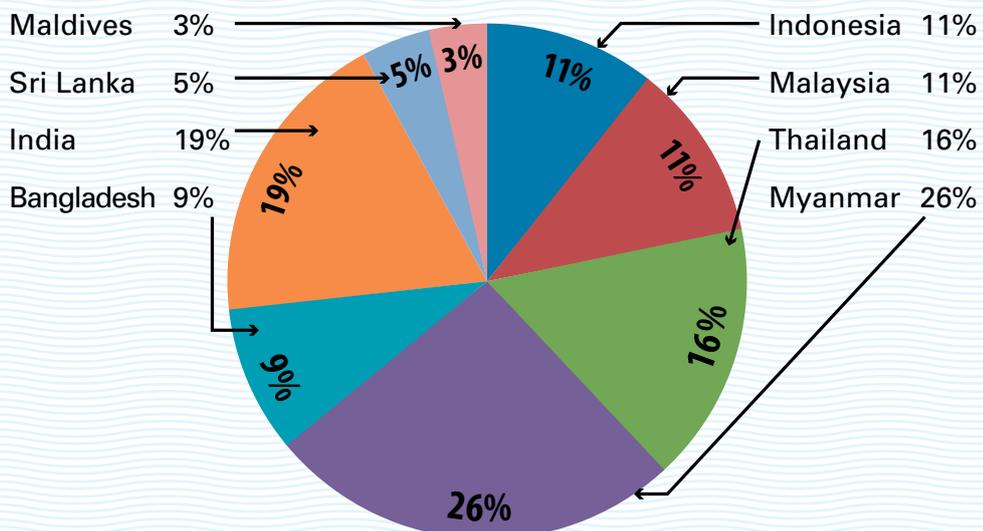
Many large rivers flow into the BOBLME. These include the Ganges, Brahmaputra and Meghna in the north that drain across Bangladesh and India; the Ayeryawady and Thanlwin in the east from Myanmar; and the Mahanadi, Godavari, Krishna and Cauvery in the west from India. These rivers discharge huge quantities of fresh water and large quantities of silt into the coastal environment. The Ganges- Brahmaputra-Meghna basin covers nearly 1.75 million km², spreads across five countries and is the second largest hydrologic region in the world. Monsoonal rains and floods have a strong influence on the BOBLME dynamics, resulting in seasonal gyres and a warm, low salinity, nutrient- and oxygen-rich surface layer to a depth of 100m. Tides are mainly semidiurnal with a wide range in some coasts (up to 7m at spring tide in Myanmar) and the saline intrusion can extend up to 340km in the north-eastern estuaries of Bangladesh.

The BOBLME has no seasonal upwelling of major biological consequence. However, in near-shore areas, the mixing of nutrient rich bottom waters and warm surface waters creates conditions similar to upwelling. During the northeast monsoon, seasonal upwelling occurs on the northeast coast of India and the western coast of Thailand, as well as off the south coast of Sri Lanka. During the southwest monsoon, the eastward-flowing Monsoon Current (replacing the westward-flowing North Equatorial Current of the northeast monsoon period) supplies nutrients to the BOBLME from the Somali upwelling in the Arabian Sea.

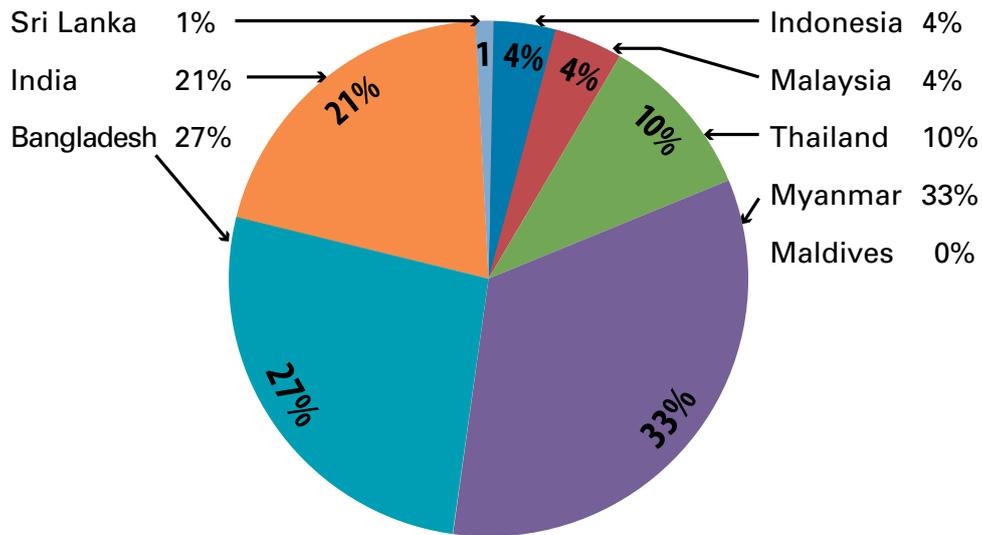
The BOBLME is rich in natural resources, including extensive mineral and energy resources; marine living resources that support major fisheries; and forest and land resources. The current fisheries production (2009) is approximately six million tonnes (seven percent of the world’s brackish water and marine catch), valued at USD 4 billion (about four percent of the value of the world catch) (FAO Fishstat, 2011). The LME is the site of three important critical habitats – mangroves (11.9 percent of world mangrove resources, Giri *et al.*, 2008 and 2010); coral reefs (8.0 percent of the world’s coral reefs, SAUP, 2010 and Spalding *et al.*, 2001) and seagrass. In the BOBLME, the largest fishery catch is taken by Myanmar and the largest area of mangroves is also in Myanmar. The Maldives has the largest area of coral reefs (Figure 2.2 A, B, C).

Figure 2.2 Distribution of (A) fisheries catch, (B) mangroves and (C) coral reefs across BOBLME countries.

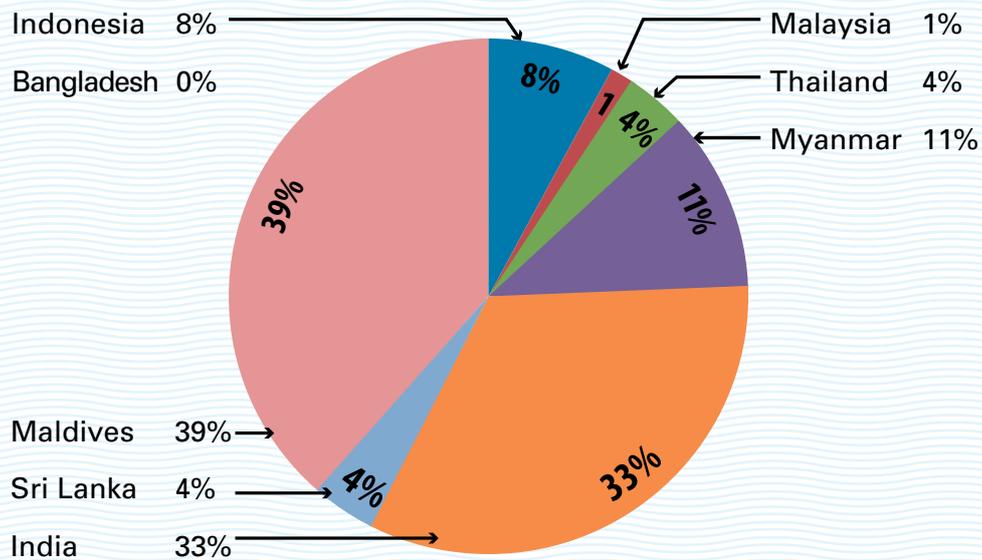
A. Fish catch



B. Mangroves



C. Coral reefs



The BOBLME is an area of high biodiversity, with a large number of endangered and vulnerable species. The LME and its natural resources are of considerable social and economic importance to the bordering countries, with activities such as fishing, shrimp farming, tourism and shipping contributing to food security, employment and national economies.

The Bay of Bengal is also one of the hydrocarbon-rich areas of the world, comparable to the Gulf of Mexico, Persian Gulf and Bohai Bay in China. Until recently it has been poorly explored due to a lack of financial support for exploration and international boundary disputes. Recent findings in the two main basins of the BOBLME – Krishna-Godavari and Mahanadi – have shown potential for nearly 18 billion barrels of oil equivalent gas (Kumar, 2008). Future revenues from oil and gas production have the potential to dwarf those generated by other economic sectors.

An increasing emphasis on the exploration for, and exploitation of, oil and gas in the BOBLME presents many different opportunities and threats. At regional level, the boundary disputes (particularly between India, Myanmar and Bangladesh) may be a threat to international cooperation. There is also an increasing risk of pollution.

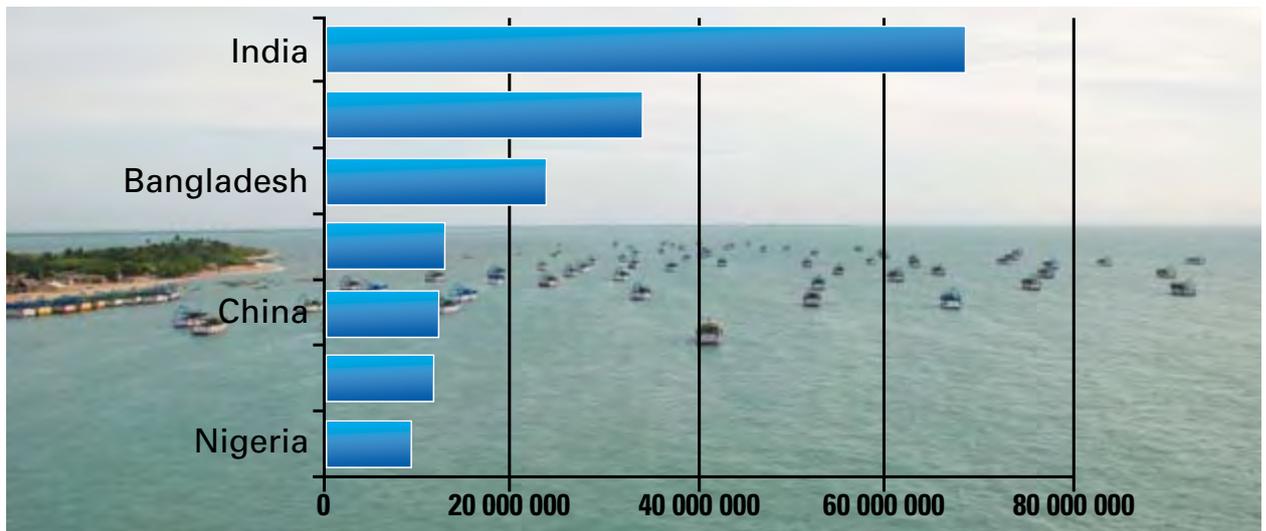
2.2 Socio-economic characteristics

The countries bordering the BOBLME include some of the largest populations on earth, with India, Indonesia and Bangladesh being among the world's top ten most populated countries. Collectively, the BOBLME countries are home to some 1.78 billion people, or approximately a quarter of the world's population. The coastal population of the BOBLME countries is estimated to be around 450 million, with fisheries employing about 4.5 million people, of which, 2.2 million are fishers working on more than 415 000 fishing boats (see Volume 2 for details).

