Transboundary Diagnostic Analysis

Volume 1: Issues, proximate and root causes

Bay of Bengal Large Marine Ecosystem Project

DRAFT – NOVEMBER 2010

ACKNOWLEDGEMENTS

Contents

NOTE. The TDA is in two volumes. Volume 1 focuses on describing the transboundary issues in the BOBLME, and their proximate and 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 in the eight countries surrounding the BOB, and an assessment of the status of the marine living resources and the marine environment in the coastal areas of the BOBLME.

EXECUTIVE
SUMMARY

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BACKGROUND

In April 2009, the Bay of Bengal Large Marine Ecosystem Project commenced.

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. This is equivalent to 25% of the world's population, and includes a coastal population of 450 million people. The region is rich in natural resources that include extensive mineral and energy resources, marine living resources that support major fisheries, and forest and land resources. The current fisheries production is 6 million tonnes per year, which amounts to more than 16% of the world's marine catch.

The LME supports a wide range of habitats, including extensive tracts of mangroves (12% of the world's mangroves), coral reefs (8% 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 bordering countries. Activities such as fishing, marine farming, tourism and shipping contribute to food security, employment and national economies.

Over 50% of the world's coastal poor people live in the BOBLME countries. The marine living resources are extremely important for the livelihoods of millions of people and their communities, in particular as source of food.

There are over 400,000 fishing boats (both motorized and non-motorized) operating in the LME, and over 4.5 million people employed in the associated fisheries activities.

Rapid population growth, high dependence on aquatic resources for food, trade, livelihoods, and as well as increased land use are having major impacts on the marine ecosystem. As a result, it is not clear how much longer the Bay of Bengal will be able to support the aspirations of the many sectors wanting to use the resources, including the poor coastal populations that depend on them for survival.

THE TRANSBOUNDRY DIAGNOSTIC ANALYSIS

The BOBLME TDA is the culmination of seven years of work.

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 BOBLME's TDA is the culmination of seven years of work, including numerous studies and extensive regional and national consultations held with stakeholders. The TDA provides the scientific basis for the collaborative development of the Strategic Action Programme that will formulate nationally and regionally coordinated activities to address the issues and their causes.

EXECUTIVE SUMMARY

THE TDA IDENTIFIES THREE MAIN AREAS OF CONCERN

1. *Overexploitation of the marine living resources*
2. *Degradation of mangroves, coral reefs and seagrass*
3. *Pollution*

A causal chain analysis was undertaken on these three areas, and this has resulted in the identification of the priority issues under each area of concern, and their underlying causes. A summary of the TDA is presented in the following boxes.

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 a global environmental benefit.

The TDA also reviews the socio-economic, institutional, legal, administrative, and climate change driving forces at work in the BOBLME. These forces pose a range of constraints and challenges to the success of actions implemented to address the three main areas of concern. This information will be an important input to the development of the Strategic Action Programme.

OVEREXPLOITATION OF THE LIVING MARINE RESOURCES

The major issues

1. Decline in overall availability of fish resources
2. Changes in species composition of catches
3. 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 shared among BOBLME countries either 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 significantly to the global problem of loss of vulnerable and endangered species

The root causes of the issues

- "Open access" regime
- Increasing fishing effort, especially trawlers and purse seiners
- High consumer demand for fish, including for seed and fish meal for aquaculture
- Weak fisheries MCS and enforcement
- Strong incentives to encroach into areas with better returns

EXECUTIVE SUMMARY

DEGRADATION OF CRITICAL HABITATS

The major issues

1. Loss and degradation of mangrove habitat
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 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

The root causes of the issues

- 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 agricultural practices.
- Increasing tourism
- Climate change

POLLUTION

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 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 among 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 organomercury undergo long-range transport
- Sedimentation and most heavy metal contamination tend to be localized and lack a strong transboundary dimension

The root causes of the issues

- 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

1. INTRODUCTION

1.1 Purpose of the TDA

1.   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 forms the basis for the implementation of nationally and regionally coordinated activities to address the issues and their causes.

2.   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 the coastal populations through improved regional management of the Bay of Bengal environment and its fisheries. One of the Projects 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 to improve the food and livelihood security of the region's coastal population. This TDA is the primary input into the SAP development. It supersedes the preliminary framework TDA (Verlaan, 2004) that was prepared under the GEF Project Development Fund-B (PDF-B) phase, as part of the preparation for the BOBLME Project.

1.2 Process for development of the TDA

3.   This document outlines the major water-related coastal and marine environmental issues as documented through 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, 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 consultations held with stakeholders and of 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 National 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)[1] and five theme reports complete by regional consultants on the basis of existing literature and the national reports (Angell, 2004), (Edeson, 2004), (Kaly, 2004), (Preston, 2004), and (Townsley, 2004).

4.   At the First Regional Workshop of the BOBLME PDF-B Programme development 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:

1.   Overexploitation of the marine living resources;
2.   Degradation of mangroves and coral reefs; and
3.   Land-based sources of pollution.

5.   At a subsequent Preparatory Meeting for the Second Regional Workshop of the BOBLME Programme, Penang, Malaysia, March 2004 (BOBLME/REP/2, 2003) the BOBLME countries requested the inclusion of ship-based sources of pollution (including dumping as covered by the

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[1] National and theme papers available on www.boblme.org

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.

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

7.   The three main areas of concern covered in this TDA, therefore, are:

  1.   Overexploitation of the marine living resources;

  2.   Degradation of mangroves, coral reefs and seagrass; and

  3.   Pollution.

8.   The TDA development was guided by National Review Groups on the National Reports, International Scientific Review Group on the Regional Theme papers, National Task Force (NTF) meetings and National Workshops. Overall guidance of TDA development has been provided by the former BOBLME Project Coordinator, Philomene Verlaan.