Many of these people are poor, with India having 27 percent of the world's coastal poor and four of the BOBLME countries ranked among the world's top seven for the number of coastal poor (Figure 2.3). Over 50 percent of all of the world's coastal poor live in the countries of the BOBLME (Brown *et al.*, 2008).

Despite the large size and populations of many of the countries, they have relatively small economies. All the economies are reducing reliance on the agriculture sector (including fisheries) because growth in the industrial and service sectors has driven long-term GDP growth. The contribution to GDP by fisheries, therefore, is relatively low. However, marine living resources are extremely important for the livelihoods of millions of people and communities, in particular as a source of food. By world standards, the BOBLME region consumes large amounts of seafood per capita (with the exception of India).

Figure 2.3 Number of the world's coastal poor calculated from estimates of poverty combined with estimates of population density in the 100km coastal strip of the BOBLME.



Source: Brown *et al.*, 2008.

Photo source: BOBP-IGO archives

In all BOBLME countries, with the exception of India, fish and seafood products make a significant contribution to the animal proteins that are consumed, e.g. Maldives, 76 percent, Indonesia 62 percent, Bangladesh 57 percent and Sri Lanka, 52 percent. Differences in the types of fish consumed by the rich and poor occur and per capita fish consumption is substantially higher in the rural areas of countries such as Bangladesh, India, Indonesia and Thailand than it is in urban areas.

Government support for urban populations is variable, with some safety nets in place. But, because of the huge areas of coast involved, many people are not covered or even aware of some of the services that are available. Moreover, all BOBLME countries performed poorly in the 2010 Transparency International Corruption Perceptions Index (CPI) which measures the perceived levels of public sector corruption in the world.

BOBLME countries are governed by a range of different systems. Despite their differences, all the governments of the region are promoting economic growth and development, including the increased exploitation of living resources. As a result, all the region's governments have set ambitious marine and freshwater fishery production targets, which in many cases do not acknowledge the biological limits to production inherent in these renewable resources. Most countries have relatively well-formulated legislation and policies to regulate the different sectors, but these are often not harmonized across sectors. Most government services are applied in a multi-layered system (national-provincial/state and local) without clear roles and responsibilities defined for the different players. Many countries now have "decentralization" policies that present new challenges for the coordination and implementation of law and order.

The complexity of the coastal areas and government bureaucracies often results in decision-making structures being inadequate or inappropriate for dealing with problems in a coordinated and effective way. Implementation of policies is often constrained by weak governance – especially at the local level – and insufficient human capacity and government funding for enforcing laws and regulations.

Enforcement is impeded by a number of factors, including weak institutions based on an “informal economy” with many perverse incentives; varying interpretations of the law; lack of funds to enforce laws and regulations; and a lack of prior consultation with, and accessibility by, stakeholders to an ever-increasing number of rules and regulations. Penalties imposed for violations of marine living resource and critical habitat laws are often inadequate and reflect the fact that in many of the BOBLME countries these laws need to be improved, revised and updated. In particular, there is a need to recognize and adopt internationally accepted concepts and norms such as the ecosystem approach and the precautionary principle.

Increasing levels of industrialization in some of the coastal zones of the BOBLME have attracted new waves of migrants and resulted in new residential and industrial zones outside established towns and cities. Such developments have the potential to displace existing coastal communities, especially where they are made up of groups such as fishers who often have little political influence. Generally, people are moving from inland areas to the coast and also from rural to urban areas in search of employment and a better life.

2.3 Regional differences

Although grouped into one large marine ecosystem there are many differences in culture, religion, and in political and biological systems, both between BOBLME countries and within the larger countries e.g. India. Nested within the large marine ecosystem, many smaller ecosystems can be recognized. Thus, the impact of the issues will vary, depending on national and local characteristics. For example, in terms of the critical habitats addressed in this TDA, some countries have large areas representing all habitats (e.g. Myanmar), while others are dominated by only one or two (e.g. the Maldives with a very small mangrove area and Bangladesh with a small area of coral reefs). States or provinces situated closer to country borders usually have a set of issues reflecting their proximity to their neighbours, especially where conflict has either occurred in the past or is ongoing. Obviously, the issues differ according to the distance from major urban centres; poor, rural coastal communities generally have a different view of regional issues than those living in the countries’ capitals.

Embedded in the diversity of the biophysical and socio-economic systems is a wide range of opinion and interpretation of the science that underpins the major issues. Even in the best-studied systems of the world, there will always be a degree of uncertainty in the assessment of the state of the environment and different interpretations are possible. The fisheries of India provide a good example of this.

During national consultations in 2011, Andhra Pradesh, Tamil Nadu, Orissa and West Bengal all identified overfishing and overcapacity as issues in their states. For example, Tamil Nadu stated “there are too many unregistered boats operating in the coastal waters which contribute to over-fishing” (Anon, 2011). Similarly, after an extensive study in 2010 and 2011, the World Bank concluded that the main policy actions that were needed were to reduce excess fishing effort, allocate more secure fishing rights to stakeholders and mitigate any negative impacts on stakeholders if fleet or capacity reductions should occur, largely for inshore fishing (World Bank, 2011). In a recent assessment of the fisheries in Tamil Nadu, FAO concluded that the issues facing the sector are awareness of excessive fishing effort and risks to the sustainability of the resource (FAO, 2011). On the other hand, according to an expert group reporting to the Indian Department of Animal Husbandry, Dairying & Fisheries (Anon, 2012), the Indian position is:

- The threshold of overexploitation and overcapacity is considerably higher for tropical stocks and this threshold has not been reached for the majority of the Indian marine fish stocks.
- Catch trends do not show decline, although stock estimates (assessments – Editor) suggest overexploitation during the last ten years. Similarly, in spite of 30 to 40 percent extraction of juveniles in India, there is no decline in catches. This stresses the fact that tools and standards evolved for temperate fish stocks may not be applicable in tropical waters.
- In India, studies show that proliferation of climate-driven fisheries such as the small pelagics, leading to “fishing down the food chain” is not due to fishing alone, but also under influence from the climate.

From this example and the known diversity in the region, arriving at a consensus on the issues and causes of transboundary elements and issues in the BOBLME is a difficult and complex task. However, this TDA reflects an agreed set of issues based on the best available science, taken from within the region and from the scientific knowledge base of other LMEs, especially other tropical LMEs.



3. Driving forces impacting the BOBLME

There are a number of driving forces at work in the BOBLME that are contributing to (i) overexploitation of marine living resources, (ii) degradation of critical habitats and (iii) pollution and water quality. These forces present a range of constraints and challenges to any actions designed and implemented to address these problems, and can be grouped into:

1. **Socio-economic drivers;**
2. **Institutional, legal and administrative drivers; and**
3. **Climate change.**

3.1 Socio-economic drivers

The principal social factors affecting BOBLME countries are:

- Population growth and increasing migration to the coast;
- Urban growth and coastal infrastructural, commercial, industrial and residential development for the expanding urban – and usually more affluent – coastal communities, e.g., tourist resorts, ports, airports, roads, harbours;
- Lack of alternatives for securing food, livelihoods and shelter (space and materials) in the poor, rural coastal communities; and
- Lack of stakeholder awareness of the issues and, in some cases, lack of commitment.

The main economic factors are:

- National demand for foreign exchange through exports, especially processed fish, live food fish and ornamental fish, shells and coral, and tourism;
- Increasing trade in cultured shrimps, rare animals and birds and (mangrove) charcoal and woodchips, without effective controls and regulations, and increasing market demand that causes irresponsible harvesting;
- Inappropriate financial and other incentives provided by governments;
- A need to increase agricultural productivity, resulting in dams for irrigation, increased use of fertilizers and pesticides;
- Undervaluing of services provided by the marine living resources and especially by the critical habitats; and undervaluing the damage to resources and habitats caused by bad practices; and
- Undervaluing of damage to human health caused by pollutants and contaminants.

The sheer number of people is probably the most important underlying driver of all the key issues in the region. The regional human population is still growing from an already large base of about 1.78 billion and it is expected that this figure will exceed two billion by 2020. The coastal population of 450 million is also expected to increase, both as a result of the general upward trend in regional population and because of urbanization and migration to the coast.

With regional population densities averaging about 410 people per square kilometre – of which at least 30 percent is concentrated along the coasts – the pressure on the coastal and marine environment of the BOBLME is likely to be one of the highest in the world (Kaly, 2004).

Domestic sewage and solid waste production and collection and disposal problems in particular, are exacerbated by the increasing number of tourists visiting the region and by population growth. For example, in the Maldives, the number of tourists arriving per year is greater than the resident population. It is estimated that 20 million tourists per year visit Thailand's Andaman Sea area.

National demand for foreign exchange is driving government policy and incentives that promote unsustainable practices (e.g. high chemical applications and clearing of land) and the increasing productivity of agriculture (and aquaculture). This puts unprecedented pressure on fish resources. Manufacturing and service industries are showing a trend of relocating to countries in the region to benefit from lower production costs that may, in part, be related to lower environmental standards. The damage to the environment – and to other sectors and public health – from industrial, agricultural pollution, unsustainable fishing and degraded habitats is not added to the cost of doing business and is not reflected in prices, taxes or national financial and development plans.

3.2 Institutional, legal and administrative drivers

At the regional level, the main institutional driver affecting a country's ability to implement change is a lack of an appropriate forum for region-wide multi-national dialogue, planning, monitoring and reporting on the progress of sustainable development.

In the BOBLME there is no overarching mechanism for planning and coordination for the marine environment. However, there are a multitude of agencies and organisations with a partial mandate to coordinate some activities in the BOBLME region. In the PDF-B phase of the BOBLME Project, 12 existing sub-regional, regional and international institutions and their current mandates were examined. Some existing institutions are currently either too narrow in their sectoral mandate [e.g. Asia Pacific Fisheries Commission (APFIC)]; too narrow in their geographic competence with respect to the BOBLME [e.g. Association of Southeast Asian Nations (ASEAN)]; or both [e.g. Bay of Bengal Programme – Intergovernmental Organization (BOBP-IGO)]. However, all are very important partners of the BOBLME Project.

BOBLME countries should recognize that the causes and solutions of priority issues extend beyond one or more national political jurisdiction. There are many benefits to be gained from addressing these issues through coordinated action at the regional level by establishing a supportive institutional and legal framework to facilitate inter-sectoral and transboundary planning and management between the BOBLME member countries.

At the national level, underpinning the key issues discussed below in Section 4 is a lack of governance and an inability to gain compliance with many of the existing laws, rules and regulations. More specifically these include:

- Poor enforcement of laws and regulations, including corrupt officials not enforcing government policies and regulations;
- Lack of monitoring;
- Changing policies and priorities;
- Lack of coordination between different enforcement agencies;
- Poor integrated planning and inadequate communication, including information exchange, between the relevant and legally responsible sectors and levels of central, state and local government;
- Lack of local stakeholder consultation and involvement in planning, decision-making, implementation and enforcement;
- Lack of management capacity at all levels for managing a multiple-use, multiple-stakeholder resource in an ecosystem context with a precautionary approach, especially at the local level; and
- Inadequate funding for the implementation and enforcement of legislation.