9.   There was a long time gap (5 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 recognized that more work was needed in some sections to provide the scientific evidence that supported the inclusion of the priority issues and also a more rigorous causal chain analysis to identify the proximate and root causes of these issues. The review also identified a process for finalizing the TDA and it was recommended that each section be re-written and updated where appropriate by regional experts and these revisions then subjected to national scrutiny and endorsement. The re-write was carried out during July and August 2010 and the draft TDA was presented in outline to the Regional Workshop on BOBLME TDA National Consultation Planning (Bangkok, August 24-25, 2010). At the workshop, each country elaborated a "roadmap" as to how and when they would seek national validation and agreement to the TDA. In general, it was thought that this could be achieved by April, 2011.

10.   The TDA is in two volumes. Volume 1 (this volume) focuses on describing the transboundary issues in the BOBLME, and contains a causal chain analysis that describes 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 in the eight countries surrounding the BOB and an assessment of the status of the marine living resources and the marine environment in the coastal areas of the BOBLME.

2.   SCOPE AND CHARACTERISTICS OF THE BOBLME

11.   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 degrees south of the equator (Fig. 2.1). As well as the high sea 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 Nicobar and Andaman Islands of India, Sri Lanka and the Maldives.
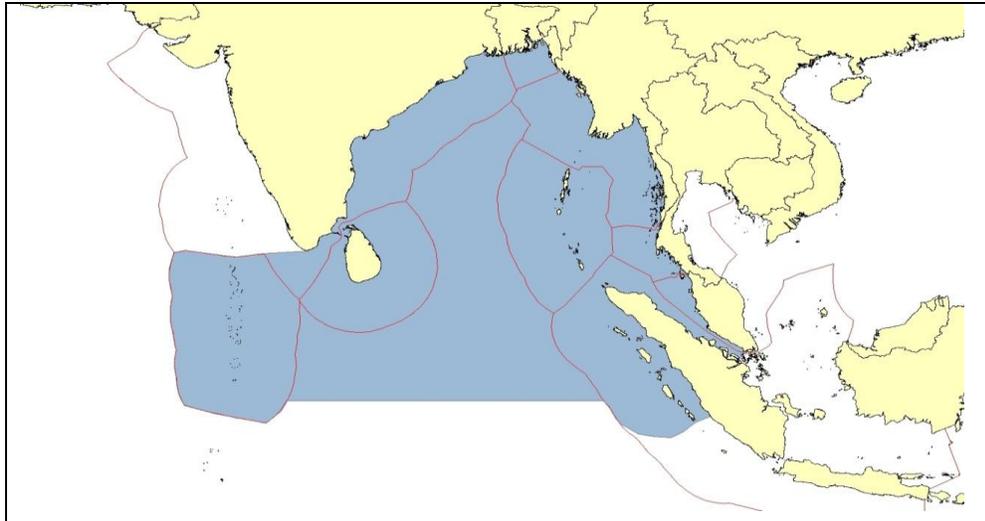
Figure 2.1. BOBLME boundaries and EEZ boundaries[2] *(Source: BOBLME Project)*

Facts on the BOBLME

AREA

Total maritime area = 6.2 million km^2

Total area of EEZs = 4.3 million km^2

Combined length of coastline = ~14,000km

PRODUCTIVITY

Primary production around 500gC/m^2/year

average 730gC/m^2/year in the EEZs

PEOPLE

Total population of countries[3] = 1.78 billion

(25% of the world)

Population of the coastal zone = 450 million

FISHERIES

Employment in fisheries = 4.5 million

Number of fishermen = 2.2 million

Number of fishing boats = more than 415,000

Total fisheries production = 6 million tonnes

Value of fisheries production = USD 4 billion

2 The designations employed and the material presented in this document do not imply the expression of any opinion whatsoever by the Food and Agriculture Organization (FAO) of the United Nations or by the author of this document on the legal status of any country, city, territory or area, or of its authorities, or concerning the delimitation of any frontiers or boundaries.

3 This refers to the total populations of all countries involved in the BOBLME. 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's and Malaysia's population is involved and about half of India.All other "pertinent facts" refer to the area of the BOBLME as defined.

2.1 Biophysical characteristics

12.   The Bay of Bengal covers 6.2 million km^2 with depths ranging between 2000 and over 4000 m 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 5000 m. About 66% of the BOBLME lies within the EEZs of BOBLME countries; thus a lot of the BOBLME is subject to national jurisdiction. The BOBLME countries with the greatest extent of estimated EEZ area in the BOBLME as defined are, from largest to smallest: India, Maldives, Myanmar, Sri Lanka, Indonesia, Thailand, Bangladesh and Malaysia. The BOBLME is relatively productive with an average primary production of 700gC/m2/year 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

13.   Many large rivers flow into the BOBLME including 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 that covers nearly 1.75 million km2 spread over five countries 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 in Bangladesh.

14.   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.
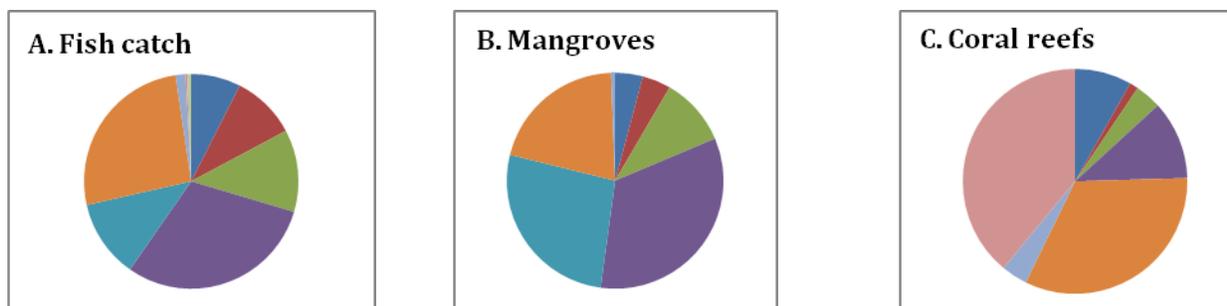

Figure 2.2. Distribution of (A) fisheries catch, (B) mangroves and (C) coral reefs across BOBLME countries. Countries are shown in a clockwise position as Indonesia (Blue), Malaysia (red), Thailand (green), Myanmar (magenta), Bangladesh (light blue), India (orange), Sri Lanka (very light blue) and Maldives (light pink)