The form and type of implementation agency or authority varies widely between the BOBLME countries but in each country, at least on paper, some form of authority has the mandate to conserve marine living resources, protect critical habitats and implement pollution control legislation and regulations. However, the exercising of this authority is largely ineffective. There are many reasons for this, but the main one is that in developing countries, such as those of the BOBLME, adequate governance systems are not in place. Governments have adopted legislation and policies similar to those in developed countries that espouse "sustainable development" but in many cases these cannot be implemented without a system that provides adequate remuneration for staff and resources that enable government departments to gain compliance. Achieving an effective level of compliance, and enforcement of laws and regulations, is an ongoing challenge and a major change to the social system, taxes, remuneration and incentives is required. Natural resources and habitats provide essential goods and services to poor local communities who have no alternatives and depend on them for survival. Without alternatives, the legislation is often flouted, overexploitation of resources and habitat degradation continues unabated and disrespect for the legal system is engendered. Sustainable management of living marine resources and critical habitats needs to address this issue more constructively.

The enforcement issue

- an example in fisheries

In the case of industrial or larger-scale fishing activities, enforcement capacity in the form of seagoing vessels and trained personnel may be lacking. In addition, many industrial fishing operations are owned or operated by persons of influence who, even if apprehended for an offence, may be able to circumvent the law. In the “informal economy” bribes and incentives change hands and can be used to subvert the law. Penalties for violating legislation relating to living marine resource exploitation and critical habitats are usually inadequate and do not act as a deterrent.

There does not appear to be any mechanism within the region through which countries can coordinate joint surveillance patrols, either by military, police or coastguard vessels or flights conducted by military or commercial aircraft.

In small-scale artisanal fisheries, fishing involves hundreds of thousands of fishers and vessels dispersed over large areas, making the logistics of surveillance and enforcement much more challenging. In addition, enforcement activities may create conflict with local fishers, a scenario that government officials are averse to for a variety of reasons. These may include fear of violence and physical harm; creation of adversarial relationships which impinge on the official’s other functions (such as extension services); loss of political support; or sympathy with the situation of the artisanal fishing community, many of whom are poor or have no alternative sources of livelihood. Many fishers are unaware of the laws and regulations.

In the case of some transboundary violations, the introduction of the United Nations Convention on the Law of the Sea (UNCLOS) resulted in fishers who used to fish in their own backyards being prevented from fishing across newly declared borders. A good example is that of Indian and Sri Lankan fishers in the Gulf of Mannar area who share a common language and long history of close contact, including marital links. New solutions to these problems are needed.

This lack of governance is further complicated because national, state and local governments have sectoral responsibility and accountability that is divided between different governmental bodies. Responsibility and accountability are not always clearly assigned and the applicable legislation, being derived from multiple sources and as a function of its essentially sectoral nature, overlaps or conflicts in some cases leading to further lack of clarity with regard to responsibility and accountability.

Referring more specifically to the legal and administrative challenges, these include:

- Gaps in the commitment of BOBLME countries to some international agreements, especially those addressing pollution;
- Fragmented, often overlapping and/or conflicting legislation and policies both across sectors and across countries;
- Complex and often conflicting roles and responsibilities of implementation bodies;
- Many domestic laws are outdated and do not include the now accepted concepts of the precautionary approach and the ecosystem approach;
- Gaps in domestic legislation, especially to protect the BOBLME from pollution; and
- Limited stakeholder participation under existing laws.

The conservation and management of the marine environment of the BOBLME requires that projects and activities are implemented effectively across all BOBLME countries through harmonized laws and policies, and robust national and regional institutions with the appropriate jurisdictional mandates and fiscal resources. The transboundary nature of the threats to the BOBLME requires the strengthening of institutional capacity and improved integration and coordination between national and local governments, so as to address these transboundary issues collectively.

3.3 Climate change

While noting that local differences will occur, global climate change is expected to have the following effects across the BOBLME region:

- Ocean acidification;
- Sea level change (rises in most areas);
- Rising sea surface temperatures;
- Changes in rainfall (decrease in some areas and increase in others); and
- Possible increased frequency or intensity of storms and cyclones.

These changes are expected to affect the ecology and biodiversity of the BOBLME. While various global scenarios have been predicted (rise in sea level, increase in the frequency of major storms and the intensity of the most extreme storms, etc.), it is not clear how these will manifest in the Bay of Bengal. In general, the changes should be kept in mind when planning future interventions and management, particularly with regard to the promotion of adaptation measures, but not used to detract from the immediate danger posed by more obvious threats that can be managed and mitigated. For example, non-climate related drivers are likely to have a greater impact on the fisheries sector in the short-term, but the region's ability to manage these will also determine the mid- to long-term impacts that climate change will have. Mismanagement that adversely affects the health of fisheries systems may diminish their resilience and impair their ability to withstand impacts related to climate change.

Relative sea level rise has been advanced as possibly the greatest threat to mangroves, especially in areas where mangrove sediment surface elevation is not keeping pace with sea level rise and there is limited area for landward migration. However, more research is needed to investigate where this is occurring in the BOBLME e.g. in the Ganges Delta where sea level change is caused mostly by subsidence and partly by climate change. In those areas it may be possible to assess the efficacy of mangrove management frameworks, and provide assistance for the management of coastal activities that prevent unsustainable impacts on mangroves and other coastal habitats, and increase resilience to climate change effects. It may also be possible to plan for any landward mangrove migration in response to relative sea level rise, but competition for this land will make this a major challenge.

Global climate change may also have a number of deleterious effects on other critical habitats. Sea level rise may cause lack of light at deeper levels and sea temperature warming is related to coral bleaching. Acidification causes an increase in dissolved bicarbonate and a decrease in the available carbonate in seawater. Thus, as dissolved carbonate concentration rises it will become more difficult and energy consuming for coral and reef animals and plants to make skeletons.

As is the case for fisheries, the countries of the BOBLME need to make a concerted effort to act on the more immediate issues and causes identified below, as the current management practices will determine the possible outcomes of future climate changes.

4. Priority transboundary issues and their causes

In a strict sense, a transboundary issue is defined as an environmental problem in which either the cause of the problem and/or its impacts are separated by a national boundary. A broader interpretation is one in which ecosystem degradation/loss contributes to a global environmental problem and finding regional solutions is considered a global environmental benefit (i.e. “is of global significance”). Thus, a transboundary environmental issue is any environmental issue that requires the involvement of more than one country to properly address the issue and its causes, and to put into place the appropriate mitigation mechanisms.

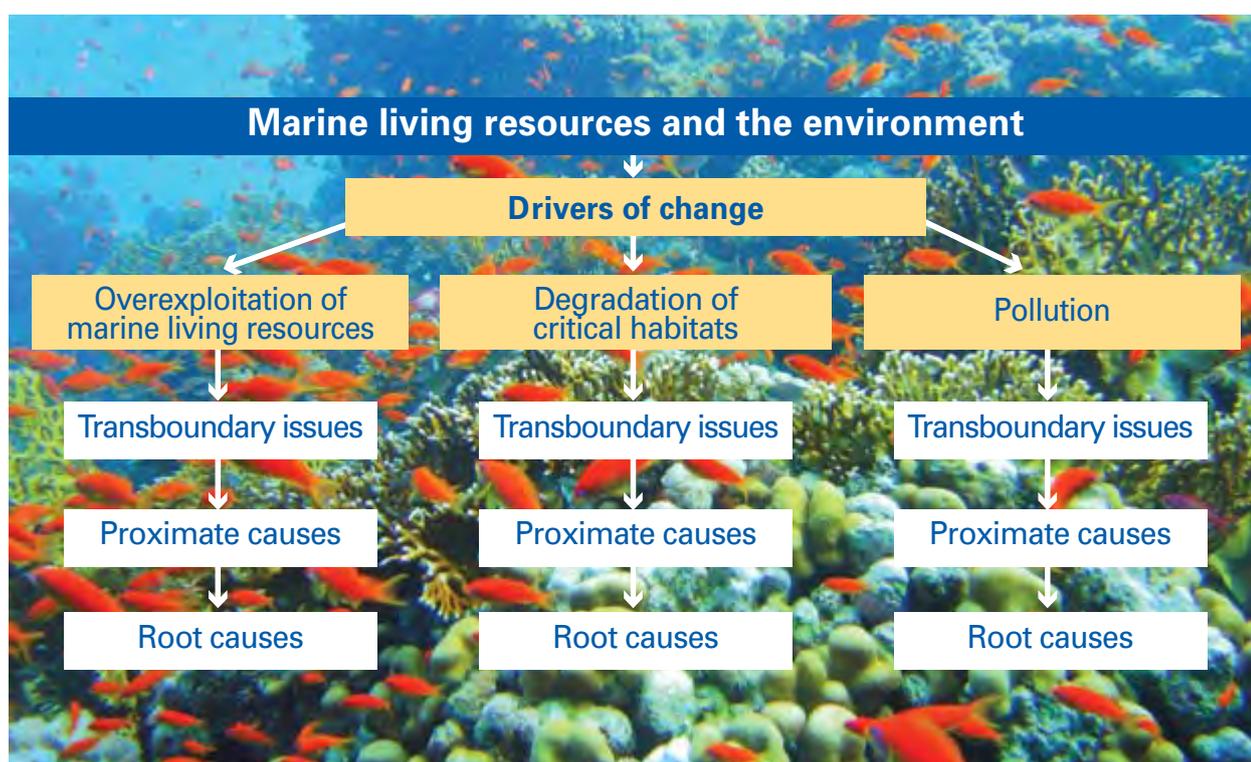
The causal chain analysis (Figure 4.1) begins with three broad themes:

1. **Overexploitation of marine living resources**
2. **Degradation of critical habitats (mangroves, coral reefs and seagrass)**
3. **Pollution and water quality**

These are the high priority themes as recognised by the BOBLME countries. However, they do not preclude the inclusion of other related issues in the development of the SAP, either at the regional level if consensus can be reached, or at the national level as part of a National Action Plan (NAP). For example, mangroves are associated with estuaries, lagoons and mudflats as part of the larger tidal wetlands. Tidal wetlands, in general, provide (i) indispensable resting, feeding and breeding sites for migratory birds; (ii) livelihood support for thousands of traditional fisher households; (iii) other ecosystem services including drainage and flood protection; and (iv) essential habitat for different life cycle stages of near-shore fish e.g. shrimp, and therefore may be included in action programmes.

The main transboundary issues within these three themes are then identified and described. This leads to an identification of their proximate causes, and subsequently root causes. In a formal causal chain analysis, each proximate cause should be directly linked to one or more issues and downwards to the root cause. However, to provide the reader with an overview, only a summary form is presented in this section. The more formal causal chain analyses are presented in Annex 1.

Figure 4.1 Diagram showing the logic of the causal chain analysis.



4.1 Overexploitation of marine living resources[†]

Note: the full causal chain analysis is provided in Annex 1.