15. The BOBLME is rich in natural resources that include extensive mineral and energy resources, marine living resources that support major fisheries, and forest and land resources. The current fisheries production (2008) is 6 million tonnes (16.3% of the world's brackish water and marine catch), valued at USD 4 billion (7.9% of the world) (FAO Fishstat, 2010). The LME is the home of three important critical habitats – mangroves (11.9% of the world) (Giri, et al, 2008) and (Giri, et al., 2010), coral reefs (8.0% of the world) (SAUP (2010) and Spalding, Ravilious, & Green, (2001) and seagrass. In the BOBLME, the largest fishery catch is taken by Myanmar, the largest area of mangroves is also in Myanmar, while the Maldives has the largest area of coral reefs (Fig. 2.2 A, B, C).

16. 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.

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

18. 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 increasing risk of pollution.

2.2   Socio-economic characteristics

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

20. Many of these people are poor, with India having 27% of the world's coastal poor and four BOBLME countries in the world's top 7 for the number of coastal poor (Fig. 2.3). The BOBLME countries contain over 50% of all of the world's coastal poor people (Brown et al. 2008).

21. Despite the large size and populations of many of the countries, they have relatively small economies. All of the economies are decreasing their reliance on the agriculture sector (including fisheries) as growth in the industry and service sectors has driven long-term growth of GDP. GDP in fisheries, therefore, is relatively low. However, despite this low GDP, marine living resources are extremely important for the livelihoods of millions of people and their communities, in particular as a source of food. On world standards, the region consumes large amounts of seafood per capita (except India), and the countries surrounding the BOBLME include some of the largest populations on earth, with India, Indonesia and Bangladesh being among the world's top ten. The current population of BOBLME countries is expected to increase from 1.78 billion people to 2.03 billion in 2020.
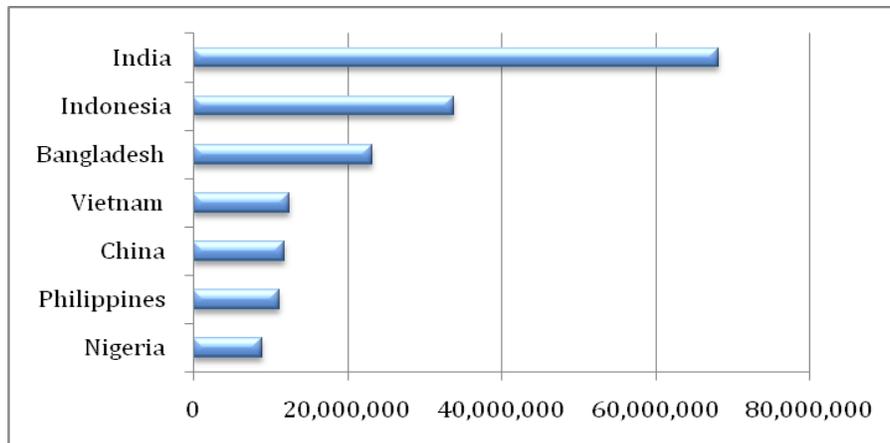
Figure 2.3: Number of the world's coastal poor calculated from estimates of poverty combined with estimates of population density in the 100km coastal strip of the BOBLME (Source: Brown et al. 2008.)

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

23. 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. Based on an estimate of the 2010 Transparency International's Corruption Perceptions Index (CPI) that measures the perceived levels of public sector corruption in the world, all the BOBLME countries perform poorly. Malaysia (ranked at 56) is the highest (or least corrupt) country within the BOBLME with Bangladesh (134), Maldives (143) and Myanmar (176) lying within the bottom 50 countries worldwide.

24. BOB 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 through 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 in 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 acknowledged among the different players. Many countries now have "decentralization" policies that present new challenges in coordination and implementation of law and order.

25. The complexity of the coastal area and the government bureaucracies often results in decision-making structures being inadequate or inappropriate to deal with the problems of the people in ways which are coordinated and effective. Implementation of policies is also often constrained by weak governance, especially at the local level and insufficient human capacity and government funding for enforcing laws and regulations.

26. Enforcement is impeded by a number of factors, including weak institutions based on an "informal economy" with many perverse incentives, varying interpretations of the laws, lack of funds to enforce laws and regulations and the lack of prior consultation as well as accessibility on the part of the various

stakeholders to the ever-increasing rules and regulations developed. 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, recognising and adopting internationally accepted concepts and norms such as the ecosystem approach and the precautionary approach.

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

3.   DRIVING FORCES IMPACTING THE BOBLME

28.   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. 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

29.   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.

30.   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 markets that causes irresponsible harvesting;
- inappropriate financial and other incentives provided by government;
- 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 on resources and habitats caused by bad practices; and
- undervaluing of damage to human health caused by pollutants and contaminants.

31.   The sheer number of people is probably the most important underlying driver of all the key issues arising in the region. The human population is still growing in the region from an already large base (now about 1.78 billion) and it is expected that the region's population will exceed 2.0 billion by 2020 for the countries as a whole. The coastal population of 450 million is also expected to increase, both from the overall population increase and with coastal migration and urbanization.

32.   With densities averaging about 410 people per km2 regionally, of which at least 30% overall will be 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).

33.   Domestic sewage and solid waste production, collection and disposal problems in particular are exacerbated by the increasing number of tourists to the region, in addition to indigenous population growth. For example, in 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.

34.   National demand for foreign exchange is driving government policy and incentives that promote unsustainable practices (e.g., high chemical applications and cleared land) as well as productivity increases in agriculture (and aquaculture) and puts unprecedented pressure on fish resources. Manufacturing and service industries are showing a trend to relocate to countries in the region to benefit from lower production costs that may in part be related to lower environmental standards.

35.   The damage to the environment and to other sectors and to 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 nor national financial and development plans.

3.2   Institutional, legal and administrative drivers

36.   At the regional level, the main institutional driver affecting a countries ability to implement change is a lack of an appropriate forum for BOBLME-wide multi-national dialog, planning, monitoring and reporting on the progress of sustainable development.

37.   In the BOBLME there is no over-arching 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 Phase-B 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), noting that all are very important partners to the BOBLME Project.

38.   BOBLME countries should recognize that the causes and solutions of priority issues extend beyond one or more national political jurisdictions. In this regard, there are many benefits to be gained from addressing these issues through coordinated action at the regional level by establishing the supportive institutional and legal framework which will facilitate inter-sectoral and transboundary planning and management among the BOBLME member countries.

39.   At the national level, underpinning all of the key issues discussed below in Section IV is the lack governance and the 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;
- poor unified planning and inadequate communication, including information exchange, between and among all the relevant and legally responsible sectors and levels of central, state and local government;
- lack of local community 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, but especially at the local level; and
- inadequate budgetary commitments to the costs of implementation and enforcement of applicable legislation.

Box 1: 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" different bribes and incentives change hands and can be used to subvert the law. Penalties for violations of legislation relating to living marine resource exploitation and critical habitats are usual 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 by military, police or coastguard vessels or over flights by military or commercial aircraft.

In small-scale artisanal fisheries, fishing involves hundreds of thousands of fishermen and vessels dispersed over large areas of coastline, which makes the physical logistics of surveillance and enforcement much more challenging. In addition, enforcement activities create conflict with local fishermen which government officials are averse to for a variety of reasons which 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 fishermen are unaware of the laws and regulations.

In the case of some transboundary "violations", the introduction of lines on the water following the United Nations Convention of the Law of the Sea (UNCLOS) meant that many fishermen, who used to fish in their own backyards, were now prevented by law from fishing across the border. For example, in the Indian fishermen versus the Sri Lankan fishermen issue in the Gulf of Mannar area, both sides have a common language and long history of close contacts (and marriage links) and new solutions to the problems resulting from UNCLOS are needed.

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40.   The form and type of implementation authorities varies widely among the BOBLME countries, but in each country, on paper, some form of authority exists that has the mandate to conserve marine living resources, protect critical habitats, and to 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 cannot be implemented without a system that provides adequate salary for implementation authority staff and resources to government departments to gain compliance. Achieving an effective level of compliance and enforcement of laws and regulations will be an ongoing challenge. A major change to the social system, taxes, remuneration

and incentives is required. The natural resources and habitats provide essential goods and services to poor local communities who have no alternative sources and depend on them for their survival. Given the absence of alternatives, the legislation is often flouted, overexploitation of the resources and habitat degradation continues, and disrespect for the legal system itself is engendered. Sustainable management of the living resources and of the critical habitats needs to address this issue more constructively.

41.   This lack of governance is further complicated because national, state and local governmental have sectoral responsibility and accountability that is divided among 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.

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

- gaps in the commitments of BOBLME countries to some international agreements, especially in 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 authorities;
- 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
- limitations for stakeholder participation under existing laws.

43.   The conservation and management of the marine environment of the BOBLME necessitate the implementation of projects and activities effectively carried out 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 imposes the need to strengthen institutional capacity and improve integration and coordination between and amongst national and local governments in order to address these transboundary issues collectively.

3.3   Climate change

44.   While noting that local differences will occur in the effect of global climate change around the BOBLME, in the region it is predicted to result in:

- 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.

45.   A major shared transboundary factor that is expected to affect the ecology and biodiversity in the BOBLME is climate change. 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 in future interventions and management, but not used to distract 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 our ability to manage these

will also determine the mid- to long-term impacts that climate change will have. Through mismanagement that is adversely affecting the health of fisheries systems, the resilience of fishery systems to withstand climate change related impacts may be impaired.

46.   Relative sea level rise has been advocated as perhaps 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 in the region and partly by climate change. In those areas it may be possible to assess the efficacy of mangrove management frameworks and provide assistance to manage coastal activities to prevent unsustainable effects on mangroves and other coastal habitats to 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 competing uses of this land will make this a major challenge.

47.   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.

48.   However, as with 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 possible outcomes of future climate changes.

4. PRIORITY TRANSBOUNDARY ISSUES AND THEIR CAUSES

49.   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 is 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. "Shared" issues are described as transboundary issues between two or more countries while "common" issues are similar issues that occur across all the eight BOBLME countries but not necessarily transboundary in nature. "Common" issues are included in this TDA where they promote regional and/or local solutions that achieve economies of scale and cost advantages which accrue from addressing the issues in a collaborative fashion.

50.   The causal chain analysis (Fig 4.1) starts off with three broad areas of concern:

1. Overexploitation marine living resources;
2. Degradation of critical habitats; and
3. Pollution.

51.   The main transboundary issues within these three areas of concern 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 the following parts of this section. The more formal causal analyses are presented in Annex 1.
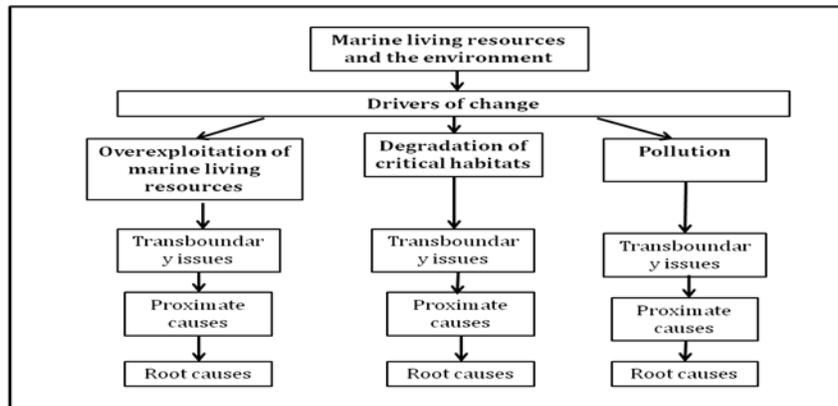
Figure 4.1: Diagram showing the logic of the causal chain analysis