Issues	Transboundary nature of the issues
<ol style="list-style-type: none"> Decline in overall availability of fish † resources Changes in species composition of catches High proportion of juvenile fish in the catch Changes in marine biodiversity, including loss of vulnerable and endangered species, such as turtles 	<ul style="list-style-type: none"> Many fish stocks are shared between BOBLME countries, through transboundary migration of fish, or larvae Fishing overlaps national jurisdictions, both legally and illegally – overcapacity and overfishing in one location forces a migration of fishers and vessels to other locations All countries (to a lesser or greater degree) are experiencing difficulties in implementing fisheries management, especially the ecosystem approach BOBLME countries contribute to the global problem of loss of vulnerable and endangered species
Proximate causes	Specific root causes
<ul style="list-style-type: none"> Excessive fishing effort and overcapacity Destructive fishing methods Unselective fishing practices and gear Illegal, unregulated and unreported (IUU) fishing, both national and international 	<ul style="list-style-type: none"> “Open access” regime Government emphasis on increasing production Inappropriate subsidies Increasing fishing effort, especially trawlers and purse seiners High consumer demand for fish, including for seed and fishmeal for aquaculture Weak fisheries MCS and enforcement Strong incentives to encroach into areas with better returns

4.1.1 The transboundary issues relating to the overexploitation of marine living resources

The main four transboundary issues are:

- Decline in overall availability of fish resources;**
- Changes in species composition of catches;**
- High proportion of juvenile fish in the catch;**
- Changes in marine biodiversity, especially though loss of vulnerable and endangered species.**

These issues have been identified through a detailed scientific assessment of the status of the marine living resources (see Volume 2 for full details).

Many indicators point to the depleted state of the fisheries resources of the BOBLME:

- The stagnation of production in six of the eight BOBLME countries for at least the past decade;
- The changing species composition of the catch over the past 30 years;
- The high proportion of juvenile fish now being taken;
- Stock assessments of major fish groups reported by APFIC (2011) and IOTC (2010);
- Declining catch rates in trawl surveys carried out over long time periods;
- Overall current catches in excess of potential yield estimates; and
- Anecdotal evidence from fishers.

[†] Marine living resources includes all living resources of which fisheries is a subset.

[‡] Fish includes finfish, crustaceans, molluscs and any aquatic animal that is harvested. A fish stock refers to the living resources in the community or population from which catches are taken in a fishery.

4.1.2 The transboundary nature of the issues

Many of the marine living resources in the BOBLME traverse the international boundaries of adjacent, and sometimes non-adjacent countries and many of them are targeted by several BOBLME countries. Fishing in one country affects the availability of stocks in another. Large pelagic species, such as tunas and billfishes, range over large ocean spaces and pass through the EEZs of many countries both inside and outside the BOBLME.

Smaller pelagic species, such as anchovies, herrings, mackerels and shads, usually migrate through the coastal waters of at least two or more neighboring countries. Examples include the BOBLME Project key species that were chosen to build capacity and methodology for application in the future SAP. These are hilsa shad, which is shared by most countries but concentrated in the waters of India, Bangladesh and Myanmar; Indian mackerel, which occurs in all countries; and sharks that are of global and regional concern.

Resources that appear to be more sedentary or only locally mobile – such as reef fish, lobsters, sea cucumbers and corals – often have patterns of larval dispersal that give their distribution a transboundary dimension. Tropical lobsters (genus *Panulirus*), for instance, have a pelagic larval lifespan that may last from four to 12 months; during this period the larvae may travel many kilometers from the place of birth to the place of adult settlement.

Most BOBLME countries fish to some degree in other countries' EEZs. Based on known access agreements (both formal and informal), the Sea around us Project (SAUP, 2010) has estimated the origin of each country's fish catch. The most wide-ranging fleet is that of Thailand; the fleet fishes in Indonesia, Malaysia, Myanmar, Bangladesh and India (including Nicobar and Andaman Islands). According to SAUP, much more is taken in Myanmar and Malaysian waters than in Thailand's own EEZ. It has been estimated that 4 000 large Thai vessels operate in the EEZs of other coastal states (mainly Myanmar and Malaysia) and 2 000 of these have licenses.

The least wide-ranging fleet is that of the Maldives which fishes almost exclusively in its own EEZ. Distant water fishing fleets (mainly from Japan, South Korea, China and Taiwan [Republic of China], Singapore and the European Union [Spain and France]) have all been active in the BOBLME in the past. As is the case in other parts of the world, foreign access to fisheries was encouraged by many BOBLME countries, but participation has changed over the years. Japan was the most active player in early years but in recent years foreign access has been allowed in Myanmar, the Maldives and India under joint venture arrangements. Most foreign fishing reported by SAUP in 2006 occurred in the Maldives.

Crews are often shared across boundaries. This is particularly prevalent on Thai fishing vessels where many of the crew are from Myanmar and some from Cambodia. Stories of mistreatment of foreign crews feature regularly in the press.

All the countries of the BOBLME are experiencing significant difficulties in improving fisheries management. All countries are facing the same challenges in terms of lack of government resources, lack of human capacity and social and market systems that provide perverse incentives against good management. Despite relatively good fisheries legislation and policies, best practice in fisheries management is difficult to find.

Malaysia and the Maldives, because of their smaller population and greater economic development probably lead the field, but here too there are problems. Fisheries that have either been controlled by traditional customary practices in the past have mainly been eroded by the introduction of western-style government and bureaucracies. "Open access" is the dominant policy in the region and this has led to overexploitation and overcapacity that is difficult to rectify. Countries are hindered by an unwillingness or inability to bear the short-term social and economic costs of reducing fishing. Some success is apparent in certain localities where co-management has been trialed (usually supported by foreign aid), but this is yet to be mainstreamed into national systems.

A long list of species has been identified as vulnerable and endangered in the BOBLME (see Volume 2). For example, the list of species recently declared to be extinct in the Sunderbans alone (Hossain, 2003) includes mammals, birds and reptiles.

4.1.3 Causes of overexploitation of marine living resources

The proximate causes of the (i) declining coastal fishery resources; (ii) changing species composition; (iii) high proportion of juvenile fish; and (iv) changing marine biodiversity are:

- Excessive fishing effort and overcapacity;
- Destructive fishing methods;
- Unselective fishing practices and gear; and
- Illegal, unregulated and unreported (IUU) fishing, both national and international.

These in turn are caused by:

- “Open access” regime;
- Government emphasis on increasing production;
- Inappropriate subsidies;
- Increasing fishing effort, especially by trawlers and purse seiners;
- High consumer demand for fish, including for seed and fishmeal for aquaculture;
- Weak fisheries MCS and enforcement; and
- Strong incentives to encroach into areas with better returns.

One of the main root causes that run across all the issues is the so-called “open access” regime. While noting that traditional and customary laws and regulations are in place in some coastal areas of the BOBLME, governments have an “open-access” policy to fishing. Under this policy, any person has the right to fish, either as a source of food or income. Experience elsewhere in the world has shown that, although the policy provides a safety net for the poor to survive, especially in hard times, uncontrolled harvesting of marine living resources results in overexploitation and overcapacity in the fishing sector (especially in large-scale industrial fisheries) and a loss of the socio-economic benefits that the resource can potentially provide. Governments should take the lead and limit entry to fisheries based on a sound analysis of the socio-economic context of a particular fishery. Customary law and rules and regulations, where they still exist, should be encouraged through a co-management system, as a path to a more “limited access” regime.

In the BOBLME there is continued growth in commercial fishing effort, especially through increased horsepower and size of fishing vessels. Open access and the competitive nature of fishing leads to irresponsible fishing practices such as destructive methods and gear and unselective gear (especially gear with very small mesh sizes) that destroy both the critical habitats and the fish resource itself. The high numbers of fish taken before they have a chance to breed is a waste of the resource. Other examples of destructive fishing include dynamite fishing and the use of cyanide and other toxins for capturing ornamental fish and live food fish; bottom trawling, causing long-term habitat change; increasingly large volumes of small, low-value/“trash” fish indiscriminately taken by trawl fisheries; and the use of various kinds of estuarine set-nets and push nets to collect prawn post-larvae for onward sale to the prawn farms.

Coupled with this “open access” is a lack in monitoring, control and surveillance (MCS) and a failure to achieve even some compliance with existing rules and regulations. Better stakeholder involvement through co-management and a reduction in the number of fishing boats (especially larger boats) would bring about reforms that will have long-lasting benefits in the BOBLME.

However, simply cleaning up one’s own back yard will not be effective if transboundary IUU fishing is allowed to continue. There is now a strong global movement to stem IUU. This movement includes the introduction of port state control measures and a strengthening of the role of regional fisheries management organisations (RFMOs). The BOBLME is without such a RFMO, except for the IOTC that has the competence for highly migratory tuna and associated species in the whole of the Indian Ocean.

IUU fishing has been identified by BOBLME countries as a major problem and highlighted in many regional and international fora (e.g. APFIC, 2007). The general conclusion has been that IUU fishing is costing the countries of the region significant amounts in lost revenue and is resulting in overexploited fisheries and adverse social costs.

The global demand for fish and fish products needs to be recognized and factored into any solution for overexploitation. World exports of fish and fishery products reached USD85.9 billion in 2006 (FAO, 2008). In real terms (adjusted for inflation), exports of fish and fishery products increased by 32.1 percent in the period 2000 to 2006. Exports of fish for human consumption have increased by 57 percent since 1996. Growth is predicted to continue but mainly in developing countries (Delgado *et al.*, 2002). Developing countries have changed from being net importers of fisheries products to large net exporters over the past 30 years. World food fish consumption is projected to grow 0.5 percent faster than population world-wide, with 36 percent of food fish consumption growth in 2020 coming from China, a near neighbour of BOBLME countries, and 61 percent from other developing countries. A major driver is the expansion of large retail chains cashing in on the demand for fish. In the USA for example, the top 20 retailers have captured 52 percent of food fish sales and in Germany and the UK, 82 percent and 60 percent of fresh seafood sales, respectively.

This globalization presents many advantages for developing countries in terms of their supply of natural resources, their cost of production and flexibility in small-scale enterprises. However, on the negative side it is placing increasing pressure on already stretched limits of fisheries production and is providing incentives for governments to insist on “increased production”, rather than a more thorough consideration of the limits to growth and the need for “increased value”.

Emerging markets for fishmeal and *surimi* are also encouraging the capture of small, low value/trash fish, with the catch often including a large proportion of juveniles of commercially important species. The total production of trash fish is around 800 000 tonnes in the BOBLME – ranging from 12 percent of the total catch in India, to 47 percent in Myanmar (APFIC, 2011). In countries where the demand for aquaculture feed is high, much of the small, low value/trash fish are either converted to fishmeal and included in formulated aquaculture diets, or fed directly into fish cages. Threadfin bream, lizard fish, bigeye, croaker and goatfish are also becoming more economically important demersal fishes as they are now commonly used as raw materials for *surimi* manufacture in the region. The total production of *surimi* for the region is growing and is roughly estimated to be 75 000 tonnes, requiring approximately 262 500 tonnes of raw material (APFIC, 2011; Lymer *et al.*, 2010).