4.1   Overexploitation of marine living resources

Note: the full causal chain analysis is given in Annex 1

Issues	Trans-boundary nature of issues
1.Decline in overall availability of fish[4] resources; 2. Changes in species composition of catches 3. High proportion of juvenile fish in the catch; 4. Changes in marine biodiversity, especially though loss of vulnerable and endangered species.	• Many fish stocks shared among BOBLME countries either 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 significantly to the global problem of loss of vulnerable and endangered species.
Proximate Causes	**Specific Root causes**
• Excessive fishing effort and overcapacity • Destructive fishing methods • Unselective fishing practices and gear • Illegal, unregulated and unreported (IUU) fishing, both national and international	• "Open access" regime; • Increasing fishing effort, especially trawlers and purse seiners; • High consumer demand for fish, including for seed and fish meal for aquaculture; • Weak fisheries MCS and enforcement • Strong incentives to encroach into areas with better returns.

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[4] Fish includes finfish, crustaceans, molluscs and any aquatic animal which is harvested

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

52.   The main four transboundary issues are:

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

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

54.   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 group reported by APFIC and IOTC;
- Declining catch rates in trawl surveys carried out over long time series;
- Overall current catches in excess of potential yield estimates; and
- Anecdotal evidence from fishermen.

4.1.2 The transboundary nature of the issues

55.   Many of the marine living resources in the BOBLME traverse 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 available stocks in another. Large pelagic species, such as tunas and billfishes, range over large ocean spaces and pass through the EEZs of many countries inside and outside the BOBLME.

56.   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 later SAP. These are hilsa, which is shared across most countries but concentrated across India, Bangladesh and Myanmar, Indian mackerel which occurs in all countries and sharks that are of global and regional concern.

57.   Resources which 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 4-12 months, during which period the larvae may travel many kilometers from the place of birth to the place of adult settlement.

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

59.   The most domestic fleet is that of the Maldives, who fish almost exclusively in their own EEZ. Other distant water fleets (mainly Japan, South Korea, China and Taiwan (Province of China), Singapore, European Union (Spain and France) have all been active in the BOBLME in the past. As in other parts of the world, foreign access was encouraged in many BOB countries, but as access was denied by the different countries participation has also changed. Japan was the most active player in early years. In recent years, foreign access is still allowed in Myanmar, the Maldives and India, under joint venture arrangements. Most foreign fishing reported by SAUP in 2006 is occurring in the Maldives.

60.   Crews are also 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 occur regularly in the press.

61.   All the countries of the BOBLME are experiencing significant difficulties in implementing better 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.

62.   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 that has led to overexploitation and overcapacity that is now difficult to rectify. Countries are now hindered by an unwillingness or inability to bear the short-term social and economic costs of reducing fishing. Some success is apparent in some localities where co-management has been trialed (usually supported by foreign aid), but is yet to be mainstreamed into national systems.

63.   A long list of species have been identified as vulnerable and endangered in the BOBLME (see Volume 2). As an example, the list of species recently declared to be extinct in the Sundarbans alone (Hossain, 2003) also includes mammals, birds and reptiles.

4.1.3 Causes of overexploitation of marine living resources

64.   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.

65.   These in turn are caused by:

- The "open access" regime;
- Government emphasis on increasing production;
- Increasing fishing effort, especially trawlers and purse seiners;
- High consumer demand for fish, including for seed and fish meal for aquaculture;
- Weak fisheries MCS and enforcement
- Strong incentives to encroach into areas with better returns

66.   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 concept, 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, an uncontrolled entry to marine living resources results in overexploitation and overcapacity in the fishing sector (especially in large-scale industrial fisheries) and a loss in 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, rules and regulations, where they still exist, should be encouraged through co-management as path to a more "limited access" regime.

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

68.   Coupled with this "open access" is a lack in monitoring, control and surveillance (MCS) to even get some compliance to 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 to the BOBLME.

69.   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, including 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 in highly migratory tuna and associated species in the whole of the Indian Ocean, and is at a great disadvantage compared with many other regions of the world.

70.   IUU fishing has been identified by BOBLME countries 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 region's countries significant amounts in lost revenue and is resulting in overexploited fisheries and adverse social costs.

71.   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 USD 85.9 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 2000–06. 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% faster than population world-wide with 36% of food fish consumption growth in 2020 coming from China, a near neighbor of BOBLME countries, and 61% 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% of food sales and in Germany and the UK, 82% and 60% of fresh seafood sales, respectively.

72.   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. On the negative side, it is putting 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".

73.   Emerging markets for fish meal and surimi are also encouraging the capture of small low value/"trash" fish, often composed of a large proportion of juveniles of commercially important species in many BOBLME countries. The total production of trash fish is around 800 000 t in the BOB – ranging from 12% of the total catch in India, to 47% in Myanmar (APFIC, in press). In countries where the demand for aquaculture feed is high, much of the small low value/trash fish are either converted to fish meal 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 for the region is growing and is roughly estimated as 75,000 t, requiring approximately 262,500 t of raw material (APFIC, in press).

4.2   Degradation of critical habitats

Note: the full causal chain analysis is at Annex 1

Issue	Trans-boundary nature
1. Loss and degradation of mangrove habitat 2. Degradation of coral reefs 3. Loss and damage to seagrasses	• 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**
• Conversion of mangroves for agriculture, aquaculture (shrimp), and salt production; • Expanding coastal development for industry, human settlement and tourism, including reclamation; • Unsustainable logging of mangroves; • Increasing pollution, eutrophication and sedimentation; • Destructive fishing practices (poisons, explosives, trawling and push-netting); and • Coastal modification, including coral and sand mining, dredging and reclamation; • Natural causes, especially coral bleaching.	• 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; • Increasing tourism; • Climate change.

4.2.1 The transboundary issues of degradation of critical habitat.

74. Three transboundary issues were identified:

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

75. 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 4,500km^2 of mangrove have been lost in the region over the last 30 years of which the majority has been lost in Myanmar, (3,001km^2) where the total area lost exceeds the sum of all losses in the other countries. Net loss of mangroves peaked at 1,374 km^2 during 1990–2000, increasing from 976km^2 during 1975–90, and declining to 139 km^2 during 2000–05. The major cause of loss of mangrove has been conversion to agriculture (82%) and conversion for aquaculture (12%).

76. Coral reefs are also classified as degraded or under threat. Coral reefs in South 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% mortality on some reefs in the Maldives but much less in the Gulf of Mannar and 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 with sea temperature rises may occur. Since early 2010 a massive bleaching of similar scale is occurring region-wide.

77. Reefs considered to be of 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).

78. 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 destructive fishing is increasing rapidly, including trawling and long-line fishing near reefs, and blast fishing. 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 Nicobar and Andaman 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.

79. According to assessments carried out after the 2004 December tsunami, coral reefs of the region suffered only minimal damage. At worst, only 8% of pre-tsunami coral coverage was lost, even if all of the tsunami-damaged coral dies. Some natural restoration following tsunami has been reported.

80. There has been a positive trend in reef status across South Asia since 2004, if coral cover is used as the sole indicator. However, the region is still struggling to recover from the massive impact of the 1998 bleaching and the smaller impacts 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.

81.   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

82.   Mangrove forests are found in all the BOBLME countries and, in some, are of global importance in coverage. About 12% of the world's mangrove cover occurs in the BOBLME. It is the home of the largest mangrove system in the world, the Sunderbans, shared by India and Bangladesh – an area declared as a Biosphere reserve.

83.   Coral reefs are also found in all the BOBLME countries (about 8.0% of the world) and some have achieved global significance e.g. India and Sri Lanka together are the home of the Mannar coral reef system, part of which was designated as a UNESCO Biosphere Reserve in India. However, the large river flows, monsoonal runoff from the land and strong currents that cause turbidity makes much of the BOBLME not suitable for corals and 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.

84.   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 areal extent and actual degradation state is unavailable.

85.   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 in their own right to the maintenance of the BOBLME region's biodiversity. In the BOBLME region at least six areas have been identified as having regional significance: the Sundarbans, Palk Bay and the Gulf of Mannar, Marine Wandur National Park in the Andaman and Nicobar Islands, the Maldives Atolls and Mu Ko Similan and Mu Ko Surin National Parks. In the Sundarbans there is a worrying number of endangered species of amphibians, birds, mammals and reptiles, and the area has already experienced species extinctions.

86.   In all the BOBLME countries industrialization is increasing rapidly, and centres 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, logging) is environmentally damaging both in situ and downstream (through, e.g., ecosystem disturbance and destruction, erosion, sedimentation).

87.   Tourism is a large source of external earnings but the resultant damage to critical habitats has usually not been considered. Resorts, roads and whole towns are being developed close to the sea without taking into account erosion and sea level rise. Tourists are often from other countries and can inject local economies with funds but do not realise the damage their requirements for infrastructure is doing.

88.   Deforestation and the resultant runoff after monsoon rains may flow into other countries, particularly where rivers are large. Upstream dams have been built in many countries on large rivers and

have caused less scouring by floods and hence 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, the Sundarbans mangroves are decreasing due to rising sea level and protrusion of salt, but deposition of silt is occurring in the delta of the Ganges. Sharing the problems of mangrove degradation and loss is a transboundary issue for India and Bangladesh.

89. The transboundary aquarium and live fish trade also 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, if not carried out sustainably, can reduce biological diversity and can damage the seagrass by trampling.

90. In the past, trade in ornamental coral was a large transboundary issue. It has been reduced by awareness campaigns and enforcement of regulations but it continues in many countries. Dredging channels so that international 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 10–14 m and aside from the immediate area of the sea bed, the consistent churning of sediment may also smother adjacent coral reefs and seagrass meadows. The increase in shipping traffic could also result in an increase in oil spills and marine pollution.

91. 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 which either contains exotic species or oil. Oil spills are obvious transboundary sources of pollution. The likelihood of oil spills is very high in the BOB but the contingency plans are unknown. 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 enter coastal waters from spray drift, leaching, run-off and accidental spills that are transboundary in nature.

4.2.3 Causes of degradation of critical habitats

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

- Conversion of mangroves for agriculture, aquaculture (shrimp), and salt production;
- Expanding coastal development for industry, human settlement and tourism, including reclamation;
- Unsustainable logging of mangroves; and
- Increasing pollution and sedimentation.

93. 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;

94. For seagrass, the main causes are:

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

95.   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; and
- Increasing tourism.

96.   Clearing mangrove for aquaculture (e.g. shrimp), agriculture (e.g. paddy rice), and salt production as well as mangrove clearing for land reclamation for housing, resorts, roads and harbours are the major causes of mangrove loss. As expected, causes of deforestation also vary with space and time, but over 1975-2005, unlike many areas of Asia, conversion to aquaculture was not the major cause of mangrove deforestation in the region. Conversion of mangroves for agriculture was the main cause in most countries, although aquaculture conversion was the main cause in Indonesia while both agriculture and aquaculture were important 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 contributes to the problem. There is often a lack of interest or awareness of private landowners (village communities and individuals) in conserving and developing 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.

97.   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. 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 the changes that are predicted 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.

98.   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 commercial uses. 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.

99.   Discharge of land-based (sewage, domestic, industrial, agriculture and aquaculture [especially shrimp farms]) liquid and solid waste is another major cause of loss, especially to coral reefs. 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.

100. Pollution from sea-based oil, 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.

101. Siltation and sedimentation from inland deforestation, agriculture, coastal construction and sandy beach development all impact on critical habitats along with 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 tourist-related activities by boat anchoring and moorings, trampling, destructive fishing practises including dynamiting, cyanide poisoning and bottom trawling, and harvesting coral building material and sand mining for construction materials and beach replenishment (sand) are all recognised proximate causes.