4.2 Degradation of critical habitats

Note: the full causal chain analysis is provided in Annex 1.

Issues	Transboundary nature
<ol style="list-style-type: none"> 1. Loss and degradation of mangrove habitats 2. Degradation of coral reefs 3. Loss and damage to seagrasses 	<ul style="list-style-type: none"> • All three critical habitats occur in all BOBLME countries • Coastal development for other uses of the land and sea are common in all BOBLME developing countries • Trade in products from all the habitats is transboundary in nature • Climate change impacts are shared by all BOBLME countries
Proximate cause	Specific root cause
<ul style="list-style-type: none"> • Conversion of mangroves for agriculture, aquaculture and salt production • Expanding coastal development for industry, human settlement and tourism, including reclamation • Lack of clear land tenure • Unsustainable logging of mangroves • Increasing pollution, eutrophication and sedimentation • Destructive fishing practices (poisons, explosives, trawling and push-netting) • Coastal modification, including coral and sand mining, dredging and reclamation • Natural causes, especially coral bleaching 	<ul style="list-style-type: none"> • Food security needs of the coastal poor • Lack of national, provincial/state coastal development plans • Increasing trade (both domestic and export) for habitat-related products • Coastal development and industrialization • Ineffective marine protected areas and lack of enforcement • Intensive upstream agriculture practices • Upstream development that affects water flow • Increasing tourism • Climate change

4.2.1 The transboundary issues relating to degradation of critical habitat

Three transboundary issues were identified:

1. **Loss and degradation of mangrove habitat;**
2. **Degradation of coral reefs; and**
3. **Loss and damage to seagrasses.**

These were based on the assessment of the status of mangroves, coral reefs and seagrass, examined in Volume 2 of this TDA. Mangroves have been classified as either degraded or under threat in all countries. Over 4 500km² of mangroves have been lost in the region over the last 30 years, with the majority being lost in Myanmar (3 001km²). In that country, the total area of mangroves lost exceeds the sum of all losses in the other countries. Net loss of mangroves peaked at 1 374 km² between 1990 and 2000, increasing from 976km² between 1975 and 1990, and declining to 139 km² between 2000 and 2005. The major cause of loss of mangroves has been conversion for agriculture (82 percent) and conversion for aquaculture (12 percent).

Coral reefs are also classified as degraded or under threat. Coral reefs in South Asia and Southeast Asia suffered large scale bleaching in 1998, caused by high water temperatures associated with the *El Nino* Southern Oscillation (ENSO)/Indian Ocean Dipole (IOD) effect. Up to 90 percent mortality on some reefs was recorded in the Maldives, but there was much less bleaching in the Gulf of Mannar and off the Andaman and Nicobar Islands (Wilkinson, 2008). Corals in most shallow reef areas of Sri Lanka were destroyed. Some recovery has occurred but further damage may occur with sea temperature rise. Since early 2010, a massive bleaching of a similar scale has occurred region-wide.

Reefs considered to be at greatest risk from a combination of (i) coastal development, (ii) overexploitation and destructive fishing practices, (iii) the impact of inland pollution and erosion, and (iv) marine pollution, are the reefs around Aceh and the islands off Sumatra in Indonesia; Malaysia west coast; Myanmar; Sri Lanka and the Gulf of Mannar (Bryant *et al.*, 1998 and Reefbase, 2010).

Myanmar has some of the region's most pristine reefs, but reef status is difficult to determine due to a lack of baseline information. However, there are growing concerns that the prevalence of destructive fishing, such as trawling and long-line fishing near reefs, and blast fishing, is increasing rapidly. There are many reports of illegal and destructive fishing by foreign fishers and the harvest of reef invertebrates for the ornamental and aquarium trade, and sea cucumbers for food and export, is increasing. The Andaman Sea coast is the coral reef area in the Bay of Bengal for Thailand, with primarily fringing reefs ranging from near-shore to offshore areas. Rapid coastal development on the Thai Andaman Sea coast over the past three decades poses a threat to the reefs. The main threat to the reefs in India's Andaman and Nicobar Islands is also thought to be fishing. The reef area of Bangladesh is extremely limited around the island of St. Martin; this is also exposed to multiple stresses from sediment, coastal tourism and other uses.

According to assessments carried out after the December 2004 Indian Ocean tsunami, coral reefs of the region suffered only minimal damage. At worst, only eight percent of pre-tsunami coral coverage was lost, even if all the tsunami-damaged coral dies. Following the tsunami, some natural restoration has been reported.

If coral cover is used as the sole indicator, there has been a positive trend in reef status across South Asia since 2004. However, the region is still struggling to recover from the massive impact of the 1998 bleaching and the lesser impact of the Indian Ocean tsunami of 2004. It is clear that the rate of recovery, with some notable exceptions, is mostly moderate or slow, largely due to direct human stresses. Similarly, many reefs in the region have changed considerably from their original state in terms of species composition and ecological functionality, e.g. changes to algal turf beds.

There is insufficient information to assess the status of seagrass, although it is thought that many of the BOBLME region's seagrass beds are either already degraded or threatened. The biodiversity supported by the seagrass beds will also be at risk, especially with regard to endangered species such as marine turtles, dugongs and seahorses, although little quantitative information is available. The productivity of the coastal fisheries supported by seagrass beds could also be declining as the seagrass beds degrade.

4.2.2 The transboundary nature of the issues

Mangrove forests are found in all the BOBLME countries and, mangrove coverage is considered to be of global importance in some countries. About 12 percent of the world's mangrove cover occurs in the BOBLME which is home to the largest mangrove system in the world: the Sunderbans, shared by India and Bangladesh and declared as a Biosphere reserve.

Coral reefs are also found in all the BOBLME countries and together comprise about eight percent of the world's coral reefs. Some reefs are of global significance, e.g. India and Sri Lanka together are the home of the Mannar coral reef system, and the Indian part is designated a UNESCO Biosphere Reserve. However, the large river flows, monsoonal runoff from the land and strong currents that cause turbidity makes much of the BOBLME unsuitable for corals; they are limited in distribution and are usually found offshore where it is shallow enough for them to establish, or in shallow inshore waters that do not have large rivers flowing nearby, e.g. Gulf of Mannar between Sri Lanka and India; the Maldives; and the Similan Islands in the Andaman Sea.

Seagrass is usually found on mud/sand flats or between coral and mangroves. Seagrass beds are found in all the BOBLME countries. However, information on their regional extent and status is not available.

Of major transboundary significance are losses in biodiversity and fisheries productivity that are associated with the degradation of critical habitats. The threatened (and extinct) species of the BOBLME are closely associated with at least one of the three habitats identified as being of critical importance for the maintenance of biodiversity in the BOBLME. At least six areas have been identified as having regional significance: the Sunderbans; Palk Bay and the Gulf of Mannar; Mahatma Gandhi Marine National Park (Wandur National Park)

in the Andaman and Nicobar Islands; the Maldives Atolls; and Mu Ko Similan and Mu Ko Surin National Parks in Thailand. In the Sunderbans there is a worrying number of endangered amphibians, birds, mammals and reptiles and the area has already experienced species extinctions.

In all the BOBLME countries industrialization is increasing rapidly. Industrialization is generally centred on transforming raw materials into steel, paper, chemicals, paints, plastics and textiles; also important are leather tanning, oil refining, and electricity generation. These resource-intensive activities produce large quantities of toxic and hazardous wastes. Raw material extraction (e.g. mining and logging) is environmentally damaging both *in situ* and downstream (through, for example, ecosystem disturbance and destruction, erosion and sedimentation).

Tourism is an important source of foreign earnings but the damage caused by tourism to critical habitats is usually not considered. Resorts, roads and whole towns are being developed close to the sea without taking into account the problems of erosion and sea level rise. Tourists are often visitors from other countries and can inject funds into local economies without realising the damage they and their requirement for services and infrastructure are causing.

Deforestation and the associated runoff after monsoon rains may impact neighbouring countries, particularly where rivers are large. In many countries upstream dams have been built on large rivers, resulting in less scouring by floods and more silt in down-river areas. This silt has, in turn, caused more flooding downstream which may increase water turbidity and affect the three critical habitats. For example, mangrove forests in the Sunderbans are declining because of rising sea level and the intrusion of salt water, but deposition of silt is occurring in the delta of the Ganges. The problem of mangrove degradation and loss is a transboundary issue for India and Bangladesh.

The transboundary aquarium and live fish trade encourages local people to dynamite or poison reefs to capture fish. Other destructive fishing methods also impact the habitats. For example trawling and push-netting across seagrass beds can damage and uproot the grass. Gleaning by local communities for molluscs, seahorses for Chinese medicine and sea cucumbers, can reduce biological diversity if it is not carried out sustainably. And seagrass may be damaged by trampling.

In the past, trade in ornamental coral was an important transboundary issue but this problem has been reduced by awareness campaigns and enforcement of regulations. However, the trade continues in many countries of the region. Dredging channels so that large ships can more easily approach the coast or – in the case of the Sethu Samudram Ship Canal Project on the coast of Tamil Nadu – enable faster sea travel between the east and west, are also of transboundary concern. Canals will require constant dredging to maintain a depth of about 10 to 14 m and aside from damage to the immediate area of the seabed, the consistent churning of sediment may smother adjacent coral reefs and seagrass meadows. The increase in shipping traffic could also result in an increased number of oil spills and marine pollution.

Other threats to the critical habitats common to all BOBLME countries come from pollution and introduced marine pests. Pollution from sea could come from ships unloading ballast water that contains exotic species, or oil. Oil spills are obvious transboundary sources of pollution. The likelihood of oil spills is very high in the BOBLME but contingency plans for such occurrences are undefined. Not much is known about introduced marine species in the BOBLME but they are brought into countries on the hulls of ships, as ballast water or when exotic species are brought in for culture. Land-based activities, such as excessive use of herbicides, can impact coastal waters as a result of spray drift, leaching, run-off and accidental spills that may be transboundary in nature.

4.2.3 Causes of degradation of critical habitats

Proximate causes that have been identified as resulting in degradation of mangrove habitats include:

- Conversion of mangroves for agriculture, aquaculture, and salt production;
- Expanding coastal development for industry, human settlement and tourism, including reclamation;
- Lack of clear land tenure;
- Unsustainable logging of mangroves; and
- Increasing pollution and sedimentation.

For coral reefs the major causes of degradation are:

- Coral bleaching associated with climate change;
- Coastal modification, including dredging and coral mining for sand and limestone;
- Eutrophication (increasing nutrients) resulting in algal blooms;

- Overexploitation of reef fish and destructive fishing methods (e.g. cyanide and blasting);
- Direct impact of tourism; and
- Sediments, pesticides and pollution from land-based activities.

For seagrass, the main causes are:

- Sedimentation and eutrophication;
- Destructive fishing practices (trawling and push-netting); and
- Coastal modification, including dredging and mining for building sand.