102. One of the main causes of seagrass loss is reduction of light caused by sediment in the overlying water or by excessive epiphytic growth on their leaves. Also using these nutrients, phytoplankton may bloom over seagrass beds and reduce light received by the seagrass. Excess nutrients enter the sea from 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, 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 damaged areas. The underground rhizomes grow slowly even though strong seedling germination may occur.

4.3   Pollution

Note: the full causal chain analysis is at Annex 1

Issue	Transboundary nature
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	• 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 among 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 Cause	**Root cause**
• Untreated or only partially treated sewage; • Untreated or only partially treated industrial discharges, especially from small industries; • Discharges of solid waste into rivers and coastal waters; Burning of solid waste; • Increasing fertilizer use in agriculture; • Increasing aquaculture; • Increasing atmospheric emissions of nitrogen from industry and fossil fuel burning; • Operational discharges of oil from shipping, dumping of used oil from small boats and land vehicles.	• 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 of pollution

103. Pollution can be a transboundary in nature both in the strict sense 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.

104. 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 organomercury compounds.

4.3.2 Transboundary nature of the issues of pollution

105. 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 and 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 localised near the source due to the rapid degradation of the organic matter and the mixing and dilution that typically accompany transport by currents. The exception is the Ganges-Brahmaputra-Meghna system, where sewage and other organic contamination are likely to be transboundary between India, Bangladesh, and Myanmar due to the high river discharge and ocean circulation patterns.

106. 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.

107. Plastic litter and derelict 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 localised near their source in the marine environment.

108. 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. Atmospheric inputs resulting from long-range transport and are inherently transboundary.

109. Shipping and associated sea-based discharges of oil are inherently transboundary. Disparities among countries in regulation and enforcement regarding operational discharges could be acting to drive such discharges from one country to another, in particularly into Bangladesh where 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.

110. Many 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 consequences of these compounds, the lack of information regarding the levels and effects of PTSs and POPs in the BOBLME constitutes a priority transboundary issue.

111. The bulk of riverine sediment inputs to the ocean settle out near the river mouth, so the effects of sedimentation are generally localised. 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 localised near their source, the exceptions being mercury and lead, although the BOB 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 organomercury contamination, in the BOBLME is not known and is a priority gap in knowledge.

4.3.3 Causes of pollution

112. The proximate causes for the identified priority issues are:

- The widespread discharges 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.

113. 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 mobilise pollutants from relatively immobile compartments such as lagoons and coastal sediments, and can render waste management systems such as landfills and sewerage systems that do exist ineffective. Such catastrophic events can cause the release or transfer of large quantities of contaminants to the coastal and marine environment (Kaly, 2004), but conversely could act to flush contaminants from coastal areas.

114.   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 has a multiplying effect on 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:
  - o   Insufficient financial and/or human monitoring and enforcement capacity;
  - o   Responsibility for implementing and enforcing environmental policy and legislation is often spread across a number of agencies, without adequate coordinating methods;
  - o   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
  - o   A general lack of incorporating the economic, health, and social impacts of pollution into development planning decisions.

5.   INFORMATION GAPS

115.   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 that was often based on national statistics and information, not the BOBLME. In some cases, for example in Indonesia where only 4 provinces are covered in the definition of the BOBLME, some extrapolations and assumptions were required to come up with estimates from larger databases.

116.   Inconsistent definitions are also 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.

117. 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 better spatial and thematic details.

118. 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.

119. These two types of gaps should be distinguished. The associated interventions—and their cost and complexity—needed to address the gaps themselves 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 and put in a larger analytical context and that are kept, often as only the single original and on open shelves, in government department offices.

120. 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 and the consequence often is no management action at all. Meanwhile 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 of those systems, on the best scientific principles.

121. 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 of the initial management plan comes in.

122. 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

123. There are many information gaps regarding 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), we can say what types 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.

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

1. *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 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.

2. *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 / developing tools to inform on these tradeoffs; and
   - Building approaches to enable national policy makers to understand, engage and deal with the complexity of BOBLME management;

3. *Understanding how key exogenous changes affect the 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 level responses. Therefore, this work can highlight the areas when 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:

- Understanding of how different management instruments perform under different exogenous pressures;
- Understanding of how global instability and uncertainty impact the livelihoods of poor people and their access to the benefits from the LME;
- Understanding of the threats and opportunities represented by exogenous change for the management of BOBLME;
- Identifying/adapting/developing approaches that have shown success in helping people to deal with change;

5.2   Information gaps for marine living resources

125.   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 has occurred and is still occurring on the coastal resources of all BOBLME countries and that action is needed.

126.   The inadequacies of fisheries statistics are also 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 on-line 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 among the BOBLME countries.   Many fish catches are reported as miscellaneous fish, especially from 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 is a misleading concept. "Triple-bottom line" reporting that reports on the economic, social and ecological status of the BOBLME based on a set of indicators is urgently needed.

127.   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 among countries so that the transboundary nature of fishing can be better qualified;
- Better information and information exchange on IUU fishing;
- More detailed reporting of fishing activities and catches, especially in Bangladesh and Myanmar;
- Better systems of analysing statistic data to make them more useful to science (e.g. catch and effort data at the boat level);
- More broad-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 dynamic; and
- Better understanding of incentives (including perverse incentives) that control and influence decision making in fisheries.

128. 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 gap exists in communication and communication skills among scientists, managers, policy makers and stakeholders. Scientific results are often only published in the grey literature and 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

129. 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 do with updating. Coral reefs information 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.

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

- areal 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 of 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

131. Information gaps for pollution include:

- Insufficient quantitative information on the levels, distribution, or effects of contaminants in the BOBLME, and consequently insufficient information to:
    - o   prioritise and determine the relative importance of pollution threats;
    - o   determine the transboundary dimensions of pollution in the BOBLME;
    - o   identify and prioritize pollution "hot spots"; including a lack of objective criteria;
    - o   determine the importance of contamination by POPs and PTSs in the BOBLME;
    - o   evaluate the relative importance of land-based and sea-based sources of oil pollution;
    - o   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. Kaly (2004) identifies this specifically as a perceived lack of essential information as defined above.
- Insufficient information to establish acceptable limits for discharges of pollutants.

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ANNEX 1: DETAILED CAUSAL CHAIN ANALYSES BY AREA OF CONCERN

1. Overexploitation of marine living resources

Transboundary nature of the concern	Issues	Proximate causes	Intermediate causes	Root causes
Many fish stocks shared among BOBLME countries either 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.	Decline in overall availability of fish resources	Excessive fishing effort and overcapacity; Unselective fishing practices and gear	Increasing fishing effort, especially trawlers and purse seiners; Illegal, unregulated and unreported (IUU) fishing, both national and international; Weak fisheries MCS and enforcement	"Open access" regime; Strong incentives to encroach into areas with better returns; High consumer demand for food fish
	Changes in species composition of catches	Excessive fishing effort and overcapacity; Unselective fishing practices and gear	Increasing fishing effort, especially trawlers and purse seiners; Illegal, unregulated and unreported (IUU) fishing, both national and international Weak fisheries MCS and enforcement	"Open access" regime; Strong incentives to encroach into areas with better returns; High consumer demand for food fish; High consumer demand for seed and fish meal for aquaculture
	High proportion of juvenile fish taken	Unselective fishing practices and gear	Weak fisheries MCS and enforcement	"Open access" regime; High consumer demand for food fish; High consumer demand for seed and fish meal for aquaculture;
	Changes in marine biodiversity plus vulnerable/endangered spp.	Destructive fishing methods	Weak fisheries MCS and enforcement	"Open access" regime; High consumer demand for food fish

2. Degradation of critical habitats

a. Preliminary causal chain analysis for the causes of the loss of mangrove habitat in the countries surrounding the BOBLME.

Trans-boundary nature	Issue	Proximate Cause	Intermediate cause	Penultimate cause	Root cause	Externalities
• 11% of global mangroves border the BOBLME • All countries contain mangroves	Loss of Mangrove Habitat	Conversion for agriculture **(82%)**	Subsistence production **(%)**	Food security of coastal poor	Growth in coastal population	
			Export production **(%)**	National Demand for hard currency earnings	National & 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
		Conversion to aquaculture **(12%)**	Subsistence production **(%)**	Food security of coastal poor	Growth in coastal population	
			Export production **(%)**	Demand for hard currency earnings	National & 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
		Conversion for salt production (?%)	Subsistence & cash income	Lack of economic alternatives	Lack of alternative livelihoods	
		Conversion for coastal tourism **(?%)**	Increasing tourism	Demand for hard currency earnings	National & Regional Economic development drivers	
		Conversion for human settlement **(1.5%)**			Growth in coastal population	
		Conversion for Industrial purposes **(?%)**			National & Regional Economic development drivers	
		Clear felling for Wood chip production **(?%)**	National demand for paper	Corporate demand for "profit"	Lack of a "green ethic" in business	
			Export demand	Corporate demand for "profit"	Lack of a "green ethic" in business	World prices
		All of the above	Lack of national provincial/ state coastal development plans	Where plans exist lack of political will to enforce plans	Lack of capacity (financial and manpower) to enforce controls	
			Lack of National, Provincial, state mangrove management plans			

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

2. Degradation of critical habitats (continued)

b. Preliminary Causal chain analysis for the causes of coral reef habitat loss and degradation in the countries surrounding the BOBLME.

Trans-boundary nature	Issue	Proximate Cause	Intermediate cause	Penultimate cause	Root cause
• 8.0% of global coral reefs border the BOBLME • All countries contain coral reefs	Loss and degradation of Reef Habitat	Land Based Activities	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 & harbour construction
			Coastal Pollution	Industry/Ports/Agriculture	Development
			Nutrient increase	Agriculture urban sewerage	Population growth
			Solid waste	Coastal urbanization	Population growth
		Marine Based Activities	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		
		Natural, Episodic events	Crown of thorns outbreaks		
			Bleaching	Increased sea surface temperature	
			Storm damage		

3. Pollution

Trans-boundary nature	Issue	Proximate Cause	Intermediate cause	Penultimate cause	Root cause
• 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 among 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 organomercury undergo long-range transport; • Sedimentation and most heavy metal contamination tend to be localized and lack a strong transboundary dimension;	1. Sewage-borne pathogens	Untreated or only partially treated sewage	Lack of sewage treatment facilities	Lack of capital investment	Increasing coastal population density
				Lack of low cost alternative treatment options	
	2. Sewage-borne organic load	Untreated or only partially treated sewage	Lack of sewage treatment facilities	Lack of capital investment	Increasing coastal population density
				Lack of low cost alternative treatment options	
	2. Solid waste/marine litter	Discharges of solid waste into rivers and coastal waters;	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	
	3. Increasing nutrient inputs	Untreated or only partially treated sewage	Lack of sewage treatment facilities	Lack of capital investment	Increasing coastal population density
				Lack of low cost alternative treatment options	
		Increasing fertilizer use in agriculture	Improper use of fertilizers	Need for maximum productivity	Increasing population
		Increasing coastal aquaculture	Improper use of feeds	Need for maximum productivity	Increasing population
		Increasing atmospheric emissions of nitrogen from industry and fossil fuel burning;	Lack of regulations for flue emissions	Lack of capital investment	
	4. Oil pollution	Operational discharges of oil from shipping, dumping of used oil from small boats and land vehicles	Non adherence to IMO agreements regarding oil and ballast water discharge	Lack of port reception facilities and enforcement	
	5. POPs/PTSs	Burning of solid waste;	Lack of regulations and or monitoring of flue emissions	Lack of capital investment	
		Industrial emissions			
	6. Sedimentation	Coastal Construction	Lack of regulations and/or monitoring and control	Lack of capital investment	Lack of awareness of policy makers, legal system, and civil society
		Land-based mining & tailings discharge			
		Coastal Dredging			
	7. Heavy metals	Industrial discharges	Lack of regulations and/or monitoring and control	Lack of capital investment	Lack of awareness of policy makers, legal system, and civil society