These in turn are caused by:

- Lack of coastal planning at the national, provincial/state level;
- Food security needs of the coastal poor;
- Coastal development and industrialization;
- Increasing trade (both domestic and export) for habitat-related products;
- Ineffective marine protected areas and lack of enforcement;
- Intensive upstream agriculture practices;
- Upstream development that affects water flow; and
- Increasing tourism.

Clearing mangroves for aquaculture, agriculture, salt production, and for land reclamation for housing, resorts, roads and harbours, are the major causes of mangrove loss. As expected, causes of deforestation vary with space and time, but between 1975 and 2005, conversion to aquaculture was not the major cause of mangrove deforestation in the region (in contrast to many other parts of Asia). Conversion of mangroves for agriculture was the main cause in most countries, although aquaculture conversion was the main cause in Indonesia; both agriculture and aquaculture were important causes of mangrove loss in Thailand. Indiscriminate tree felling and lopping, mainly for fuel wood, woodchip, pulp and charcoal production, fodder and timber for houses (especially in areas close to human habitation) also contribute to the problem. There is often a lack of interest, or awareness by private landowners (village communities and individuals) to conserve and develop the mangroves on their lands. Other unsustainable practices include removal (including selective overharvesting) of mangrove animals for food and trade, especially brood stock for shrimp seed.

Sea temperatures in the BOBLME have increased by 0.5°C since 1957. Coral bleaching occurs when the thermal tolerance of corals and their photosynthetic symbionts (zooxanthellae) is exceeded. Climate studies (Ove, 1999) have indicated that the thermal tolerances of reef-building corals are likely to be exceeded every year within the next few decades. Warming events as severe as the 1998 event (the worst on record) are likely to become commonplace within 20 years. Most information suggests that the capacity for acclimation by corals has already been exceeded and that adaptation will be too slow to avert a decline in the quality of the world's reefs. The rapidity of predicted changes indicates a major problem for tropical marine ecosystems and suggests that unrestrained warming cannot occur without the loss and degradation of coral reefs on a global scale.

Fishing on coral reefs has seen a change from a traditional and sustainable fishery for domestic and local consumption to increasing exploitation of reef areas for tourism and commerce. The live food fish trade for both human consumption and ornamental fish is a global system that links fishing communities with markets, primarily in Hong Kong and mainland China. Many of the fish are captured on coral reefs with poisons (cyanide) or dynamite blasting. While the majority of these fish do not survive the blast fishing, the fish that are only stunned are collected for the live food fish trade.

Discharge of land-based liquid and solid waste (sewage, domestic, industrial, agricultural and aquacultural waste [especially from shrimp farms]) is another major cause of coral reef loss. Nutrients from sewage and agricultural runoff can cause algal turf to grow on bleached coral and eventually the polyps die. Solid waste damages corals by knocking pieces off. Aquaculture effluent and solid waste coming from farmers draining their ponds may enter the sea, adding nutrients and chemicals that may affect the coral.

Pollution from undersea oil drilling, ballast water and waste are also threats to coral reefs and mangroves. A lack of infrastructure to process industrial and domestic wastes is seen as a root cause that could be addressed.

Siltation and sedimentation from inland deforestation, agriculture, coastal construction and sandy beach development, all impact on critical habitats. This is compounded by changes in salinity caused by the diversion of the flow of fresh water by onshore activities. This has been identified as being particularly severe in the Sunderbans. Uncontrolled tourist activity including trampling, reef curio collecting and destructive anchoring

and moorings by tourist boats; destructive fishing practises including dynamiting, cyanide poisoning and bottom trawling; and harvesting and mining coral and sand for building material, construction and beach replenishment (sand) are all recognised as proximate causes.

One of the main causes of seagrass loss is reduction of light caused by sedimentation or excessive epiphytic growth on leaves. Also, by utilising nutrients, phytoplankton may bloom over seagrass beds, thereby reducing light. Nutrients enter the sea in runoff from cities; sewage or partly treated sewage; fertiliser from agriculture; and nitrogen from factories. Sediments come from road building; land development; landslides after heavy rain on deforested country; and dredging. Sediment may also be disturbed by changing coastal hydrology with sea walls and causeways; attempts at erosion mitigation; and propellers running in shallow water. Physical modification of seagrass beds will damage them, sometimes irreparably. Seagrass plants take a long time (sometimes decades) to recover because underground rhizomes grow slowly even when strong seedling germination occurs.

4.3 Pollution and water quality

Note: the full causal chain analysis is provided in Annex 1.

Issues	Transboundary nature
<ol style="list-style-type: none"> 1. Sewage-borne pathogens and organic load 2. Solid waste/marine litter 3. Increasing nutrient inputs 4. Oil pollution 5. Persistent organic pollutants (POPs) and persistent toxic substances (PTSs) 6. Sedimentation 7. Heavy metals 	<ul style="list-style-type: none"> • Discharge of untreated/partially treated sewage is a common problem; sewage and organic discharges from the Ganges-Brahmaputra-Meghna system are likely to be transboundary • Marine litter, including plastics and discarded fishing gear can be transported long distances across national boundaries • High nutrient discharges from rivers could intensify large-scale hypoxia; atmospheric transport of nutrients is inherently transboundary • Differences between countries with regard to regulation and enforcement of shipping discharges may drive discharges across boundaries; tar balls are transported long distances • POPs/PTSs and mercury, including organo-mercury, undergo long-range transport; sedimentation and most heavy metal contamination tend to be localized and lack a strong transboundary dimension
Proximate causes	Specific root causes
<ul style="list-style-type: none"> • The widespread discharge of untreated or inadequately treated domestic, industrial, and agricultural wastewater • Inadequate solid waste management, including widespread discharges of solid waste into rivers and coastal waters and the open burning of solid waste, which generates dioxins and furans • Increasing emissions of nutrients from fertilizer use in agriculture, expanding aquaculture and atmospheric emissions from industry and fossil fuel burning • Routine operational discharges of oil from shipping and dumping of waste oil by vessels and vehicles on land 	<ul style="list-style-type: none"> • Increasing coastal population density and urbanization • Increasing per capita consumption • Migration of industry into BOBLME countries and a proliferation of small industries • Low per-capita GDP • Inadequate investment in water management and wastewater treatment • Lack of reception facilities for used oil and oily wastes • Lack of enforcement of environmental regulations • Lack of awareness of policy makers, legal system and civil society

4.3.1 Transboundary issues relating to pollution

Pollution can be transboundary in nature, both in the strict sense in that contaminants or the effects of pollution are transported across national boundaries, and also in the sense that problems are widespread in all countries of the region.

The priority transboundary pollution issues in the BOBLME region are:

- Sewage-borne pathogens;
- Organic load from sewage and other sources;
- Marine litter;
- Increasing nutrient inputs;
- Oil pollution;
- Persistent organic pollutants (POPs) and persistent toxic substances (PTSs); and
- Mercury, including organo-mercury compounds.

4.3.2 The transboundary nature of the issues

Some pathogenic bacteria and viruses can remain viable for up to several months in the marine environment, but when the organisms are deposited in sediments relatively immobile sewage-borne pathogens are generally unlikely to be transported long distances from their point of discharge into the marine environment (Ashbolt, 1995). The effects of high organic loads are also likely to be localized near the source due to the rapid degradation of the organic matter and the mixing and dilution that typically accompanies transport by currents. The exception is the Ganges-Brahmaputra-Meghna system, where sewage and other organic contaminants are likely to be shared by India, Bangladesh and Myanmar due to the high river discharge and ocean circulation patterns.

Therefore, sewage-borne pathogens and organic load from sewage and other discharges are probably not major transboundary issues in the sense of the contaminants, or their effects, being transported across national boundaries. Discharges of untreated or inadequately treated domestic sewage and high organic loads from other sources are, however, transboundary in that successful measures to address these issues can be transferred from one country to another within the region.

Marine litter, including plastic and discarded fishing gear, can be transported long distances in the marine environment and are clearly a major transboundary issue. Other components of solid waste tend to remain localized near their source.

Increasing nutrient inputs from rivers have the potential to lead to inner-shelf hypoxic zones near rivers which could expand or be carried across borders, or adversely affect transboundary fish stocks. Increasing river and atmospheric nutrient inputs could also intensify the natural oxygen minimum zone in deeper waters offshore, potentially leading to increasing incursions of hypoxic deep water onto the shelf. An increase in nutrients is also resulting in harmful algal blooms (HABs), also known as red tides.

Atmospheric inputs resulting from long-range transport are inherently transboundary, as are shipping and associated sea-based discharges of oil. Disparities between countries in the regulation and enforcement of operational discharges could be acting to drive such discharges from one country to another. For example, in Bangladesh, discharges of oil ballast water are unregulated (Hossain, 2003). Residual oil in the form of tar balls is known to be transported long distances across national boundaries.

Many persistent toxic substances (PTSs) undergo long-range transport in the atmosphere or via other pathways. Therefore, PTSs are likely to have a transboundary distribution in the BOBLME. Because of the potentially serious impacts of these compounds, and the lack of information about the levels and effects of PTSs and persistent organic pollutants (POPs) in the BOBLME, this constitutes a priority transboundary issue.

The bulk of riverine sediment inputs to the ocean settle out near the river mouth, so the effects of sedimentation are generally localized. The northern portion of the BOBLME, where river inputs from the Ganges-Brahmaputra-Meghna system are most likely to have transboundary effects, is subject to high natural sediment inputs. Sedimentation is therefore unlikely to have a strong transboundary dimension. In general, metals also remain localized near their source – the exceptions being mercury and lead – although the BOBLME sediment fan has been traced as far south as the equator. Lead inputs are expected to decline with the phasing out of leaded fuels, but the status of mercury contamination (including organo-mercury contamination) in the BOBLME is not known and is a priority gap in knowledge.

4.3.3 Causes of pollution

The proximate causes for the identified priority issues are:

- The widespread discharge of untreated or inadequately treated domestic, industrial and agricultural wastewater;
- Inadequate solid waste management, including widespread discharges of solid waste into rivers and coastal waters and the open burning of solid waste which generates dioxins and furans;
- Increasing emissions of nutrients from fertilizer use in agriculture, expanding aquaculture, and atmospheric emissions from industry and fossil fuel burning; and
- Routine operational discharges of oil from shipping and dumping of waste oil by vessels and vehicles on land.

A pollution phenomenon highlighted by the regional thematic review (Kaly, 2004), but not identified in national reports, is that of severe episodic events such as floods, cyclones, and storm surges. These periodically mobilize pollutants from relatively immobile compartments such as lagoons and coastal sediments and can render waste management systems such as landfills and sewerage systems ineffective. Such catastrophic events can cause the release or transfer of large quantities of contaminants into the coastal and marine environment (Kaly, 2004), but conversely, could also act to flush contaminants from coastal areas.

These proximate causes are, in turn caused by:

- Increasing coastal population density and urbanization resulting from intrinsic population growth, migration to coastal areas and coastal tourism;
- In many areas, increasing per capita consumption of goods and services which adds to the effect of increasing population density;
- A low per capita GDP which tends to preclude public investment in environmental management measures, including waste management infrastructure and environmental monitoring;
- The migration of industries into BOBLME countries from elsewhere, often driven by a perceived or actual relaxation of environmental regulations and constraints compared to other countries. This has been accompanied by a shift from “heavy” industries such as steel, paper and chemicals, which are increasingly well-regulated, to “lighter” industries. These lighter industries often involve smaller but more numerous plants which are inherently more difficult to regulate and service with waste management systems than a smaller number of large production facilities;
- A lack of awareness of the impacts of marine pollution among the public, the judicial system and policy makers. This contributes to public behaviour that increases pollution, reduced enforcement of environmental legislation and regulations, and a low policy priority for environmental investment;
- Poor enforcement of environmental regulations. Most BOBLME countries have adequate environmental legislation and supporting regulations, but these are often not enforced adequately. Reasons for inadequate enforcement include:
 - Insufficient financial and/or human monitoring and enforcement capacity;
 - Responsibility for implementing and enforcing environmental policy and legislation is often spread across a number of agencies, without adequate coordinating methods;
 - Lack of awareness of the importance of environmental legislation so that violations of environmental laws may not be regarded as serious offenses by the judicial system; and
 - A general lack of incorporating the economic, health and social impacts of pollution into development planning decisions.



5. Information gaps and state of knowledge of the BOBLME

Two categories of information gaps are relevant in the LME management context:

- An actual lack of essential information. This is information that really does not exist and without which a sensible approach to the problem at hand is constrained; and
- A perceived lack of essential information. This is information that is important for problem-solving as defined above but that does actually exist; however, in the region it is either not widely known in the circles that need it, or it is not in a useable form, or it is not available at all, although it is available elsewhere.

These two types of gaps should be distinguished. The interventions needed to address the gaps – and their cost and complexity – will be very different. For example, addressing an actual lack of essential information may require a long and costly research programme. Information that already exists is far easier and usually far cheaper to obtain and make useful. Preston (2004) remarks that in the BOBLME region, much valuable information on fisheries resources is contained in studies that have never been synthesized or placed in a larger analytical context and are kept, often as only the single original and on open shelves, in government department offices.

There have been some very significant advances in science in the region, especially in the understanding of the large oceanographic processes and improvements have been made in reporting. The understanding of the complex ecosystem is probably on par with many other LMEs. Although a system-wide ecosystem model is yet to be developed, the necessary data and information are available.

This TDA is one of the first attempts to review and synthesize the vast amount of information that is available in the BOBLME countries, and as such, should form a baseline for future analyses.

In synthesizing the data a number of challenges were encountered. Firstly, because the BOBLME includes only a part of the coast of several countries, providing data at the appropriate geographic scale is a challenge. Many of the reports used data that was collated at the national level and based on national statistics and information, not the BOBLME. In some cases, for example in Indonesia where only four provinces are covered in the definition of the BOBLME, some extrapolations and assumptions were required to come up with estimates from larger databases.

Secondly, inconsistent definitions are a major impediment in collating the necessary information. As an example, there are several apparently conflicting values for the area of mangroves in the different countries. Part of the reason for this is that “mangrove forests” are defined differently in the different countries.

Thirdly, different technologies also produce different results. Again, using the mangrove example, newer satellite data are becoming available and better mapping techniques are being used to map data in greater spatial and thematic detail. These, at least, provide consistent definitions and technologies, making country comparisons possible.

The concept of “best scientific advice” and the “precautionary approach” in assessing information gaps also merits further consideration. In the context of managing natural (eco)systems, a lack of scientific data is often – and often inaccurately – equated with a lack of essential information. The consequence often is no management action at all, while the environmental problems to be addressed worsen. The fundamental reality driven by the nature of scientific research itself, is that even in the best-funded programmes in the wealthiest countries there will probably never – within useful time scales for planners and managers – be enough scientific (which usually means quantitative) data for the development and implementation of rigorous management plans for those systems, on the best scientific principles.

In most circumstances, however, there is likely to be enough qualitative information and (though not required) at least some supporting quantitative data available to permit the establishment of a reasonable set of initial management actions to address a given environmental problem. These can – and should, as should all management actions, no matter how “scientifically” based – be adapted (so-called adaptive management) as experience from the field, with the results from the initial management plan, comes in.

The precautionary principle should be used to deal with such uncertainty. The principle states that where the possibility exists of serious or irreversible harm, lack of scientific certainty should not preclude cautious action by decision-makers to prevent such harm. Management needs to anticipate the possibility of ecological damage, rather than react to it as it occurs.

5.1 Information gaps for socio-economic characteristics

There are many information gaps concerning socio-economic information, both regionally and nationally. However, identifying specific information required (and how this should be delivered) for decision making can only be done in any meaningful way with a much more detailed understanding of the national social, economic and political contexts. Without an understanding of these complex systems (which are in a constant state of change), it is possible to say what types of information could be good to complete a better picture of the socio-economic context of the BOBLME, but not what information is required to inform and influence management decisions in the BOBLME.

There are, however, three broad areas of knowledge that if addressed could significantly strengthen the ability of the BOBLME Project and national governments to recognize and respond to the challenge of LME management and development. These are:

Understanding the roles of the BOBLME marine living resources (notably fisheries) in the national development processes:

Some literature exists on the importance of marine resource use in the livelihoods of rural people and there are also very general data on the economic importance of fisheries but this often reflects poorly on their true value. There is a clear lack of tools, methods and approaches for incorporating the local level values of marine resources into a broader analysis of how marine resources contribute to processes of local and national growth and development, and how important they are in ensuring that development processes are more inclusive of the poor.

Examples of the types of knowledge and research that could help include:

- Evidence of the current and potential role of marine resources in the different contexts of the BOBLME countries;
- Building evidence of the role of marine resources (particularly renewable marine resources) into early stages of development; and
- Identification, development or adaptation of tools to undertake analysis of the tradeoffs that enable maximization of the contribution of the LME to national development.

Understanding how the political economy context influences the use and management of the marine resources in the different BOBLME countries:

It is increasingly acknowledged that the ways in which marine resources contribute to the livelihoods of the poor, broader national development, poverty reduction and resource conservation are, above all, a product of the structures and incentives that influence political choice. However, appreciation of this relationship is not explored in any detail in any of the BOBLME countries. This type of information is critical in developing effective strategies for influence and appropriate approaches for management in the BOBLME countries. Examples of the types of knowledge and research that could help here include:

- Understanding of the influence of the political economy on trade-offs between the management of different ecosystem services from the LME and also between coastal developments and the marine environment;
- Identifying, adapting or developing tools to inform on these trade-offs; and
- Building approaches to enable national policy makers to understand, engage and deal with the complexity of BOBLME management;

Understanding how key exogenous changes affect marine resource management and exploitation in the BOBLME and how these influences can be addressed, capitalized on or mitigated:

The future role, and in many cases the very existence of marine resources in BOBLME, will be strongly affected by an increasingly volatile and all-pervasive set of exogenous changes such as climate change, carbon markets, population and migration, the prices of energy and commodities and cross-border financial flows.

Information that helps the BOBLME countries to understand the extent, depth and impacts of these influences, means of evaluating these and understanding their implications, is important. In respect to many of these changes there are clear incentives for regional responses. Therefore, this work has the potential to highlight areas where regional cooperation can help the BOBLME countries to cope with, and perhaps even capitalize on, the changes.

Examples of the types of knowledge and research that could help include:

- An understanding of how different management instruments perform under different exogenous pressures;
- An understanding of how global instability and uncertainty impact the livelihoods of poor people and their access to the benefits from the LME;
- An understanding of the threats and opportunities represented by exogenous change for the management of the BOBLME;
- Identification, adaptation and development of approaches that have succeeded in helping people to deal with change.

5.2 Information gaps for marine living resources

Although there are many gaps in our knowledge of marine living resources and their exploitation, it should be noted that there is enough data and information available to demonstrate that overexploitation of the coastal resources of all BOBLME countries has occurred and is still occurring and that action is needed.

The inadequacies of fisheries statistics are well known, especially for small-scale fisheries, and most data on production and value are probably underestimates. Much of the data are not available in electronic form and, despite efforts from organizations such as the Southeast Asian Fisheries Development Centre (SEAFDEC) to provide basic fisheries data online for its member countries, there are many gaps. Different countries report their production statistics to the FAO, but the timeliness and the level of detail varies greatly between the BOBLME countries. Many fish catches are reported as “miscellaneous fish”, especially in Myanmar and Bangladesh. There is also a paucity of data relating to the value of the fish catch – especially in terms of social benefits – and better socio-economic indicators that could be used to highlight the importance and benefits of marine living resources to coastal communities are needed. Simply relying on GDP data is misleading: “triple-bottom line” reporting, that records the economic, social and ecological status of the BOBLME based on a set of indicators, is urgently needed.

Examples of the types of data that would be useful in future include:

- Better stock assessments of the BOBLME Project key species, based on country collaboration in data collection and an independent stock assessment expert;
- Better information on the access agreements that exist between countries so that the transboundary nature of fishing can be better understood;
- Better information and information exchange on IUU fishing;
- More detailed reporting of fishing activities and catches, especially in Bangladesh and Myanmar;
- Better systems for analysing statistical data to make them more useful to science (e.g. catch and effort data at the boat level);
- More wide-scale information on the socio-economic context of fishing (now collected at local level by many NGOs and agencies but not shared);
- Better understanding of market chains and market dynamics; and
- Better understanding of incentives (including perverse incentives) that control and influence decision making in fisheries.

Having this extra information would help decision making, but even with this information it is difficult to influence policy making and management in BOBLME countries. A major communication gap exists between scientists, managers, policy makers and stakeholders. Scientific results are often only published in the grey literature and too little effort is made to make the findings accessible to others in a form that they can understand and act on. Political power, in fact, is often greater with a lack of information and in strong hierarchical systems information sharing is not welcome. Many scientists are afraid to speak out for fear of recrimination.

5.3 Information gaps for critical habitats

Of the three critical habitats considered in this TDA, only mangroves had sufficient data on the causes of habitat loss to enable preliminary causal chain analysis. However, even these data referred to the period prior to 2005 and could be updated. Information on coral reefs was, apart from information on the 1998 coral bleaching episode, very general and vague. Seagrass data was very sparse, with little scientific evidence of seagrass loss or causes of any loss.

The main information gaps for critical habitat degradation, therefore, are:

- A real extent and environmental status of the seagrass beds of the BOBLME as a whole, including any historical analyses of changes in seagrass extent and quality, and the status of the associated biodiversity and productivity in the BOBLME;
- Quantitative data on the causes of coral reef loss and degradation around the BOBLME, especially for Myanmar;
- An update on the extent and quality of mangroves around the BOBLME;
- Valuation of goods and services provided by the mangrove, coral reef and seagrass ecosystems;
- The relationship between mangroves and commercial fish species, and between seagrass and commercial fish species in the BOBLME; and
- The existence and relevance of traditional ownership and customary use systems associated with the critical habitats.

5.4 Information gaps for pollution

Information gaps for pollution include:

- Insufficient quantitative information on the levels, distribution, or effects of contaminants in the BOBLME, and consequently insufficient information to:
 - prioritise and determine the relative importance of pollution threats;
 - determine the transboundary dimensions of pollution in the BOBLME;
 - identify and prioritize pollution “hot spots”, including a lack of objective criteria;
 - determine the importance of contamination by POPs and PTSs in the BOBLME;
 - evaluate the relative importance of land-based and sea-based sources of oil pollution;
 - evaluate the importance of floods and other episodic events;
- Information on emissions of most contaminants by source;
- Information on human health impacts of contamination by sewage-borne pathogens and toxic chemicals;
- Valuation of the pollution attenuation services provided by, in particular, the mangrove and seagrass bed critical habitats;
- Information on appropriate and affordable clean production technology and best practices;
- Insufficient information to establish acceptable limits for discharges of pollutants.

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ANNEX 1

Detailed causal chain analyses by theme

1. Overexploitation of marine living resources

Transboundary nature of the concern	Issues	Proximate causes
<ul style="list-style-type: none"> Many fish stocks shared between BOBLME countries through transboundary migration of fish or larvae 	Decline in overall availability of fish resources	<p>Excessive fishing effort and overcapacity</p> <p>Unselective fishing practices and gear</p>
<ul style="list-style-type: none"> Fishing overlaps national jurisdictions, both legally and illegally - overcapacity and overfishing in one location forces a migration of fishers and vessels to other locations 	Changes in species composition of catches	<p>Excessive fishing effort and overcapacity</p> <p>Unselective fishing practices and gear</p>
<ul style="list-style-type: none"> All countries (to a lesser or greater degree) are experiencing difficulties in implementing fisheries management, especially the ecosystem approach 	High proportion of juvenile fish taken	Unselective fishing practices and gear
	Changes in marine biodiversity plus vulnerable/ endangered species	Destructive fishing methods

Intermediate causes	Root causes
<p>Increasing fishing effort, especially trawlers and purse seiners</p> <p>Illegal, unregulated and unreported (IUU) fishing, both national and international</p> <p>Weak fisheries MCS and enforcement</p> <p>Inappropriate subsidies</p> <p>Government emphasis on increasing production</p>	<p>“Open access” regime</p> <p>Strong incentives to encroach into areas with better returns</p> <p>High consumer demand for food fish</p>
<p>Increasing fishing effort, especially trawlers and purse seiners</p> <p>Illegal, unregulated and unreported (IUU) fishing, both national and international</p> <p>Weak fisheries MCS and enforcement</p> <p>Inappropriate subsidies</p> <p>Government emphasis on increasing production</p>	<p>“Open access” regime</p> <p>Strong incentives to encroach into areas with better returns</p> <p>High consumer demand for food fish</p> <p>High consumer demand for seed and fishmeal for aquaculture</p>
<p>Weak fisheries MCS and enforcement</p>	<p>“Open access” regime</p> <p>High consumer demand for food fish</p> <p>High consumer demand for seed and fishmeal for aquaculture</p>
<p>Weak fisheries MCS and enforcement</p>	<p>“Open access” regime</p> <p>High consumer demand for food fish</p>



2. Degradation of critical habitats

a. Mangrove habitat loss and degradation

Transboundary nature	Issue	Proximate cause	Intermediate cause
<ul style="list-style-type: none"> 11% of global mangroves border the BOBLME All countries contain mangroves 	Loss of mangrove habitat	Conversion for agriculture	Subsistence production
			Export production
		Conversion to aquaculture	Subsistence production
			Export production
		Conversion for salt production	Subsistence and cash income
		Conversion for coastal tourism	Increasing tourism
		Conversion for human settlement	
		Conversion for industrial purposes	
		Clear felling for wood chip production	National demand for paper
			Export demand for paper
		All of the above	Lack of national provincial/state coastal development plans
			Lack of national, provincial/state mangrove management plans
			Lack of clear land tenure
Dwindling upstream water flows			

Note: Little data are available for the situation in the Maldives.

Penultimate cause	Root cause	Externalities
Food security of coastal poor	Growth in coastal population	
National demand for hard currency earnings	National and regional economic development drivers	World prices
Corporate demand for profit	Lack of a “green ethic” in business	World prices
Individual demand for higher incomes	Lack of economic alternatives	World prices
Food security of coastal poor	Growth in coastal population	
Demand for hard currency earnings	National and regional economic development drivers	World prices
Corporate demand for profit	Lack of a “green ethic” in business	World prices
Individual demand for higher incomes	Lack of economic alternatives	World prices
Lack of economic alternatives	Lack of alternative livelihoods	
Demand for hard currency earnings	National and regional economic development drivers	
	Growth in coastal population	
	National and regional economic development drivers	
Corporate demand for profit	Lack of a “green ethic” in business	
Corporate demand for profit	Lack of a “green ethic” in business	World prices
Where plans exist lack of political will to enforce them	Lack of capacity (financial and human resources) to enforce standards	

2. Degradation of critical habitats (continued)

b. Coral reef habitat loss and degradation

Transboundary nature	Issue	Proximate cause
<ul style="list-style-type: none"> ● Eight percent of global coral reefs border the BOBLME ● All countries contain coral reefs 	Loss and degradation of reef habitat	<p>Land based activities</p> <hr/> <p>Marine based activities</p> <hr/> <p>Natural, episodic events</p>

Intermediate cause	Penultimate cause	Root cause
Increased sedimentation	Mining	Uncontrolled tailings discharge
	Coastal construction	Coastal tourism
		Infrastructure development
		Maritime transport (ports and harbours)
Agriculture	Food security	
Land reclamation	Coastal construction	Coastal tourism, port and harbour construction
Coastal pollution	Industry/ports/agriculture	Development
Nutrient increase	Agriculture, urban sewerage	Population growth
Solid waste	Coastal urbanization	Population growth
Destructive fishing	Lack of surveillance	Lack of enforcement
Blasting	Coastal poverty	Population growth
Cyanide	Aquarium fish trade	Global demand
Coral mining	Construction materials (Maldives)	Lack of alternative material
	Lime production	
Overfishing	Lack of management information	Lack of management control
Discarded fishing gear		
Crown of thorns outbreaks		
Bleaching	Increased sea surface temperature	
Storm damage		

3. Pollution and water quality

Transboundary nature	Issue	Proximate cause
<ul style="list-style-type: none"> ● Discharge of untreated/ partially treated sewage is a common problem; sewage and organic discharges from the Ganges-Brahmaputra-Meghna system are likely to be transboundary ● Plastics and derelict fishing gear can be transported long distances across national boundaries ● High nutrient discharges from rivers could intensify large-scale hypoxia; atmospheric transport of nutrients is inherently transboundary ● Differences between countries with regard to regulation and enforcement of shipping discharges may drive discharges across boundaries; tar balls are transported long distances ● POPs/PTSs and mercury, including organo-mercury, undergo long-range transport ● Sedimentation and most heavy metal contamination tend to be localized and lack a strong transboundary dimension 	Sewage-borne pathogens	Untreated or only partially treated sewage
	Sewage-borne organic load	Untreated or only partially treated sewage
	Solid waste/marine litter	Discharges of solid waste into rivers and coastal waters
	Increasing nutrient inputs	Untreated or only partially treated sewage
		Increasing fertilizer use in agriculture
		Increasing coastal aquaculture
		Increasing atmospheric emissions of nitrogen from industry and fossil fuel burning
	Oil pollution	Operational discharges of oil from shipping, dumping of used oil from small boats and land vehicles
	POPs/PTSs	Burning of solid waste
		Industrial emissions
	Sedimentation	Coastal construction
		Land-based mining and tailings discharge
		Coastal dredging
Heavy metals	Industrial discharges	

Intermediate cause	Penultimate cause	Root cause
Lack of sewage treatment facilities	Lack of capital investment	Increasing coastal population density
	Lack of low cost alternative treatment options	
Lack of sewage treatment facilities	Lack of capital investment	Increasing coastal population density
	Lack of low cost alternative treatment options	
Improper siting and management of solid waste dumps	Lack of dump site capacity	Increasing coastal population density
		Increasing consumption
Dumping in coastal rivers and the marine environment	Lack of management controls	
Lack of sewage treatment facilities	Lack of capital investment	Increasing coastal population density
	Lack of low cost alternative treatment options	
Improper use of fertilizers	Need for maximum productivity	Increasing population
Improper use of feeds	Need for maximum productivity	Increasing population
Lack of regulations for flue emissions	Lack of capital investment	
Non adherence to IMO agreements regarding oil and ballast water discharge	Lack of port reception facilities and enforcement	
Lack of regulations and or monitoring of flue gas emissions	Lack of capital investment	
Lack of regulations and/or monitoring and control	Lack of capital investment	Lack of awareness of policy makers, legal system and civil society
Lack of regulations and/or monitoring and control	Lack of capital investment	Lack of awareness of policy makers, legal system and civil society

Abbreviations and Acronyms

ADB	Asian Development Bank
APFIC	Asia-Pacific Fishery Commission
BOB	Bay of Bengal
BOBLME	Bay of Bengal Large Marine Ecosystem
BOD	Biochemical Oxygen Demand
BBS	Bangladesh Bureau of Statistics
CBM	Community-Based Management
CPI	Corruption Perceptions Index
DIN	Dissolved Inorganic Nitrogen
DDT	D ichlorodiphenyl t richloroethane
EEZ	Exclusive Economic Zone
ESI	Environmental Sustainability Index
ESCAP	Economic and Social Commission for Asia and the Pacific
EVI	Environmental Vulnerability Index
EU	European Union
FAO	Food and Agriculture Organization
GBM	Ganges-Brahmaputra-Meghna (river system)
GDP	Gross Domestic Product
GEF	Global Environment Facility
GFC	Global Financial Crisis
GPA	Global Programme of Action for the Protection of the Marine Environment from Land-based Activities
HAB	Harmful Algal Bloom
HDI	Human Development Index
IOTC	Indian Ocean Tuna Commission
IW	International Waters
LME	Large Marine Ecosystem
NGO	Non-Governmental Organization
NPK	Nitrogen, Phosphorus, Potassium
OMZ	Oxygen Minimum Zone
PBT	Persistent, Bioaccumulative and Toxic
PCDD	P olychlorinated d ibenzo- p - d ioxins
PCDF	P olychlorinated d ibenzofurans
PDF	Project Development and Preparation Facility
POP(s)	Persistent Organic Pollutant(s)
PTS	Persistent Toxic Substances
SAP	Strategic Action Programme
SEDAC	Socioeconomics Data and Applications Centre
TBT	Tributyl Tin
TDA	Transboundary Diagnostic Analysis
UN	United Nations
UNDP	United Nations Development Programme
UN ESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UNSD	United Nations Statistics Division
USD	United States of America Dollar
VLIZ	Flanders Marine Institute, Belgium (Maritime Boundaries Geodatabase)
WRI	World Resources Institute, Washington
WWF	Worldwide Fund for Nature



TRANSBOUNDARY DIAGNOSTIC ANALYSIS
VOLUME 1 ISSUES, PROXIMATE AND ROOT CAUSES

BAY OF BENGAL LARGE MARINE ECOSYSTEM PROJECT
Eight countries connected by one ecosystem, working together to secure its future

Photo source: BOBP-IGO archives



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